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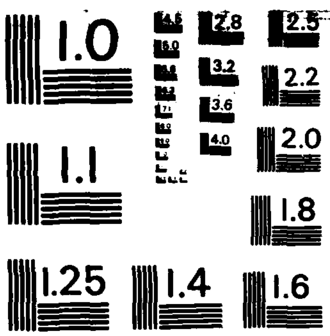

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STUDY REPORT
CAA-SR-84-2

AD

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TRANSPORTATION WORKLOAD FORECASTING (TWF) STUDY

JANUARY 1984

PREPARED BY
STRATEGY, CONCEPTS AND PLANS DIRECTORATE

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The study examined the Army process of forecasting its overocean surface cargo transportation requirements, identifies the nature and extent of forecasting errors and examines methods of improving the forecasts. Specific analysis is made of systemic and methodological aspects of the Army forecasting process and external system factors contributing to forecasting error. The study examines several system solutions and develops models to be used within the system. Box-Jenkins and Winters Models for each of several commodities are developed and presented as accurate forecasting tools when used with program information.

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DEPARTMENT OF THE ARMY
US ARMY CONCEPTS ANALYSIS AGENCY
8120 WOODMONT AVENUE
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REPLY TO
ATTENTION OF

CSCA-SPP

15 March 1984

SUBJECT: *Transportation Workload Forecasting (TWF) Study*

Deputy Chief of Staff
for Logistics
Department of the Army
ATTN: DALO-TSP
Washington, DC 20310

1. Reference letter, DALO-TSP-C11, 11 May 1983, SAB.

2. The Deputy Chief of Staff for Logistics requested that the US Army Concepts Analysis Agency study US Army transportation workload forecasting and develop procedures to improve the system.

3. This report describes the study approach, the current forecasting system, and several alternative systems and methods that should result in improved forecasts of over-ocean cargo transportation requirements.

David C. Hardison

DAVID C. HARDISON
Director

CAA	**TRANSPORTATION WORKLOAD FORECASTING (TWF) STUDY**	**ONE SHEET STUDY GIST CAA-SR-84-2**

THE PRINCIPAL FINDINGS of the work reported herein are as follows:

(1) The transportation workload forecasting system has produced inaccurate forecasts resulting in inefficient Military Sealift Command (MSC) industrial fund operations.

(2) Accurate forecasting of cargo transportation requirements can be accomplished by forecasting at a single activity.

(3) Either HQ Military Traffic Management Command (MTMC) or HQ, US Army Materiel Development and Readiness Command (DARCOM) is a suitable location for a single point forecasting activity.

(4) The Box-Jenkins and Winters Forecasting Models can provide accurate forecasts when used in conjunction with program information.

(5) Changes to the allocation of transportation account codes and requirements for forecasting shipping mode are also required to improve forecasting accuracy.

THE MAIN ASSUMPTION on which the work reported herein rests is that transportation workload forecasting requirements, contained in JCS Publication 15, would not be changed.

THE PRINCIPAL LIMITATIONS of this work which may affect the findings are as follows:

(1) Only the forecasting of peacetime over-ocean surface cargo transportation requirements was evaluated.

(2) Historical lift data was extracted exclusively from MSC records and could not be validated from Army sources.

THE SCOPE OF THE STUDY was taken to include an analysis of the Army's long-range cargo transportation requirements forecasting process and its impact on budgets and transportation costs.

THE STUDY OBJECTIVE was to develop cost effective systems and methods for improving the forecasting of Army over-ocean surface cargo transportation requirements.

THE BASIC APPROACH followed in this study can be defined as: research was conducted into the nature and extent of the forecasting problem, to identify its impact, and its systemic and methodological causes. Several alternative systems were evaluated based on their relative costs and efficiency. Then a series of mathematical techniques was evaluated for suitability as forecasting tools. Two of the techniques, the Box-Jenkins and Winters models, were used to forecast the 1982 cargo transportation requirements based on 1977 to 1981 MSC cargo lift data.

REASONS FOR PERFORMING THE STUDY are mainly as follows: recent forecasts of Army over-ocean surface cargo transportation requirements have been inaccurate. As a consequence MSC industrial funds have incurred significant losses and the MSC controlled fleet was not efficiently utilized for cargo transport. This study was directed to develop methods to improve the forecasts.

THE STUDY SPONSOR was the Deputy Chief of Staff for Logistics, who also established the objectives and monitored the study activities.

THE STUDY EFFORT was directed by LTC James N. Keenan, Strategy, Concepts and Plans Directorate.

COMMENTS AND QUESTIONS may be directed to CAA, ATTN: Assistant Director for Strategy, Concepts and Plans.

(Tear-out copies of this synopsis are at back-cover.)

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TRANSPORTATION WORKLOAD FORECASTING (TWF) STUDY

CHAPTER 1

INTRODUCTION

1-1. INTRODUCTION. The Department of Defense transports approximately 7.5 million tons of cargo annualy via the Defense Transportation System (DTS). In excess of 50 percent of this cargo is generated by the Army. Planning for and use of military and commercial shipping is dependent on the accurate forecasting of the services' requirement for movement of cargo. The current Army transportation workload system does not produce accurate forecasts of Army cargo movement requirements. As a consequence, the Deputy Chief of Staff for Logistics (DCSLOG), Headquarters, Department of the Army (HQDA), tasked the US Army Concepts Analysis Agency (CAA) to study the transportation workload forcasting issue and to report the study findings in January 1984. This report discusses the study approach, the forecasting system, other studies of the issue, other service solutions to the problem, and approaches to the Army's forecasting problem.

1-2. BACKGROUND. The Army is required to submit periodic forecasts of its over-ocean transportation to Military Sealift Command (MSC). Recent Army forecasts have shown considerable variance from actual cargo lift. This discrepancy between forecasted and actual lift requirements impacts adversely on the operation of the MSC and Military Traffic Management Command (MTMC) industrial funds, on the MSC controlled fleet sizing process, and on Army transportation budget preparation and execution.

1-3. PURPOSE AND SCOPE. The purpose of this study was to develop procedures to improve the US Army transportation workload forecasting system. The study focus was primarily on the long-range, over-ocean surface transportation requirement forecasting process.

1-4. OBJECTIVES. Objectives of the study were to determine the nature and extent of the transportation workload forecasting problem and to explore and evaluate alternative solutions.

1-5. LIMITATION. Historical lift data, used in model development. was extracted exclusively from Military Sealift Command records and could not be validated from Army sources.

1-6. ELEMENTS OF ANALYSIS. The elements of analysis of the study were designed to explore those facets of the transportation workload forecasting environment which would help identify the extent of the problem, contributing factors, and potential solutions. These elements were as follows:

a. What are the recorded variances between long-range transportation workload forecasts and actual utilization of cargo shipping?

b. Do systemic conditions exist which contribute to unrealistic forecasting? If so, what are they?

c. What is the economic and operational impact of long-range forecasts which are at variance with actual utilization?

d. Do short-range forecasts impact on long-range forecasting? If so, how?

e. What is the impact of the current separation of responsibility for long- and short-range forecasting?

f. What methodologies exist in the other services which could be applied to the resolution of the Army problem?

g. What DARCOM activities affect major items of equipment planned for overseas distribution?

h. What is the impact of the Total Army Distribution Program (TAEDP) on forecasting of requirements?

i. What is the commodity impact of Army and Air Force Exchange Service (AAFES) forecasting procedures?

j. What are the feasible and cost effective methods for improving forecasting accuracy?

k. What, if any, unique commodities are marked as general or special cargo?

1-7. STUDY TASKS. To fulfill the study objectives and to answer the elements of analysis, five principal tasks were identified and were the basis of the study methodology. These tasks were:

a. Identification of the nature and extent of the variances between forecasts and actual lift.

b. Determination of the impact of erroneous forecasts.

c. Development and examination of forecasting systems and methods.

d. Evaluation of alternative locations for forecasting responsibility.

e. Documenting recommended methodology.

1-8. STUDY METHODOLOGY. The methodology used in the study is depicted in Figure 1-1.

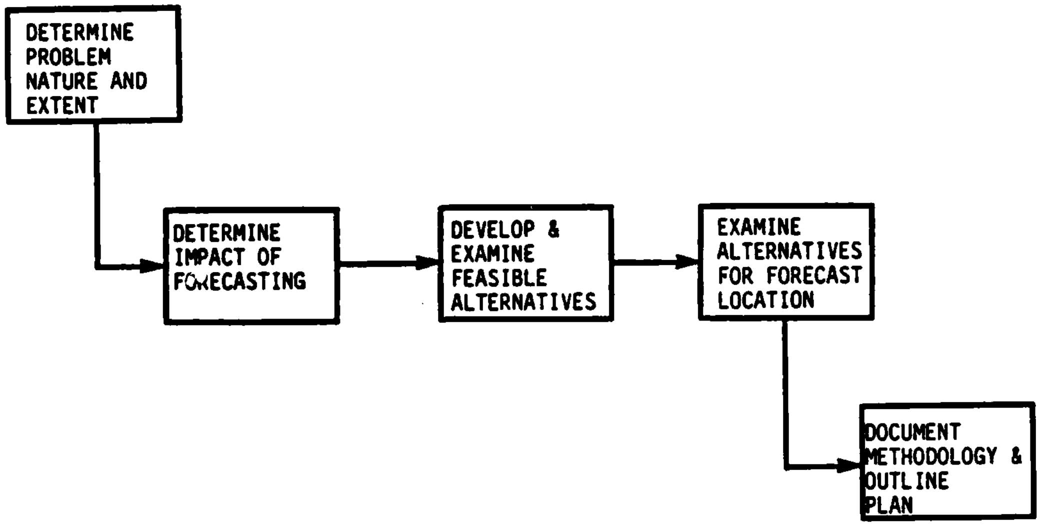

Figure 1-1. Study Methodology

a. Activities in the determination of the nature and extent of the problem consisted of:

(1) Research into completed and ongoing studies of the transportation workload forecasting problem.

(2) Research into Joint Chiefs of Staff (JCS) publications, MSC, Military Airlift Command (MAC), and MTMC directives, and Army, Navy, and Air Force regulations which were related to transportation workload forecasting and operations.

(3) Analysis and evaluation of the procedures used by Army transportation workload forecasting and budgeting agencies.

(4) Analysis of MSC, MTMC, and MAC operations and the relationship between these commands and the Army transportation forecasting system.

(5) Collection and analysis of 4 years of forecasts and 6 years of cargo lift data.

b. Activities in the determination of the impact of long-range transportation workload forecasts on the Army budgets and on the industrial funds of MSC and MTMC included:

(1) Examination of the interfaces between the forecasting system and budgetary process and quantification of the effects of incorrect forecasts.

(2) Review of HQDA budget documents and interviews with personnel involved in the budget process.

(3) Examination of the development and operation of MSC industrial funds.

(4) Investigation of the MSC controlled fleet sizing process.

c. Actions in the development and examination of alternative methods for increasing forecasting accuracy consisted of:

(1) Analysis and evaluation of previously collected performance data, focusing on systemic contributions to erroneous forecasts.

(2) Identification of the forecasting systems data requirements and the most accurate data sources.

(3) Formulation of alternative forecasting systems and evaluation of costs in terms of personnel and facilities.

(4) Investigation of Navy and Air Force forecasting systems.

(5) Evaluation of mathematical forecasting techniques to determine their suitability as tools in transportation workload forecasting.

(6) Application of several mathematical techniques to historical cargo lift data to determine the most appropriate technique and to identify the parameters of the forecasting model.

d. Examination and evaluation of alternative locations for forecasting responsibility consisted of the following actions:

(1) Evaluation of the availability and accuracy of the information required to manage the transportation workload forecasting system.

(2) Identification and evaluation of the availability of data processing support which is required by proposed systems.

e. Documenting the recommended methodology consisted of documentation of the Box-Jenkins and Winters models and the actions required to improve the systemic and external aspects of the forecasting system.

CHAPTER 2

THE CURRENT ARMY TRANSPORTATION WORKLOAD SYSTEM

2-1. GENERAL. The Army's transportation workload forecasting system is governed by Joint Chiefs of Staff (JCS) Publication 15, AR 55-23, AR 55-30, and several MSC, MAC, and MTMC directives. This chapter defines the regulatory basis for the system, observations on how the actual system works, the performance of the system in terms of forecasting accuracy, the effects of inaccurate forecasts, and some external factors which may contribute to the inaccuracies.

2-2. THE REGULATORY FORECASTING SYSTEM

a. JCS Pub 15, Mobility Systems Policies, Procedures and Considerations, 2 June 1974, contains approved joint transportation procedures applicable to the submission of common user movement requirements. Specifically Chapter 4 (Transportation Requirements, Allocations, and Priorities) addresses, inter alia, shipper service forecasted cargo movement requirements. It requires that each military service and the Defense Logistics Agency (DLA) submit four specific forecasts of sealift requirements.

(1) On 1 May a preliminary annual forecast (MSC-9) is submitted which states the worldwide MSC surface movement requirements for the fiscal year which begins 17 months later (e.g., 1 May 84 for fiscal year 1986).

(2) An annual forecast (MSC-10) is submitted on 1 March for the subsequent fiscal year (e.g., 1 Mar 85 for FY 86). This forecast refines the preliminary forecasts.

(3) A sealift cargo requirement (short range) is submitted by the fifteenth day of each month for the succeeding 3 months. Each of the reports states the monthly sealift cargo requirements in measurement tons for each traffic route, program, commodity, and type of shipment or mode.

(4) Change reports are required when significant changes to the above forecasts are anticipated.

b. Each military service is also responsible for the collection and submission of movement requirements of government agencies outside DOD for which the service has sponsorship responsibility and whose requirements have been approved by competent authority as eligible to be handled within the DOD transportation system.

c. AR 55-23, Military Sealift, implements JCS Pub 15 within the Army. It identifies 57 numbered traffic areas and their associated geographic areas. These areas are the terminals of the traffic channels for which forecasts are submitted. Additionally, AR 55-23 identifies sponsor codes, budget programs, cargo classes/commodities, types of shipment, and formats for reports submitted to the Military Sealift Command. These are discussed below.

(1) Budget programs to be used in the forecasts are Troop Support, Military Construction, Military Aid, and Civilian Aid.

(2) Cargo classes/commodities to be forecasted in the reports are:

Reefer-chill (CHL)
Reefer-freeze (FRZ)
Coal and Coke (COK)
Bulk-Other (BLK)
Privately Owned Vehicles (POV)
Household Goods (HHG)
Ammunition and Explosives (AMO)
General Cargo (GEN)
Special Cargo (SPC)
Assembled Aircraft (AAC)
Empty Conex (CNX)
Cargo Carrying Trailers (CCT)

(3) Type shipments or modes to be forecasted in the reports are break-bulk, container, and MILVAN.

d. AR 55-30, Space Requirements and Performance Reports for Transportation Movements, prescribes procedures for the preparation and submission of cargo requirements and performance reports and defines responsibilities for report submission.

(1) Responsibilities defined in AR 55-30 are as follows:

(a) The Deputy Chief of Staff for Logistics, HQDA, is responsible for developing longe-range cargo movement requirements (preliminary and annual forecast reports) and for programing and budgeting for transportation services.

(b) DARCOM Logistics Control Activity (LCA) has DA responsibility for developing and programing short-range movement requirements.

(c) The following commanders and agency heads are responsible for the provision of inputs to both long-range and short-range forecasts:

Military Postal Service Agency
Army and Air Force Exchange Service
Armed Forces Courier Service
US Army Intelligence and Security Command
Chief of Engineers
National Security Agency
Ballistic Missile Defense Systems Command
US Army Communications Command

US Army, DARCOM, Logistics Control Activity
US Army, Europe
US Army, Japan
Eighth US Army
Western Command
US Army Forces Command
193d Inf Bde (Panama)
172d Inf Bde (Alaska)
Deputy Chief of Staff Logistics, HQDA

(2) The commands and agencies listed in paragraph 2-2d(1)(c) above, are required to submit their long-range reports to US Army Management Systems Support Agency (USAMSSA). USAMSSA provides a consolidated report to the Director for Transportation, Energy and Troop Support, ODCSCLOG, who analyzes and adjusts the stated requirements. The adjusted data is then provided to USAMSSA for preparation and submission to MSC and MTMC. As an exception, the US Army Installation Support Activity, Europe, Energy Center, Rheinau is required to submit long-range solid fuel (coal and coke) requirements semiannually to HQDA ODCSLOG.

(3) Short-range requirements for surface cargo movement are to be submitted monthly to DARCOM LCA. LCA is required to consolidate the reports and forward the Army's statement of requirements to MSC and MTMC.

(4) Change reports are to be submitted when there is a 600-measurement-ton-change over a traffic area (e.g., Gulf Coast to Europe).

e. Military Sealift Command uses the long-range forecasts to plan the use of its nucleus fleet and, when required, plans for augmentation by commercial or National Defense Reserve Fleet resources. (The total of these assets is the MSC controlled fleet.) The long-range forecasts are also used by MSC to formulate the shipping rates to be charged to the services for cargo shipped and by the services for budget preparation. The stated use of short-range forecasts by MSC and MTMC is the scheduling of ship and port workloads.

f. JCS Pub 15 directs that monthly utilization reports be provided to the Army comparing final forecasted requirements with actual cargo for a particular month.

g. The Army's forecasting system is portrayed at Figure 2-1, and the report submission sequence is shown at Figure 2-2.

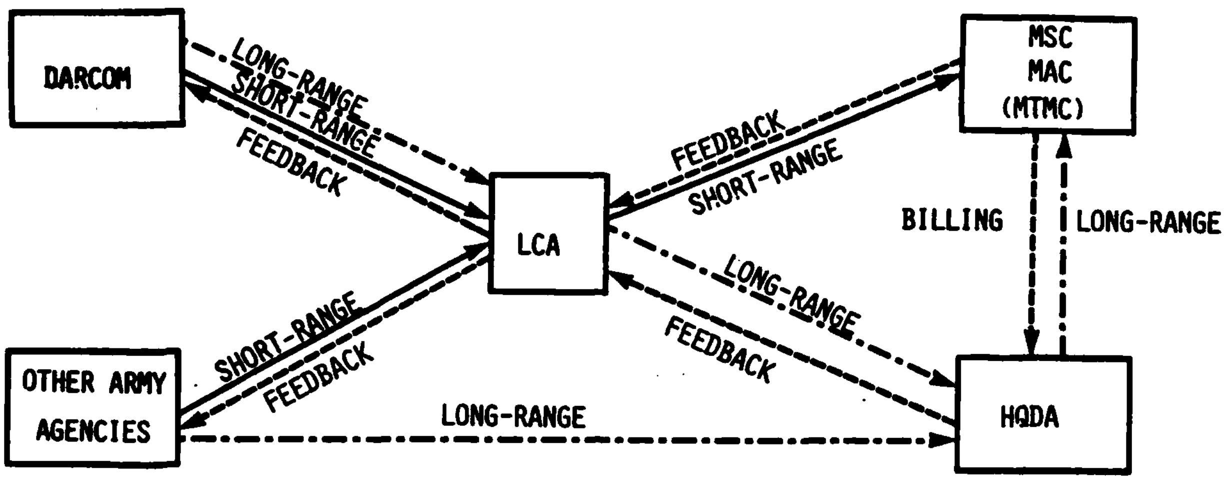

Figure 2-1. The Army Forecasting System

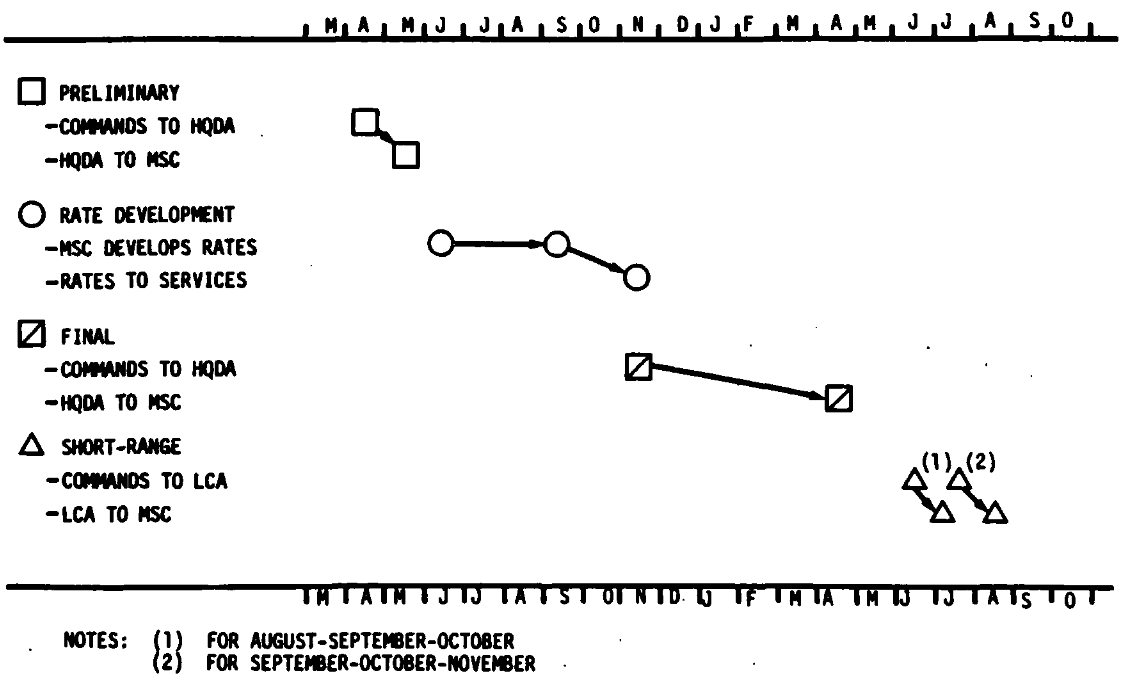

Figure 2-2. Report Submission Sequence

2-2. OBSERVATIONS OF THE ARMY FORECASTING SYSTEM

a. Long-range Forecasts. The long-range forecasts, as required, are submitted by the forecasting agencies identified in AR 55-30. However, methods and procedures for preparation of these reports are inconsistent and vary extensively in their accuracy. A synopsis of forecasting procedures by the various commands follows.

(1) DARCOM forecasts for major items and ammunition are prepared at the DARCOM major subordinate command inventory control points (ICP). The reports are, in theory, based on The Army Equipment Distribution Plan (TAEDP), Materiel Movement Reports (MMR), Logistics Intelligence File (LIF), and forecaster judgment. Due in part to forecaster mistrust of the TAEDP accuracy, inability to accurately correlate LIF data with actual movement, and the absence of accurate timely feedback, significant subjective forecasting is made. Additionally, indications are that there is inadequate information exchange between the item managers and the personnel making the forecasts. Consequently the program information available to the transportation workload forecaster may not be the most current.

(2) DARCOM forecasts for secondary items are prepared by the Logistic Control Activity using the previous year's actual lift data extracted from MSC billing records.

(3) Army/Air Force Exchange System forecasts are prepared using the arithmetic mean of three previous years of lift history. This is adjusted by anticipated sales growth; inflation factors, changes in troop strengths; opening, closing, or consolidation of facilities; and changes in mode of transportation.

(4) The Military Postal Service Agency (MPSA) uses historical data on the volume of consolidated Army and Air Force mail moved over an MSC channel. Adjustments are made based on knowledge of strength increases, new missions, and changes to traffic routes. History is developed from MSC billing tapes which are provided directly by MSC to the MPSA. An automated management information system, the Military Automated Mail Accounting System (MAMAS), is used by MPSA in their forecast formulation.

(5) The Chief of Engineers forecasts are submitted only by the US Army Engineer District, New York, and apply only to cargo originating at Bayonne, NJ and destined for Thule, Bremerhafen, Rotterdam and the Azores. The forecasts are based on previous forecasts and have not changed for several years. Forecasts are not made by, or for, other engineer commands or agencies.

(6) The Ballistic Missile Defense Systems Command forecasts are prepared by the Logistics Support Contractor (LSC) at Kwajalein Missile Range from inputs submitted by six range contractors who perform range services. Forecasts are based on 3 years of historical data as determined by the contractor records of items shipped. The quantities obtained from the contractors' historical data have not agreed with the cargo movement feedback reports provided by LCA.

(7) The US Army Communications Command reports that their forecasts are "strictly guesswork."

(8) US Army Europe has not submitted the required surface cargo movement forecasts for at least 2 years.

(9) Eighth US Army forecasts are derived from data provided by nine subordinate elements based on forecast history.

(10) US Army Japan (USARJ) forecasts are based on history and projected requirements. USARJ does receive monthly feedback reports from LCA.

(11) Western Command forecasts are straight line projections from historical data adjusted by experience.

(12) 193d Infantry Brigade (Alaska) uses monthly tonnage reports compiled locally as the historic basis for their forecasts.

(13) 172d Infantry Brigade (Panama) forecasts are based on historical cargo lift data provided by the local MTMC facility.

(14) ODCSLOG, HQDA consolidates and adjusts the aggregated inputs of the Army forecasting commands and agencies. It also prepares the long-range CONUS outbound household goods and POV cargo space requirements forecasts. The household goods and POV forecasts are based on the most recent year of complete cargo movement data available.

b. Short-range Forecasts. Short-range forecasts are prepared by all activities which submit long-range forecasts and by Headquarters, Forces Command.

(1) Many of the short-range forecasts are a straight line monthly average of the annual forecast and do not account for monthly or seasonal variations. Others, particularly DARCOM, use program and historical data.

(2) Forces Command does not prepare a long-range forecast. It does prepare and submit a short-range forecast for all CONUS outbound household goods and privately owned vehicles, although it does not have knowledge of all movements. In FY 81 and FY 82, household goods were approximately 20 percent and 11 percent, respectively, overforecast in the long-range

forecasts and approximately 80 percent and 38 percent, respectively, overforecast in the short-range forecasts.

(3) LCA consolidates the short-range forecasts provided by the forecasting agencies and forwards the report to MSC and MTMC. Additionally, LCA prepares the short-range forecast of DARCOM secondary items using a modified Kalman filter algorithm and data from the LIF. A recent DARCOM Inventory Research Office study concluded that the current smoothing algorithm was not optimal and recommended a replacement.

c. Performance Reports

(1) Chapter 3, AR 55-30, requires DARCOM LCA to produce monthly feedback reports for each reporting command or agency which reflect the forecasted and actual lift of surface cargo tonnage. The data provided are to be used as guidance in the preparation of the long-range and short-range forecasts. Most Army forecasters cite there is a lack of information on shipments and identify this as a barrier to improved forecasts.

(2) Feedback reports produced by LCA are extracted from the MSC billing tapes and the forecasts provided by the forecasting agencies or commands. LCA attempts to identify the cargo shipper either through a comparison of the shipping information to the LIF or through the Transportation Account Code (TAC). The LIF to shipping information comparison cannot identify a large number of transactions due primarily to the absence of the information within the LIF. Identification of the shipper through TACs, under which all shipments are reported, is not currently achievable. This is primarily a result of the current TAC structure which allocates a single TAC to all cargo shipped by DARCOM and several other commands and agencies.

d. Cargo Transportation Budgeting. The MECHTRAM (Mechanization of Selected Transportation Movement Reports) system produces long-range cargo forecast reports and provides them to DCSLOG and DCSPER to be used in budget preparation. Review of the budget formulation process indicates that the MECHTRAM reports are not used and that other tools have been developed. MILPERCEN personnel reports, MSC/MTMC provided shipping rates and historical factors are the basis of the transportation costs within Military Personnel Army (MPA) budget, while history and program knowledge are the basis of the second destination transportation costs in Military Assistance Program (MAP), and Operations and Maintenance (OMA) budgets. None of the forecasting commands or agencies have any responsibility for budget formulation and execution. Payment of shipping charges is made by US Army Finance and Accounting Center based on MSC and MTMC billings.

2-3. FORECASTING SYSTEM PERFORMANCE

a. Forecasts submitted by the Army in recent years have generally overstated requirements. While the total forecast compared to actual shipment has shown significant improvement, forecasts by commodity and type of shipment have continued to exhibit significant variances. Table 2-1 shows in thousands of measurement tons (MTON) the aggregated long-range forecast and the actual lift and error, by commodity and type shipment for FY 1981. Table 2-2 portrays the same data for FY 1982. It should be noted that overforecasts for some commodities in some modes are offset by underforecasts in the same commodities in other modes. For example, breakbulk general cargo was overforecast by 115,000 tons and seavan general cargo was underforecast by 191,000 tons.

b. Forecasting errors by the Army in FY 81 were much greater than those of other services. In FY 82, the differences were less pronounced as Army forecasts were more accurate. As the Army's cargo accounts for approximately 60 percent of all cargo carried by MSC, the effects of percentage errors are much more severe than errors by the other services. Tables 2-3 and 2-4 show comparisons of the aggregate 1981 and FY 82 breakbulk forecasts and shipments by the shipper services.

Table 2-1. FY 81 Forecast Performance (000 MTON)

	Breakbulk			Seavan			MILVAN		
Commodities	Forecast	Lift	Error	Forecast	Lift	Error	Forecast	Lift	Error
General	465	170	-286	1,736	1,610	-126	11	21	-10
Household	45	42	-3	65	36	-29	--	13	+13
Special	671	579	-92	19	20	+1	--	--	--
POVs	350	286	-64	136	198	+62	1	--	-1
Reefer	0	1	+1	36	41	+5	--	--	--
Ammunition	165	120	-45	--	3	+3	28	20	-8
CCT	54	76	+22	--	--	--	--	--	--
CNX	5	2	-3	--	--	--	--	--	--
Coal/bulk	462	377	-85	--	2	+2	--	--	--

Table 2-2. FY 82 Forecast Performance (000 MTON)

Commodities	Breakbulk			Seavan			MILVAN		
	Forecast	Lift	Error	Forecast	Lift	Error	Forecast	Lift	Error
General	297	182	-115	1,639	1,830	+191	18	14	-4
Household	61	32	-29	39	52	-20	--	5	+5
Special	519	321	-198	27	9	-18	--	--	--
POVs	344	278	-66	138	240	+102	--	1	+1
Reefer	--	1	+1	31	50	+19	--	--	--
Ammunition	135	132	-3	0	3	+3	36	43	9
Aircraft	--	2	+2	--	--	--	--	--	--
CCT	64	75	+11	--	--	--	--	--	--
CNX	4	1	-3	0	2	+2	--	--	--
Coal/bulk	436	-53	--	--	--	--	--	--	--

Table 2-3. FY 81 Comparison of Service Forecasts

Component	FY 1981 breakbulk cargo (000 MTON)				FY 1981 seavan cargo (000 MTON)			
	Forecast	Actual	Error	Percent	Forecast	Actual	Error	Percent
Army	2,208	1,676	532	24 over	1,992	1,910	82	4 over
Navy	456	377	79	17 over	939	897	42	4.7 over
Air Force	486	487	1	.2 over	562	531	31	5.5 over

Table 2-4. FY 82 Comparison of Service Forecasts

Component	FY 1982 breakbulk cargo (000 MTON)				FY 1982 seavan cargo (000 MTON)			
	Forecast	Actual	Error	Percent	Forecast	Actual	Error	Percent
Army	1,860	1,407	453	24 over	1,874	2,186	312	17 under
Navy	375	393	18	18 over	918	934	16	2 under
Air Force	523	463	16	11 over	557	684	127	23 over

2-4. EFFECTS OF FORECASTING

a. General. Erroneous forecasting has several negative effects. It results in inefficient MSC shipping and MTMC port operations, as measured by losses in MSC and MTMC industrial funds, in ship utilization, in unreliable service budgets, and in inaccurate MSC-controlled fleet sizing.

b. Industrial Fund Impact. The MSC industrial fund losses for FY 82 attributable to erroneous Army forecasts are shown in Table 2-5. Losses to the industrial fund are initially absorbed by the MSC but are recouped in the following year through increases in the rates charged to the shipper services. This would appear to be an accounting problem. However, the industrial fund losses do reflect inefficient use of cargo carrying resources and expenditures in the subsequent year which would not occur if the forecasts were accurate.

Table 2-5. Losses in MSC Industrial Fund

	Tons (000)	Miles (000.00)	Income ($ 000)
FY 1982 rates (developed on preliminary requirements)	2,076	8,378	$257,132
Actual FY 1982 Army lift	1,470	5,240	157,293
Difference	(606)	(3,138)	$(99,839)

c. Budget Impact. Budget preparation for second destination (over ocean) costs of shipping cargo is impeded by the lack of accurate forecasts of the cargo movement requirements. As stated earlier, budget preparers have developed their own tools to produce the budget. OMA (p 7) is the predominant source of funds for over-ocean cargo movement. Table 2-6 shows the FY 82 performance of this budget element.

Table 2-6. Army Budget Performance

FY 82 budget OMA (p 7)	$ 601.3 million
Anticipated disbursements	$ 576.6 million
Deobligated	$ 24.7 million

d. MSC Controlled Fleet Impact

(1) The MSC-controlled fleet consists of a nucleus fleet of Navy-owned cargo ships and time chartered commercial vessels. These are used primarily to carry breakbulk cargo. The size of this fleet is calculated from the cargo movement requirements forecasted by the shipper services. MSC uses the percentage of cargo that historically was shipped on the various types of lift within the controlled fleet and then allocates

that percentage of the forecasted cargo to each type lift. From this, contracts are entered into between MSC and the commercial carriers for provision of required vessels. If the forecasted cargo is not generated, more shipping is available than required. Since ships are contracted for a minimum of 1 year, they are not returned until the end of the contracted period but are placed in reduced operating status. During FY 1982 the MSC controlled fleet average utilization rate was 40 percent. Army breakbulk forecast for FY 1981 was 555,000 measurement tons and in FY 1982 was 453,000 measurement tons in excess of actual shipments. This equates to a peacetime requirement excess of a minimum of four breakbulk cargo vessels within the MSC controlled fleet.

(2) MSC controlled fleet vessels are also considered by MSC when calculating its contingency shipping requirements. Therefore, it may be expected that the MSC fleet would not be reduced by a number equal to the savings generated by accurate forecasts and that the cost of operating contingency vessels would be absorbed by a source other than the shipper services. An excellent study on MSC controlled fleet sizing is contained in the OSD Logistics Systems Analysis Office Dry Cargo Sealift Forecast Study, December 1982.[1]

2-5. OTHER OBSERVATIONS. During the study of the Army's forecasting system, several factors were observed which have major impacts on the preparation and the use of the forecasts which were not all under the control of the Army. These include mode determination, household goods shipment mode, the use of short-range forecasts, commodity classification, and the MSC billing process.

a. Mode Determination

(1) JCS Pub 15 and AR 55-30 require that forecasts state the mode or type shipment as breakbulk, container, or MILVAN. However, the decision as to whether cargo is transported by breakbulk or container vessel generally does not rest with the Army forecaster or shipper, but with MTMC. As most breakbulk cargo is carried on MSC controlled fleet vessels and most container cargo on commercial shipping, this decision has a significant impact on forecast accuracy. As stated, MSC uses this data for MSC controlled fleet sizing and in the development of commercial cargo rates. Examination of FY 82 forecasted and lift data shows that breakbulk cargo was overforecast by 453,000 MTON or 24 percent and that container cargo was underforecast by 312,000 MTON or 17 percent. Table 2-7 shows those commodities in which offsetting forecasted versus shipped cargo variances occurred in FY 82.

Table 2-7. Selected FY 82 Breakbulk vs Container Forecast Performance (000 MTON)

Commodity	Forecast	Actual	Error
		Breakbulk	
General	297	182	115 over
Household	61	32	29 over
POVs	344	319	66 over
		Container	
General	1,639	1,830	91 under
Household	39	72	13 under
POVs	138	240	102 under

(2) From this analysis of the FY 82 forecast performance, it appears that a significant portion of the forecasting error is attributable to the breakbulk versus container shipping decision. Continuation of the requirement for the shipper to forecast the type or mode of shipment will most likely result in continued forecasting problems and consequently in MSC controlled fleet sizing errors. Routing of annual forecasts through MTMC to MSC would allow MTMC and MSC to determine the allocation of cargo between the various modes.

b. Household Goods Shipments. International household goods shipments are classified into six categories, one of which (door-to-door container, surface code 5) is processed by MSC. Door-to-door container, code 4, is processed totally by commercial carrier and does not appear in MSC billing information. Currently, code 5 shipments are less than 3 percent of those shipped under code 4. Minor shifts of cargo from code 4 to code 5 have a major impact on the accuracy of the forecast of household goods to be processed by MSC. As the forecasting agencies do not make the modal decision for household goods shipments, the accuracy of their forecasts is not under their control.

c. Use of Short-range Forecasts

(1) JCS Pub 15 and AR 55-30 direct submission by the shipper services of sealift cargo requirements (short range) each month for the succeeding 3 months. Discussions with MTMC personnel indicate that ships are not booked until MTMC has been notified by the shipper that a shipment is available and that short-range forecasts are not used in the process. Given the nature of shipping schedules, it is highly unlikely that schedules can be firmly arranged if only the month and area of shipment are known and not the date and port.

(2) Evaluation of short-range forecasts indicate that, in general, they are as inaccurate as the long-range forecasts and for some commodities and modes they are much less reliable. This may, in part, explain their nonuse. Table 2-8 shows the performance of short-range forecasts for FY 81 and FY 82. Long-range error is shown in parentheses.

(3) Observations of most commodity shipping history reveals monthly and seasonal trends that should be predictable with reasonable accuracy as components of the long-range forecast when progrm information is included in the assessment. Discussion with MSC personnel indicate that an accurate long-range forecast and periodic change reports would be adequate for their use.

d. Commodity Classification

(1) The special cargo commodity contains all military wheel and track vehicles (including sedans) and all items measuring 30 feet in any dimension. Most special cargo is carried by the MSC controlled fleet. Privately owned vehicles are a separate commodity and are transported by breakbulk and sea-van carrying vessels. As there is no physical difference between POVs and military sedans and other small military vehicles, the transportation requirements should be the same. Therefore military sedans and other small vehicles should be in the same commodity group.

(2) The general cargo category contains a significant number of end items, particularly communications-electronics equipment. Current Army transportation account code (TAC) structure does not facilitate the identification of these items. As a result, general cargo requirements contain elements which are affected by program decisions and for which impact on forecasts cannot be readily assessed.

(3) The empty CONEX and assembled aircraft commodities constitute a small segment of the total cargo and do not vary significantly. The previous year's lift, extracted from the billing information, should be adequate forecasts for these commodities unless program information indicated otherwise.

e. MSC Billing Process. Analysis of several years of MSC billing information, discussion with personnel involved in the budget process and forecasting personnel, review of data developed by US Navy Support Command, and information received at Air Force Logistics Center indicate that the monthly billings received from MSC usually do not contain all bills for the reported month and usually contain erroneous entries. Improvements to the MSC billing process are needed if the services are to accurately capture monthly and seasonal cargo shipping behavior to improve their forecast.

Table 2-8. Short-range Forecasting Error (000 MTON)

Commodity	FY 81			FY 82		
	Breakbulk	Container	MILVAN	Breakbulk	Container	MILVAN
General	+42(-286)	+110(-126)	-38(+10)	+39(-115)	+248(+191)	--(-4)
Household	-3(-3)	-89(-29)	+13(+13)	-71(-29)	-20(+13)	+5(+5)
Special	-4(-92)	+15(+1)	-- --	-15(-198)	+7(-18)	-- --
POV	-26(-54)	-12(+62)	-- --	-41(-66)	+17(+102)	+1(+1)
Reefer	+1(+1)	+1(+5)	-- --	+1(+1)	+9(+9)	-- --
Ammo	+19(-45)	+3(+3)	-14(-8)	-23(-3)	+3(+3)	-- --
Cargo trailer	+36(+22)	-31(0)	-- --	+50(-11)	-10(-)	-- --
CONEX	+2(-3)	-- --	-- --	--(-3)	+2(+2)	-- --
Coal/bulk	-334(-85)	+2(+2)	-- --	-108(-53)	-- --	-- --

( ) Long-range forecast error.

2-6. SUMMARY OF OBSERVATIONS

a. General. Observations in the study of transporation workload forecast system were categorized into three principal areas: systemic--those aspects involving the structure and interactions within it; methodological--those aspects relating to the methodologies used by various forecasters; and external environmental--those aspects within the JCS directed forecasting system which the Army does not control.

b. Systemic Observations

- The Army's transportation workload forecasting is not a closed loop system and can be classified as many forecasters performing duplicative functions at widely separated locations.

- The long-range and short-range forecasting systems are not independent but flow on separate reporting and aggregation channels.

- The budget and cargo forecast systems are not supportive of each other.

- Review and adjustment of forecaster input at HQDA and LCA is restricted by aggregation of inputs and lack of performance data.

- Army historical lift and forecast files are limited to 1 year of lift data.
- Present allocation of TAC does not facilitate forecast performance evaluation or identification of shippers' programs, or specific sources of errors.
- Some agencies are required to submit cargo movement requirements for commodities and programs about which they have limited information.
- The link between the various programs and statements of their transportation requirements is not well defined.
- The present operation processes of the MECHTRAM system are not adequate for accurate forecast or budget formulation.

c. <u>Methodological</u>

- There are no standard forecasting methodologies or tools in use within the system.
- Extensive subjective forecasting is used throughout the system.
- An adequate data base does not exist within the Army on which to base forecasts.
- MSC billing information is the most complete source of shipping data but does not currently identify shipper and program in sufficient detail to develop accurate forecasts for all commodities.
- Current methodologies generally do not produce accurate forecasts.
- Those agencies using several years of historical data and program knowledge as the basis for their forecasts have traditionally been most accurate.

d. <u>External Environment</u>

- JCS Pub 15 requires the Army to forecast the shipping mode (container vs breakbulk), but the decision on mode is generally made by MTMC.
- Household goods shipments through MSC constitute a small percentage of total household goods shipments. The accuracy of shipper forecasts can be significantly affected by shifts between modes. This decision is not made by the shipper service.

- Indications are that short-range forecasts are not used for port and ship scheduling and are otherwise of questionable value.
- The MSC billing system, which is the primary data source, is slow and may contain significant inaccuracies.
- The TAEDP is not currently an accurate source of information for forecasting of equipment distribution.

CHAPTER 3

RECENT STUDIES OF THE TRANSPORTATION WORKLOAD FORECASTING PROCESS

3-1. GENERAL. During the study of transportation workload forecasting, several related studies and reports, which were conducted during the previous 10 years, were reviewed to minimize duplication of effort and to benefit from data already available. Most recent of these were the Dry Cargo Sealift Movement Forecasting and Sizing of the MSC Fleet Study, conducted by the OSD Logistics Systems Analysis Office (LSAO) in December 1982 for the Deputy Assistant Secretary of Defense (L&MM); the Over-ocean Cargo Forecasting Procedures Study, conducted by the DARCOM Inventory Research Office (IRO) in September 1983; and an MTMC Forecasting Methodology (draft) 1983.

3-2. OSD LSAO STUDY. The OSD LSAO Study focused on breakbulk cargo forecasting only and its impact on the MSC-controlled fleet sizing process. The study was critical of the Army forecasting process and highly recommended both the current Air Force and developmental MTMC methodologies. They concluded that a wide range of forecasting methods with varying degrees of accuracy were now in use, and that the most accurate methods (USAF) use minimum judgment, are mathematically simple, use program data, have a single computation point, and have accurate feedback systems. Their recommendations include a proposal that the DASD (L&MM) direct the services to develop forecasting methodologies containing the characteristics as outlined above and contained in the USAF system. As stated, the LSAO Study only addressed breakbulk and not container cargo. This omitted consideration of the relationship between the cargo shipping modes. Further, it did not address (as previously discussed) the function of MTMC in determining the type of shipment or mode. The study focused on FY 81 data only.

3-3. THE DARCOM STUDY. The DARCOM IRO has recently completed a study of the procedures now in use within DARCOM. Their observations paralleled many of those contained in this study and were developed in coordination with the study team. They recommended a new mathematical forecasting model (Winters), an expansion of the number of TACs to identify program items, that more effort be given to producing an accurate long-range forecast, and that the use of the TAEDP be evaluated.

3-4. MTMC DEVELOPMENTAL FORECASTING METHODOLOGY. HQ MTMC is developing a methodology which would allow MTMC to prepare improved transporation workload forecasts. Initial efforts were to create and evaluate a 4-year average. This was later revised to include a smoothing technique. The OSD Dry Cargo Sealift Movement Forecasting Study recommends that the MTMC model be used to evaluate the service forecasts.

CHAPTER 4

OTHER SERVICE FORECASTING SYSTEMS

4-1. GENERAL. USAF and USN transportation workload forecasting systems were investigated to determine the methodologies used and their efficacy, and to identify elements which had potential application to the solution of the Army forecasting problem.

4-2. USAF FORECASTING SYSTEM

a. USAF forecasts of transportation requirement procedures are contained in AFR 75-15, dated 6 June 1979 (currently being revised). Headquarters, USAF Logistics Command (AFLC) has responsibility for forecasting and budgeting for Air Force cargo requirements. AFLC automated data processing procedures are contain in AFLC Regulation AFL171-125 dated 15 November 1979. This regulation provides a detailed operational description of the system and its associated environment.

b. The Air Force long-range forecast is developed from a bivariate regression analysis of projected flying hours with an 8-year data base of actual lift history which has been developed from MSC billing information. Additionally, designated commands are required to report nonrecurring or unusual requirements which are added to the forecast. In those cases where a commodity constitutes a small percentage of the total forecast, the previous year's actual shipment is used for the forecast. Mode of shipment is based on the percentage of the total shipment sent by the particular modes during the previous year.

c. Short-range forecasts are prepared by a triple exponential smoothing of the 8-year data base.

d. USAF TACs are structured to identify both the program and the shipping customer.

e. The USAF system includes effective procedures to validate MSC billing information.

4-3. US NAVY FORECASTING SYSTEM

a. Forecasting of US Navy sealift requirements is governed by NAVSUPINST 4620.7D. Navy Material Transport Office (NAVMTO), Norfork, Virginia, collects and submits both long-range and short-range forecasts for the Naval Support System Command, which is responsible for the forecasting system.

b. Navy cargo transportation requirements forecasting is currently a manual process which uses historical data, major program requirements, and forecaster judgment. Sealift requirements, excluding personal property, Coast Guard items, construction material, and aircraft, are reported only as an exception to the previous year's lift.

c. Navy over-ocean cargo movement requirements are approximately one-third of those required by the Army and, as a consequence, their errors have less impact. Their greatest diffculties are determining the shipping mode and the route to be used. Additionally, the delay in receiving complete actual lift and billing data from MSC complicates both forecasting and budget execution.

d. The Navy has approved a program to automate their forecasting system. The objectives of the automated system are to maintain historic lift and forecast files, and generate all required forecasts. It is expected that the system will incorporate the essential features currently used in the USAF system.

4-4. APPLICATION TO ARMY FORECASTING. The USAF system, with the exception of the forecasting routines, is an appropriate paradigm on which to base a revised Army forecasting system. The USAF system contains all the components required for forecasting, cost and performance reporting, Transportation Operating Agency (TOA) bill processing, and data base maintenance.

CHAPTER 5

ALTERNATIVE METHODOLOGIES CONSIDERED TO IMPROVE THE FORECASTING SYSTEM

5-1. GENERAL. The requirements of the forecasting system, the sources of information, and the systemic, external environment, and methodological aspects of the forecasting system were considered in the development of proposals for changes to the current projects. Systemic and external environment factors are discussed in this chapter. Forecasting methodologies are discussed in Chapter 6.

a. System Requirements. To satisfy the essential requirement of JCS Pub 15, AR 55-23, AR 55-30, and an accurate cargo forecasting process, the systems should provide the following capabilities:

(1) Forecasts of cargo movement requirements by commodity, route, mode, and program.

(2) Forecasts of budget requirements.

(3) System performance data by commodity, route, mode, and program.

(4) A historical data base of cargo movement requirements.

b. Information Sources. Cargo which generates peacetime over-ocean movement requirements is generally in support of personnel and equipment deployed overseas or in support of specific programs such as force modernization. As peacetime overseas deployed personnel and equipment densities do not vary significantly, historical cargo movement requirements and current program information contain most of the data required for forecast development. The MSC cargo billing is the most comprehensive and could be the most accurate source of historical lift data. Sources of program data are (1) personnel related programs--MILPERCEN and ODCSPER, (2) materiel related programs--DARCOM and DCSRDA, (3) fuels (coal and coke)--ODCSLOG, and (4) AAFES and MPSA for their specific programs.

5-2. ALTERNATIVE SYSTEM STRUCTURES

a. General. Several system structures were examined considering the requirements of the system, the sources of the information, and the costs in personnel and facilities. In each case it was assumed that (1) improved forecasting models or procedures were available, (2) TACs were restructured to ensure identification of force modernization items and the specific generators of general and special cargo, and (3) that the present forecasting requirements will continue. There are many possible system structures which can satisfy the forecasting requirements to some degree. Of these, four predominate: (1) the current system with improved methodology, (2) the current system with the long-range and short-range systems combined, (3) forecasting by a single Army agency using historical program data from DARCOM, DCSLOG/DLA and MILPERCEN, (4) forecasting by MTMC and other TOA with program input from the Army. The first two represent decentralized options while the latter two are centralized options.

b. Current Forecasting System Retained. This alternative, which is portrayed in Figure 5-1, envisions the retention of the present forecasting agencies and channels, correction of current forecasting anomalies, and improved forecast and budget coordination. It assumes that, given an improved methodology and restructured TACs, improvements in forecast accuracy could be achieved within the framework of the present system. This option requires that each forecasting agency/command be provided (or develop) an accurate mathematical forecasting model capability an accurate data base, and that the forecasters have access to program data. The TAC structure is such that it allows each forecasting agency to identify the amount of each commodity that it has shipped and the program responsible for the shipment. The time sequencing and frequency of reports remain as required by the current procedures. Reports stating forecasted tonnage by route, commodity, and program are prepared using a directed forecasting methodology for all commodities except for nonrecurring or program specific items. Program data is derived from the most appropriate sources. These sources include TAEDP, Materiel Management Reports (MMR), the Committee on Ammunition Logistics Support Report, and the Annual Solid Fuels Requirement Report. The final annual forecast and each short-range forecast are updated versions of the previously submitted forecast including the effects of program changes. Also, in this option, the LCA system and MECHTRAM are modified to identify forecasts which are significantly different from expected values and periodically compare performance reports with individual command/agency forecasts. Significant variances are resolved between the forecasting agency and HQDA for long-range forecasts and with LCA for the short-range forecasts. The monthly performance reports are segregated at LCA and forwarded to the forecasting/shipper agencies for comparative analysis and retention for data base purposes.

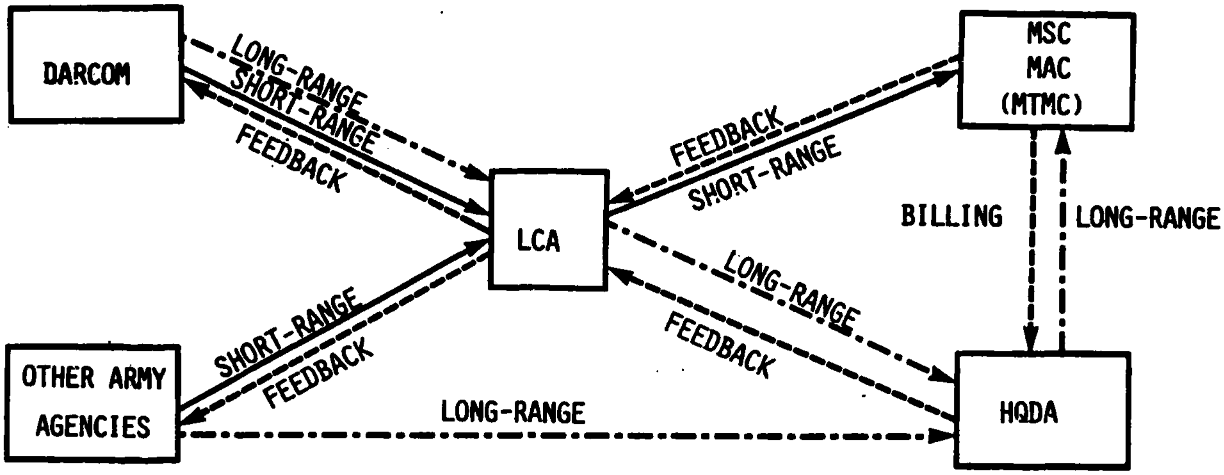

Figure 5-1. Current Forecasting System

c. Current System Modified with Long-range and Short-range Forecast Systems Combined. This alternative, Figure 5-2, requires that the same agencies as in the previous alternative prepare and submit forecasts, except that both the long-range and short-range forecasts are submitted to one agency versus two for consolidation and adjustment. This agency could be either HQDA, HQ DARCOM, LCA, or any other designated agency. All other processes are as in the previous alternative. Consolidation of the two procedures provides a more positive linkage between the long-range and short-range forecasts.

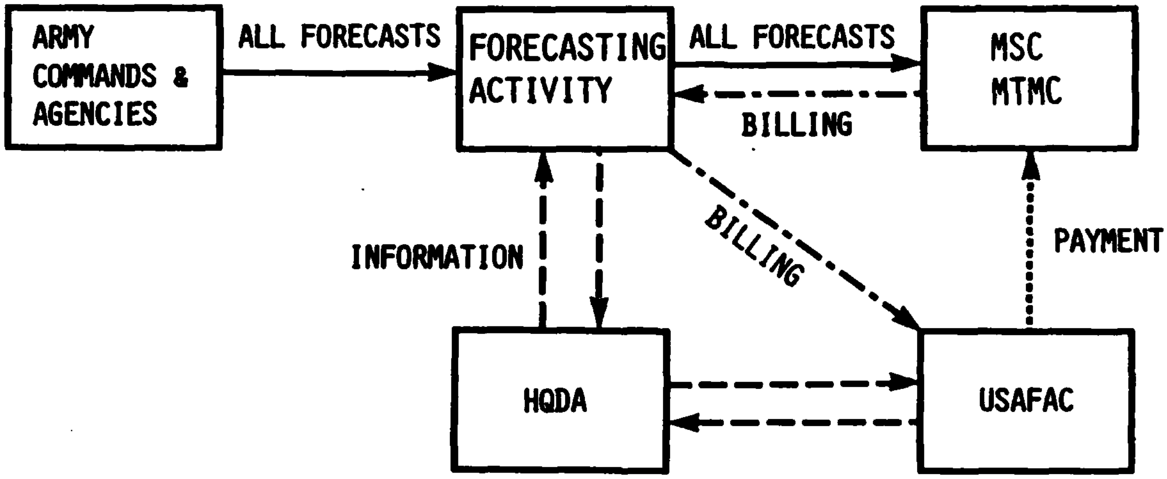

Figure 5-2. Current Forecasting System Modified

d. Single Agency Forecasting with Program Input. The alternative, Figure 5-3, envisions a single agency preparing the forecasts for all commodities, routes, and programs based on forecasting model outputs. These are modified by current information on specifically identified programs such as coal and coke, ammunition, and force modernization items. Program data is submitted by AAFES, MPSA, DARCOM, and DCSLOG annually, stating projected monthly shipping requirements by item, origin, and destination. All other commands report projected or nonrecurring requirements. Negative reports are required. Projected annual personnel movements are provided from MILPERCEN/DCSPER to the forecasting agency. Where the personnel movement forecast is significantly different from the previous year's, the model generated forecasts for POV and household goods (if forecast) shipments are modified to reflect the expected movements. Agencies submitting annual program information also forward quarterly reports indicating changes to the previously submitted annual reports. Other change reports would be submitted when shipments on a given route are expected to differ from the forecast by 600 MTON. Monthly performance reports are analyzed by the forecasting agency to evaluate the accuracy of the forecasts. The reports are used to identify and resolve discrepancies between forecasts and actual lift, and to modify forecasting models. The forecasting activity in this option requires an automated data processing system which provides for those capabilities currently in the MECHTRAM system. It provides a route and system performance monitoring process such as that employed by USAF and incorporates mathematical forecasting capabilities developed in this study. MSC bills received by the forecasting agency are validated. They are then used as source data for forecast performace evaluation and for the data base to be used in future forecast formulation. Activities of the agency would consolidate all actions now performed in the MECHTRAM system at HQDA and the ADP support to forecasting at LCA. Personnel in the forecasting all should be of military rank 04/03, MOS 49, or their civilian equivalent who possess a knowledge of the Defense Transportation System and computer operations.

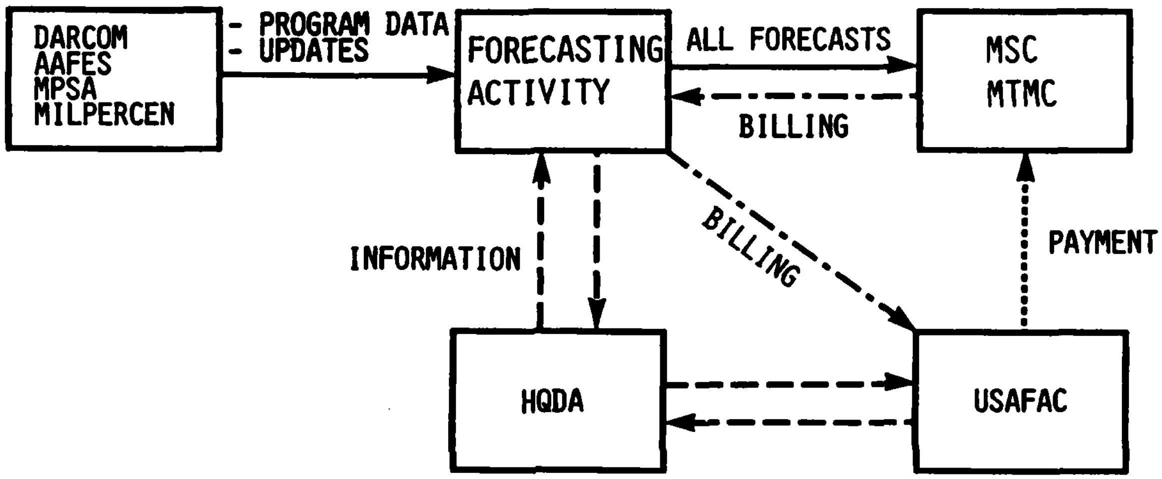

Figure 5-3. Single Agency Forecasting

e. Forecasting by the TOA (Objective System). In this alternative, Figure 5-4, MTMC prepares the annual forecasts based on cargo movement history and program information provided by the shipper services. HQDA consolidates program information provided by DARCOM, MILPERCEN, and the Army Staff and forwards it to the MTMC. MTMC computes cargo requirements based on forecasting model output and program information, provides the forecast to MSC, and from this, transportation costs are estimated. The TOA provide HQDA with forecasted tonnages and costs for service budget preparation purposes. Transportation costs are paid as under the present system. Budget performance reporting and validation of billing information functions are performed by the MECHTRAM or similiar system. MECHTRAM also produces monthly, and as required, cost and performance reports for the various HQDA staff elements (DCSLOG, DCSPER). As the historical shipping data used in forecasting is originated from TOA billing and the TOAs are supported by extensive computing facilities, it is feasible and desirable for the TOAs to develop the forecasts. In particular, HQ MTMC is capable of producing forecasts of over-ocean cargo movement requirements for both MTMC and MSC as a result of its own forecasting model development which has occurred concurrent with this study. Model parameters developed by this study, and discussed in the next section, can be provided to MTMC to assist in forecast development.

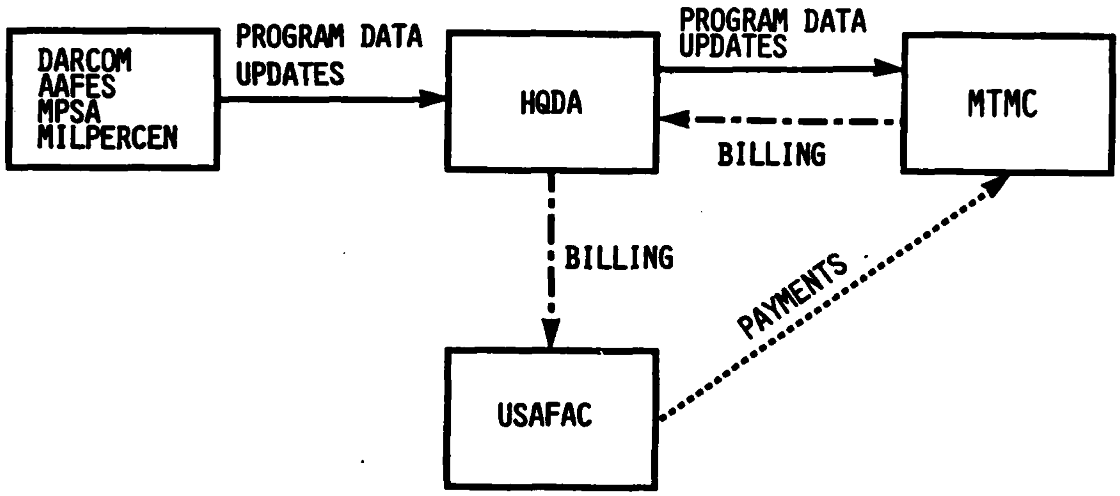

Figure 5-4. Forecasting by TOA

5-4. EVALUATION OF ALTERNATIVE SYSTEMS. Table 5-1 portrays the identifiable direct cost associated with the four alternatives previously described. This section discusses the four alternatives in terms of personnel and operational costs.

Table 5-1. Alternative System Costs

	(1) Current system	(2) Current system modified	(3) Single Army forcasting activity	(4) Forecast by TOA (objective system)
Man-years	14	13	6	5
Models	17	16	1	1
Data bases	17	16	1	1

a. Alternative 1, the present system, requires at least 23 personnel. Of these, 9 are full-time forecasters. The efforts of the other 14 range from 10-50 percent of their time. This effort equates to approximately 14 man-years annually. By eliminating the dual reporting system as in Alternative 2, an estimated one space would be saved as the result of combining the HQDA-LCA effort. Largest savings of personnel occur in Alternatives 3 and 4. Alternative 3 envisions a three-person forecasting cell, a HQDA program officer, a DARCOM program coordinator, and part-time effort by one person at AAFES and MPSA. Alternative 4 would reduce the size and effort of the Army forecasting cell and, if adapted by all shipper services, would result in similar personnel savings by each shipper service.

b. In addition to the direct costs in personnel, already discussed, there are significant indirect costs associated with the forecasting activitives. These include management, clerical, and communications support. Currently, 17 separate commands or agencies and HQDA prepare forecasts. Additionally, several of these agencies consolidate forecasts prepared by subordinate commands, e.g., LCA, a forecasting agency, also consolidates forecasts prepared by five DARCOM commands. This would be reduced significantly in Alternatives 3 and 4. Reduction of the number of agencies, as in Alternatives 3 and 4, also reduces lead time required for forecasts, thus allowing more recent data to be considered when they are developed.

c. Accurate forecasting and use of a predictive model requires each forecasting agency/command to maintain an accurate historical record of cargo forecasted and cargo shipped. Most forecasting models require a minimum of 50 data points. This results in a data base at least 50 months of shipping data. Current estimates of MSC records of Army shipments are 30,000 records, each containing 140 characters per year. Alternative 1 has a complete data base at MSC/MTMC, HQDA, and LCA. Each forecasting agency in turn maintains the data relevant to its operations. Alternative 2 would eliminate either the HQDA or LCA data base. Alternative 3 requires only one Army data base and Alternative 4 requires only the retention of the MSC/MTMC data base, which is the source of data for all other data bases in the other alternatives.

d. Accurate forecasting requires the use of some form of predictive model. Alternatives 1 and 2 require the development and maintenance of a large number of models, as it is unlikely that a general model would be applicable to each commodity and each shipper. This, combined with the maintenance of the data bases, requires a significantly greater effort than Alternatives 3 and 4. (Specific forecasting models are discussed in Chapter 6.)

e. Forecasting systems require accurate and timely information on their programs. All agencies which currently forecast, with the exception of HQ FORSCOM and District Engineer, New York, have access to the program information which is required to formulate the cargo movement requirement for which they are responsible. However, aggregated program information is available at HQDA/HQ DARCOM to determine most materiel associated cargo movement requirements and at HQDA/MILPERCEN to determine personnel associated cargo movement requirements. As AAFES and MPSA have other service responsibilites, these agencies alone have cognizance of the programs which will affect their requirements for cargo movement. Historic cargo lift data is available from the MSC and MTMC billing tapes at HQDA, LCA, and to a limited extent at some of the forecasting agencies. Options 1 and 2 require the processing of program information and, as discussed earlier, the MSC billing information by all forecasting commands/agencies. Options 3 and 4 use consolidated program information and TOA bills. They convert program and historic information into forecasts at a single location. The quality of the program information available to forecasters in any of the options should be comparable. However, the translation of the data into cargo movement requirements would appear to be more efficient if performed at a single location as in Options 3 and 4.

5-4. COLLOCATION OF CARGO MOVEMENT REQUIREMENTS AND BUDGET FORECASTING ACTIVITIES

a. Discussions during the early stages of the study surfaced a concern that an underlying cause of current forecasting inaccuracies is the separation of budget and cargo movement requirements forecasting. Investigation of the forecasting system did not confirm this as a condition or source of error. From a management perspective, if the budgets are the estimated costs of shipping the cargo, then the budgets should be developed from the forecast of the cargo movement requirements and the projected cost schedule. This does not imply that the cargo movement and budget forecasts should be performed by the same office but does imply that a procedure exists which ensures coordination and interdependence of the two processes. The documentation of the MECHTRAM process describes this function as occurring at HQDA; however, as discussed earlier, the current budget development process does not use the MECHTRAM reports.

b. USAF and USN budget systems were examined to determine what effects, if any, could be attributed to the separation or collocation of cargo forecasting and budget preparation processes. USAF budget development and execution and cargo movement requirements forecasting are all performed by a single office at USAF Logistics Command. USN has separated the functions. Budget processes are performed by Naval Supply Systems Command, Arlington, Virginia, while cargo movements forecasting is performed by the Navy Material Transport Office (NAVMTO), Norfolk, Virginia. The systems are equally accurate. No other systems were identified wherein the separation of operations forecasting and fiscal forecasting made a difference to the accuracy of the operations forecasting, and no alternatives were developed which varied budgeting responsibility.

CHAPTER 6

METHODOLOGY DEVELOPMENT

6-1. GENERAL. The purpose of this section is to describe the development of the forecasting methodologies used to model the transportation workload forecasting (TWF) data. Paragraph 6-2 describes the data gathering and data manipulation processes. Paragraph 6-3 discusses time series analysis and the reasons for using this type of data analysis. Paragraph 6-4 provides a general description of the Box-Jenkins modeling approach for time series data. (A detailed description of this approach is discussed in Appendix E.) Paragraph 6-5 discusses the Winters approach to modeling time series data. (A detailed description of the Winters method is discussed in Appendix G.) Paragraphs 6-6 thru 6-14 discuss the individual commodities that were forecasted, the processes involved in developing the mathematical models, and the forecasting results. Figures 6-2 through 6-10, presented later, compare the commodity forecasts of the Box-Jenkins and Winters models with the actual lift data for FY 82. Appendix F details specific analytic steps of Box-Jenkins model building for each commodity. Appendix H contains similar information for Winters models. Paragraph 6-15 summarizes the results of the forecasting models.

6-2. DATA DESCRIPTION. This paragraph details the steps taken to develop the TWF data base: (1) data acquisition, (2) computer system conversion, (3) data format and condition, and (4) data reduction.

a. Data Acquisition. Six years of lift information (tonnage) on Army cargo shipments was acquired from MSC. The data provided by MSC contained lift information by route, commodity, and mode of shipment.

b. Computer System Conversion. The following specifications were followed during tape creation:

Tracks	9
Code	ASCII
File(s)	Sequential, unformatted
Density	1,600 BPI
Logical record length	80
Block size	3,200
Label	None

c. Data Format and Condition. Each record contained 35 columns of data, formatted shown in Table 6-1.

Table 6-1. Data Format

Columns	Data entry
1-2	Fiscal year
3-4	Sail year
5-6	Sail month
7	Container type
8-10	Port of embarkation (POE)
11-12	POE traffic area
13-15	Port of debarkation (POD)
16-17	POD traffic area
18-21	TAC
22-23	Commodity
24-35	Measurement tons

Initial attempts to read the data with a univariate statistics program failed, due to the existence of nonnumeric entries in data fields. Records containing aberrative subfields were corrected or deleted, as appropriate. Records indicating zero shipment of measurement tons were removed. This process reduced the original data base of 184,645 records to a final count of 150,387 records covering the timeframe October 1977 through June 1983.

d. Data Reduction. Several special purpose FORTRAN programs were developed in order to transform the revised data base into forms suitable for analysis.

(1) In preparation for preliminary time series analysis, the data base was broken out into 12 general commodity files, each of which contained records of shipment tonnage versus time.

(2) The 12 (raw) commodity files were segregated into various route subfiles and 7,202 "credits" discovered in the original data base were removed. The credits had been entered into the original data base in order to offset certain debits.

(3) Time series data were developed for 424 unique routes, and the routes were rank-ordered according to decreasing levels of shipment activity.

(4) Finally, tonnage was segregated on a monthly basis and according to chronological shipment date. One program was designed to process routes individually. The other was designed to form composites of all routes for each commodity.

e. Time Series. Aggregated time series data for each commodity are contained in Figures G-1 through G-12, Appendix G. Of the 81 months of data, 60 were deemed necessary for model construction and adequacy verification. It is generally recommended that at least 50 observations be used, if possible, when developing Box-Jenkins time series. Specifically, data from October 1977 through September 1981 were used to build both the Box-Jenkins and Winters models.

f. Forecast Interval. The 12 observations from the sixth year of data (FY 82) were used as the basis for testing the forecasting accuracy of each model. Two measures of forecasting accuracy were selected from among several potentially acceptable alternatives:

(1) Annual Percentage Error. The annual percentage error between forecasted and actual cargo shipments was used as a simple aggregate measure of relative accuracy from a practical point of view.

(2) Mean Square Error (MSE). The mean squared error of the 12 monthly observations was used to capture the absolute accuracy from a statistical standpoint.

6-3. TIME SERIES ANALYSIS

a. Background. Time series analysis is the application of analytical techniques to model historical data. It differs from most types of historical data analysis in that no attempt is made to determine the factors affecting the behavior of the historical trend. Another difference is that time series analysis is concerned with historical data that are serially correlated and not independent. Time series analysis attempts to model behavioral trends and relationships between consecutive observations.

b. Analysis Considerations. Time series analysis techniques were considered the most apropriate analytic tools to forecast the US Army transportation workload requirements after considering three important factors: (1) data pattern, (2) time and efficiency, and (3) accuracy of forecasts.

(1) Time series analysis is usually the analysis of a single variable over time, i.e., univariate. In many cases, the univariate series exhibits a behavioral pattern over time. The pattern may be seasonal or a persistent trend may exist in the data. This behavior is usually made up of dependent observations and unlike most analytic techniques, time series analysis does not rest on the assumption of independent observations. Instead, time series analysis capitalizes on the dependency of the observations, determines the patterns in the data and then models the patterns. The data contained in the TWF study was highly dependent, therefore time series analysis was selected as the most appropriate statistical modeling tool.

(2) Due to the complexity of events that produced the transportation lift history, it was virtually impossible to determine all the factors that affected the historical process. In many cases the factors affecting the

process could not be defined quantitatively or a causal relationship between the factors and the process could not be determined. Sufficient proxies, such as troop density, could have been developed to resolve these issues, however, the time and energy required to obtain statistically relevant factors would have been immense. Time series analysis enables quick development of forecasting models since factors affecting the process are for the most part ignored. Several studies which compared simple time series models to complex econometric models indicated that time series models can provide comparable forecasting results and, in some cases, better forecasting results than the complex models.

(3) Finally, as indicated earlier, time series models are primarily concerned with identifying systematic behavioral patterns in the data. Once the systematic pattern is identified, the data can be separated into two components: (1) the data pattern and (2) the random error of the data pattern. This statement is expressed as:

DATA = PATTERN + RANDOMNESS

If the future observations of a time series can be predicted, without any error, then a deterministic model is sufficient because the randomness of the data is negligible.[4] If the data exhibit random behavior over time, the predictions of future observations are mainly concerned with the identification, modeling, and prediction of the error term. Time series analysis is the best forecasting methodology to employ when the accurate modeling of the error term is critical. TWFS data exhibited a random behavior over time; thus, stochastic time series analysis was determined to be the most appropriate modeling approach.

6-4. BOX-JENKINS MODELING APPROACH

a. Background. Box-Jenkins models are a unique set of linear time series models used to model stochastic time series data. Box-Jenkins models fall into three classes: autoregressive (AR), moving average (MA), and mixed (ARMA). Box-Jenkins models find their origin in the AR models that were first introduced by Yule (1926) and later generalized by Walker (1931). MA models were first developed by Slutzky (1937), and ARMA models were initially theorized by the work of Wold (1938). George Box and Gwelym Jenkins are responsible for collating these previous works and establishing an approach to apply these models.[2] The Box-Jenkins approach consist of three steps (see Figure 6-1):

(1) Identification - the first step in applying the Box-Jenkins methodology was to identify the degree of homogeneity in the data, i.e., how many times the series must be differenced to achieve stationarity. Once the degree of homogeneity was established, the data pattern was identified as AR, MA, or ARMA.

(2) Estimation - After the data pattern was correctly identified, parameter estimates for AR, MA, or ARMA models were generated to obtain a model that best fit the data.

(3) Verification - Finally, a test run using the estimated model parameters was conducted. The results and diagnostic checks were performed on the model parameter estimates and residual estimates to ensure goodness of fit and adequacy of the model. The predictive value of the model was evaluated and analyzed using historical data that was not used to develop the original model. If the model was not adequately verified, then steps 1-3 were repeated until an appropriate model was identified.

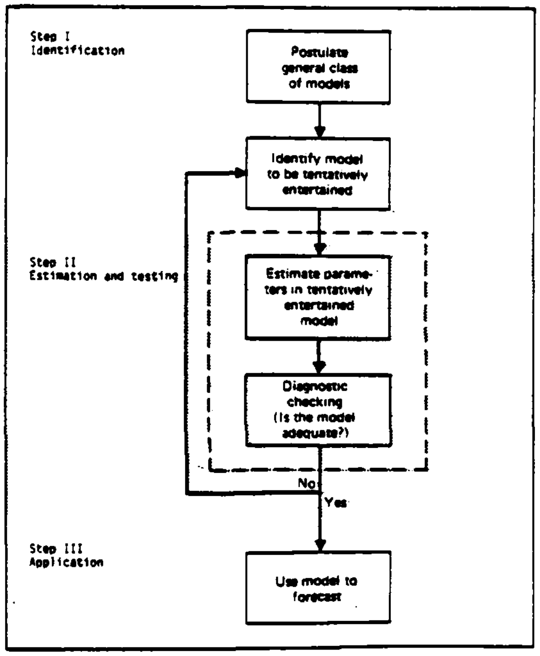

Figure 6-1. Box-Jenkins Modeling Approach

b. Stationarity. The most crucial element in applying Box-Jenkins models is the principle of stationarity. Stationary data are defined as data that are invariant with respect to time. A stationarity data series is characterized by a constant mean, variance and covariance throughout the series, i.e., no change over time.

c. Data Transformations. It is uncommon for a data series existing in its natural form to be stationary. Thus, the data must be transformed to achieve stationarity. Three major transformations were applied to the data to achieve stationarity: (1) differencing the series, (2) applying natural log transformations to the series, and (3) applying a square power transformation to the series. If these techniques did not produce stationary data, then differencing of the logged series (#2) or differencing of the squared series (#3) was attempted. Model applications to differenced series are referred to as integrated and noted by the letter "I."

d. Box-Jenkins Models. Once stationarity was achieved, the data were modeled using the three general classes of Box-Jenkins models: AR, MA, or ARMA.

(1) Autoregressive (AR) Models. AR models follow the general form

$$x_t = \delta + \phi_1 x_{t-1} + \phi_2 x_{t-2} + \dots + \phi_n x_{t-n} + \epsilon_t$$

where δ is drift, x_t are the dependent observations of the series, ϕ_n are the regression estimates of the model, and ϵ_t is the error term. The most common models are the AR(1) model

$$x_t = \delta + \phi_1 x_{t-1} + \epsilon_t$$

and the AR(2) model

$$x_t = \delta + \phi_1 x_{t-1} + \phi_2 x_{t-2} + \epsilon_t$$

Autoregressive models differ from the general regression equations in that there are no independent variables to regress upon. The regression is performed on past values of the dependent variable, thus the term autoregressive.[6]

(2) Moving Average (MA) Models. MA models follow the general form

$$x_t = \mu + \epsilon_t - \theta_1 \epsilon_{t-1} - \theta_2 \epsilon_{t-2} - \dots - \theta_n \epsilon_{t-n}$$

where μ is the mean of the series, ϵ_t are the past error terms and θ_n are the parametric estimates of the model. The most common form of MA models are the MA(1) model

$$x_t = \mu + \epsilon_t - \theta_1 \epsilon_{t-1}$$

and the MA(2) model

$$x_t = \mu + \epsilon_t - \theta_1 \epsilon_{t-1} - \theta_2 \epsilon_{t-2}$$

Unlike the AR models which are a linear function of past observations, MA models are a linear combination of past errors. Also, unlike the general moving average models where the sum of parameters equals 1 ($\theta_1 + \theta_2 + \dots \theta_n = 1$), Box-Jenkins MA model parameters do not necessarily add up to 1. Finally, the error terms of the model are assumed to be distributed normally with a mean of zero (0) and a constant variance (σ^2).[6]

(3) Autoregressive - Moving Average (ARMA) Models. ARMA models are combination models which are derived from the following equality:

$$\phi(B)\, x_t = \theta(B)\, \epsilon_t$$

where ϕ and θ are the AR and MA parameters, x_t and ϵ_t are the past observations and error terms, and B is the backshift operator $Bx_t = x_{t-1}$. In essence, this equality states that a complex AR process can be expressed as a MA process of infinite order and vice versa. The resultant of this equality is the general equation for forecasting X_t:

$$X_t = \phi_1 x_{t-1} + \ldots + \phi_n x_{t-n} + \delta + \epsilon_t - \theta_1 \epsilon_{t-1} - \ldots - \theta_n \epsilon_{t-n}$$

The combination of AR and MA terms produces a model that is more accurate than the pure MA or AR models.[6] A more detailed discussion of the Box-Jenkins modeling approach is contained in Appendix E.

e. To standardize model identification, all models are specified as autoregressive integrated moving averages (ARIMA) of order p, d, q, where p refers to the order of autoregressive parameters, d refers to the number of differencing transformations, and q refers to the order of moving average parameters. Therefore, all models will be referred to as ARIMA (p,d,q) models.

f. Box-Jenkins models for the TWFS were developed using the BMDP Statistical Software package.[3] All figures depicted in Appendix F are copies of the computer printouts from BMDP program applications.

6-5. WINTERS MODEL

a. Background. Historically, the fitting of systematic functions to observations has typically relied on least-squares criteria in which all the observations are given equal weight. However, it is often the case, when data is being observed as a function of time, that more weight should be given to the recent past, and that observations taken a long time ago should be discounted in comparison. In 1957, C. C. Holt published a paper entitled "Forecasting Seasonals and Trends by Exponentially-weighted Moving Averages." The procedure proposed therein addressed development of a set of weights proportional to powers of a parameter β, where β was defined to be greater than zero but less than unity. Thus, the set of weights were 1, β, β^2, etc. Constraints were imposed whereby the sum of the weights must equal unity, and β must serve to minimize the mean square error. Holt ultimately considered two parameters, the import of the second being to account for a trend in the data. In 1960, P.R. Winters extended Holt's method to cover seasonal effects. Thus, the model for which he is responsible is a three-parameter model.

b. Applications. Winters model owes its development primarily to the fact that there are many time series that cannot be adequately modeled by a polynomial. Time series with cyclical or seasonal variations fall into this category. For example, at least a cubic equation (which has a single point of inflection between regions of upward and downward concavity) is required to capture the cyclical pattern of periodic data. Furthermore, from an applications viewpoint, many industrial time series exhibit seasonal behavior. Good examples include the seasonal movement of specific commodities such as POVs.

c. General Form. The general form of Winters model expresses an observation x_t at time t as

$$x_t = (a_1 + b_2 t)\, c_t + \epsilon_t.$$

The three parameters of the model are a_1, b_2, and c_t, while the term ϵ_t is taken to represent the usual random error component. The parameter a_1 is called the permanent component, and is analogous to a y-intercept. Similarly, the parameter b_2, or trend factor, corresponds to the slope of a simple linear equation. The third parameter, c_t, represents a set of seasonal factors for each cycle. The seasonal factors induce fluctuations above and below the line segments that are fitted to each cycle. The Winters model as described herein is a multiplicative seasonal model, so named because the seasonal parameter c_t is applied multiplicatively, not additively. Multiplicative seasonal models are most appropriate for time series in which the amplitude (or excursion) of the seasonal pattern is *proportional to the* average level of the series. This pattern was evident in the TWFS data.

d. Specific Form. The specific form of Winters prediction equation is

$$\hat{x}_{T+\tau}(T) = \left[\hat{a}_1(T) + \hat{b}_2(T)\tau\right]\hat{c}_{T+\tau}(T+\tau-L)$$

where, conventionally, carats are used to denote estimates. The equation gives the forecast at time T for an observation at time $T + \tau$. Quantities in parentheses indicate the times of computation of the estimates. Thus in order to forecast period $T + \tau$, the seasonal factor which was computed one season (L periods) ago in period $T + \tau - L$ must be used.

e. Parameters. As mentioned earlier, the three parameters of the Winters model are the permanent component, the trend component, and the seasonal factor. Estimates of these parameters for the period T are weighted and combined with estimates from previous periods. The manner in which the current estimate of a parameter is apportioned with respect to a previous value is such that the mean square error is minimized over the entire time series. Smoothing constants (or weights) are used to apportion present and past estimates. For example, if the smallest mean square error were produced by a weight of 0.80 for the current estimate of a parameter and 0.20 for the previous estimate of the parameter, then this would mean simply that the current estimate is four times as important in the parameter updating process as the previous estimate.

(1) Permanent Component. The estimate of the permanent component is updated by

$$\hat{a}_1(T) = \alpha \frac{x_T}{\hat{c}_T(T-L)} + (1-\alpha)\left[\hat{a}_1(T-1) + \hat{b}_2(T-1)\right]$$

where $0 \leq \alpha \leq 1$. Note that the value of x_T is divided by $\hat{c}_T$ (T - L), which is the estimate of the seasonal factor for period T computed one season (L periods) ago. This is done in order to eliminate seasonal fluctuations from x_T, i.e., to deseasonalize the current observation. The deseasonalized observation is then combined with the contribution of the permanent component and trend for the previous period T-1. This shifts the origin of time to the end of the current period. The adjustment for seasonality can best be understood by considering the case when $\hat{c}_T$ (T-L) is greater than 1. This occurs when the value in period T-L is greater than average in its seasonality. Dividing x_T by this number greater than 1 gives a value that is smaller than the original value by a percentage just equal to the amount that the seasonality of period T-L was higher than the average. Of course, the opposite adjustment occurs when the seasonality number is less than unity. It should be noted that the reason for using the seasonal factor from the previous season (L periods ago) is that the seasonal factor for the current season cannot be computed until the permanent component itself is calculated.

(2) Trend Component. The estimate of the trend component is updated by

$$\hat{b}_2(T) = \beta[\hat{a}_1(T) - \hat{a}_1(T-1)] + (1-\beta)\hat{b}_2(T-1)$$

where $0 \leq \beta \leq 1$. This equation is exactly as Holt's equation for smoothing the trend. The estimate of the trend component is simply the smoothed difference between two successive estimates of the permanent component. The procedure of determining the trend component is similar to evaluating the slope of a line segment, where the endpoints of the line segment correspond to the beginning and end of the period T.

(3) Seasonal Factor. The estimate of the seasonal factor is updated by

$$\hat{c}_T(T) = \gamma \frac{x_T}{\hat{a}_1(T)} + (1-\gamma)\hat{c}_T(T-L)$$

where $0 \leq \gamma \leq 1$. This equation specifies the seasonal index as the ratio of the current value of the series, x_T, to the current smoothed value for the series, $\hat{a}_1(T)$. If x_T is larger than $\hat{a}_1(T)$, the ratio will be greater than 1, while if it is smaller than $\hat{a}_1(T)$, the ratio will be less than 1. It is important to understand that $\hat{a}_1(T)$ is a smoothed average value of the series that does not include seasonality. The values of x_T, however, do contain seasonality (as well as randomness). Notice that equation smoothes (weights) the current observed seasonal variation ($x_T/a_1(T)$) with the estimate of the seasonal factor for period T computed L periods ago. That was the last opportunity to observe this portion of the seasonal pattern.

f. Smoothing Constants and Model Initialization. The method of initializing model parameters and of solving for the smoothing constants is not central to understanding the Winters method. A short explanation of these procedures has been included as Appendix G.

6-6. POV FORECASTING MODEL DEVELOPMENT

a. POV data is fairly constant on an annual basis; however, the monthly data is highly seasonal. Stationary data was achieved after differencing the series at a lag of 12 months.

b. The appropriate model for POV data was a nonseasonal ARIMA (2,0,0) model and seasonal ARIMA (0,1,1) model:

$$\underset{}{(1 - \underset{(.19)}{.0221}B - \underset{(3.05)}{.3554}\, B^2)(1 - B^{12})\, X_t = (1 - \underset{(16.77)}{.8581}\, B^{12})\ \epsilon_t}$$

$$x^2\ (3,20) = 16.35$$

The results indicate that all of the estimated coefficients of the model, except ϕ_1 are significant at the 5 percent significance level. Verification of the model's adequacy using the Box-Pierce test indicates that the autocorrelations of the estimated model residuals are not significantly different from zero at the 30 percent significance level. (Details of the Box-Pierce test and model adequacy are contained in paragraph E-6, Appendix E). Using this model to forecast FY 82 POV shipments resulted in a forecast of 501.37 K/MTON versus an actual shipment of 510.25 K/MTON, which corresponds to an underforecast of 1.7 percent (see Figure 6-2). The MSE of the POV forecast for FY 82 was 8.54.

c. Variations of the aggregate POV data model were used to forecast POV mode requirements. The POV container shipments during FY 82 were underforecast by 20.1 percent. The POV breakbulk shipment forecast was overforecast by 8.8 percent. Specific details pertaining to Box-Jenkins modeling of POV data and all other commodities are contained in Appendix F.

d. When the Winters model was used to forecast POVs for 1982, an underforecast of 5.3 percent occurred. The aggregate forecast was 483.12 K/MTON, corresponding to an MSE of 12.92. Separation of this commodity by mode of shipment produced smaller errors of -3.3 percent (breakbulk) and 3.0 percent (containerized). However, based on increased mean square errors, the overall fits were not as good. The specific Winters parameters for each commodity and month have been included at Appendix H.

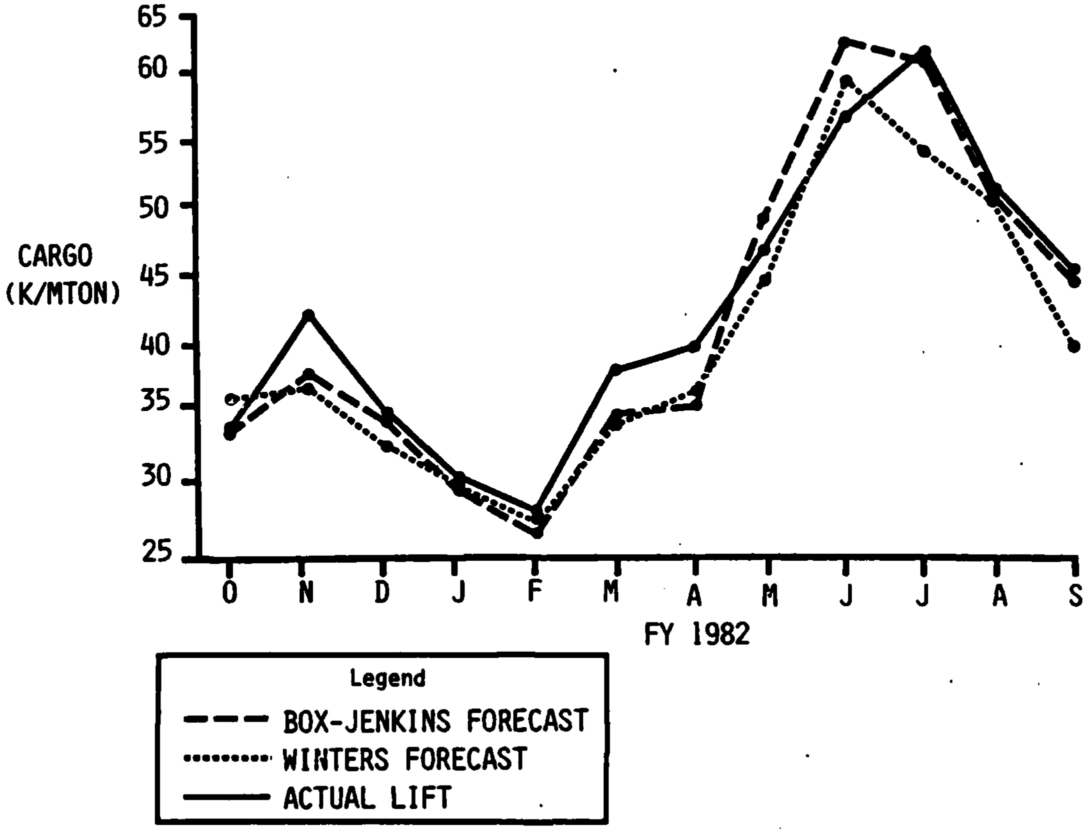

Figure 6-2. POV Cargo Forecast - FY 82

6-7. GENERAL CARGO FORECASTING MODEL DEVELOPMENT

a. General cargo accounts for the largest amount of cargo shipped under any single commodity code. General cargo accounts for approximately 50 percent of all cargo shipped by the US Army during any individual year. This commodity code not only includes operational and facility maintenance items, but also force modernization program data. The inclusion of this force modernization data within the time series data hinders the development of accurate forecast models for the general cargo commodity. If new TAC codes are used to isolate force modernization equipment, the accuracy of general cargo forecasts will improve. To demonstrate this point, the general cargo data series was separated into two components: (1) A205 TAC data--primarily DARCOM items and (2) non-A205 TAC data--other items shipped as general cargo. The results of this effort will be discussed later.

b. Annual general cargo data fluctuates within a narrow range of ±10 percent; however, the data is seasonal. Stationarity was achieved after two successive differencing operations. First the series was differenced at a lag of 12 months. This operation did not produce stationary data, thus the seasonally adjusted series was differenced at a lag of 1 month.

c. The appropriate model for general cargo data was a mixed ARIMA (1,1,1) nonseasonal model and a seasonal ARIMA (0,1,1) model:

$$(1 - \underset{(2.5)}{.3579}\, B)\ (1 - B^{12})\ (1 - B)\ X_t = (1 - \underset{(8.31)}{.7962}\, B)\ (1 - \underset{(13.43)}{.7753}\, B^{12})\ \epsilon_t$$

$$\chi^2\ (3,20) = 12.8$$

The results indicate that all of the estimated coefficients are signficant of the 5 percent significance level. The Q statistic for 20 degrees of freedom is 12.8. Thus, the null hypothesis, estimated model residuals are uncorrelated, should not be rejected at the 10 percent significance level. The general cargo seasonal model forecasted that 1856.61 K/MTON would be transported during FY 82 versus an actual shipment of 2021.55 K/MTON, equating to an underforecast of 4.6 percent error (see Figure 6-3). (Note: another model developed for general cargo underforecast the FY 82 lift by 4.2 percent. The goodness of fit of this model was not as good as the ARIMA (1,1,1) x (0,1,1) model, but the forecast accuracy of both models should be tracked in the future.) The MSE of the general cargo forecast for FY 82 was 318.54.

d. Box-Jenkins modeling of the general cargo mode shipments produced a 9.8 percent underforecast of container data and an 8.5 percent underforecast of breakbulk data. The non-A205 (non-DARCOM) forecast for general cargo was underforecast by 2.2 percent.

e. Application of the Winters model to general cargo resulted in a forecast of 1870.38 K/MTON. The prediction was about 7.5 percent below the actual shipment, while the MSE was 279.89.

f. Several excursions were conducted on general cargo in order to assess this important category accurately. The Winters model was accurate to within 1.4 percent for non-A205 (non-DARCOM) shipments (breakbulk and container combimed) and to within 1.6 percent for non-A205 (container only). Overall, the Winters model did not fit the breakbulk time series well (28.6 percent overforecast). The Winters general container forecast was within 4.9 percent of the actual data.

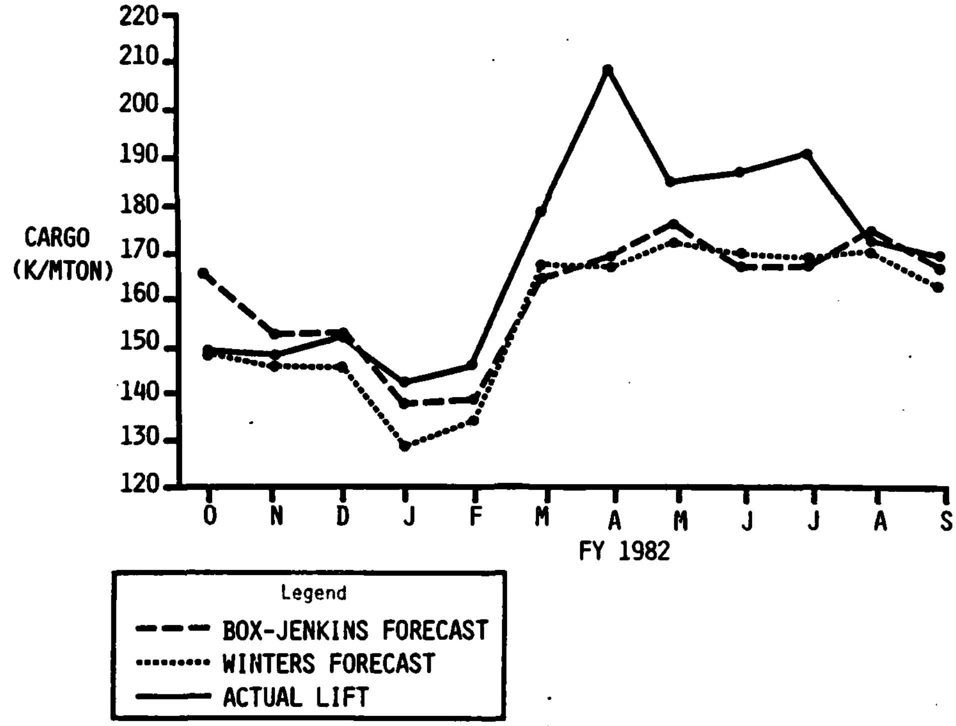

Figure 6-3. General Cargo Forecast - FY 82

6-8. HHG FORECASTING MODEL DEVELOPMENT

a. Transportation arrangements for DOD-sponsored household goods (HHG) are made by MTMC, using primarily two methods: freight forward (Code 4), and those that are MSC processed (Code 5). Freight forward shipments are shipments of HHG that are contracted with private carriers from door to door; shipments of HHG that are shipped using the assets of MSC are Code 5 shipments. Additionally, some HHG are returned to CONUS via MAC when cargo space is available.

b. Data used in the study only consisted of Code 5 shipments. According to other HHG shipment data that was gathered from MTMC, Code 5 shipments comprise less than 4 percent of the total HHG tonnaged shipped during a given fiscal year. However, any aberration in the commercial shipping process will cause HHG shipments by MSC to increase significantly. For example, assuming that Code 5 shipments comprise 4 percent of total HHG transported, a 1 percent change in Code 4 shipments due to a commercial shipping strike will increase Code 5 shipments by 25 percent. This fact complicates the development of accurate models to forecast the amount of HHG shipped by MSC. It also lends credence to the argument that MTMC should be involved in the HHG forecasting process. An accurate forecasting model for all HHG shipments cannot be developed until additional probability and economic analysis of commericial shipping is integrated into the forecast model.

c. Only data from October 1978 through September 1981 was used to develop the forecasting models due to the volatility of HHG during the period under study. As noted in Figure F-26, Appendix F, HHG shipments in FY 78 were approximately three times greater than any other year due to commercial shipping aberrations. Annual HHG data during FY 79 through FY 81 exhibited a slight trend downward, but the monthly data was seasonal. To achieve stationarity, the data were differenced at a lag of 12 months.

d. The appropriate model for HHG data was a nonseasonal ARIMA (0,0,1) model and a seasonal ARIMA (1,1,0) model with a series mean:

$$\underset{(-2.33)}{(1 + .3198B^{12})}\,(1-B^{12})\,X_t = \underset{(-3.67)}{1.163} + (1-\underset{(1.88)}{.3397B^4})\,\epsilon_t$$

$$\chi^2\,(2,20) = 6.26$$

All of the estimated coefficients, except θ_4, are significant at the 5 percent significance level. θ_4 is significant at the 7 percent significance level. Verification of the model's adequacy using the Box-Pierce test with 20 degrees of freedom indicates that the null hypothesis (uncorrelated residuals) should not be rejected at the .5 percent significance level. This model forecasted FY 82 HHG shipments to be 80.19 K/MTON versus an actual lift of 87.68 K/MTON (see Figure 6-4). The MSE of the forecast was 5.24 and the annual forecast error was -8.5 percent. Mode forecast of HHG data resulted in a 23.4 percent overforecast of container data and a 16.9 percent underforecast of breakbulk data.

e. The Winters fit resulted in a forecast of 76.079 K/MTON, amounting to an overall underforecast of 13.2 percent. The MSE was 3.361. Separation of household goods into breakbulk and containerized shipments only served to worsen the forecast. The breakbulk fit produced an overforecast of 43 percent, while the containerized model resulted in a 36.5 percent underforecast.

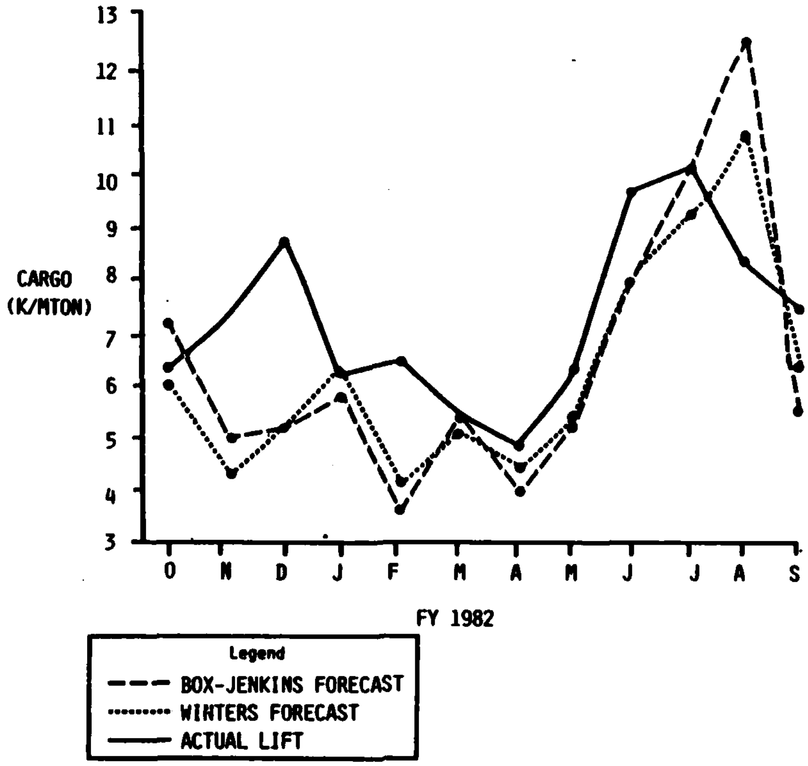

Figure 6-4. HHG Cargo Forecast Data - FY 82

6-9. COAL FORECASTING MODEL DEVELOPMENT

a. Coal shipments are concentrated on the shipping routes between East Coast/Gulf Coast to Europe. Less than .01 percent of all coal shipped is inbound for ports other than Europe. Coal forecasts are prepared by the Energy Center, Rheinau and forwarded to Defense Logistics Agency (DLA-DFSC). DLA is responsible for soliciting the contracts for the coal requirements and approving the negotiations. Once contracts are approved, the Energy Center at Rheinau and the MSC coordinate the shipment scheduling of coal.

b. During October 1977 to September 1981 (timeframe used to construct the statistical forecasting model), several factors affecting coal shipments occurred.

(1) In recent years, contract negotiations for coal procurements have been delayed due to several reasons, which in turn have delayed coal shipments during a given fiscal year. Thus, the data obscure the fact that some coal shipments which are ordered to be delivered in one fiscal year

are delayed and actually shipped in another fiscal year. Over time, this accordion effect will disappear. However, accurate forecasting for any given year is hindered because the current data are clouded by events external to the forecasting system.

(2) During the conservation efforts of the past few years, coal burners in Europe have transferred their source of fuel from anthracite to bituminous. Although the effort is made for cost and conservation purposes, the true impact of the change cannot be determined from the data. The total tonnage of coal shipped has not changed appreciably since any reduction of anthracite has been mostly offset by the increase in bituminous.

In sum, mathematical forecasting for coal shipments should be modified based upon knowledge of the energy program and external events that impact on the program.

c. Coal data during the period under study did not exhibit a recurring pattern or seasonal trend. However, it is evident that some adjustments to the raw data are necessary to improve the accuracy of the forecasts. Stationary data was achieved after differencing the raw series at a lag of 1 month.

d. The appropriate model for coal data was an ARIMA (1,1,1) model:

$$\underset{(9.46)}{(1 - .3461B)}\,(1 - B)\,X_t = \underset{(2.06)}{(1 - .859B)}\,\epsilon_t$$

$$x^2\,(2,20) = 10.87$$

The results indicate that all of the estimated coefficients are significant at the 5 percent significance level. The estimated ARIMA (1,1,1) model was verified using the Box-Pierce test and a visual examination of the estimated residuals of the model. The Q statistic test is 10.87, which indicates that the null hypothesis, uncorrelated residuals, should not be rejected at the 6 percent significance level. The ARIMA (1,1,1) model forecasted the FY 82 coal tonnage shipped to be 373.53 K/MTON as compared to the historical FY 82 lift of 375.94 K/MTON (-.6 percent) and the actual FY 82 DLA coal contract of 440.67 K/MTON (15.2 percent error). The forecast MSE was 192.60. Figure 6-5 illustrates the monthly forecast.

e. When the Winters model was used to predict the historical FY 82 lift, a forecast of 351.93 K/MTON resulted. Although the average forecast error was only 6.4 percent, the MSE was fairly high (210.18), indicating a relatively poor fit.

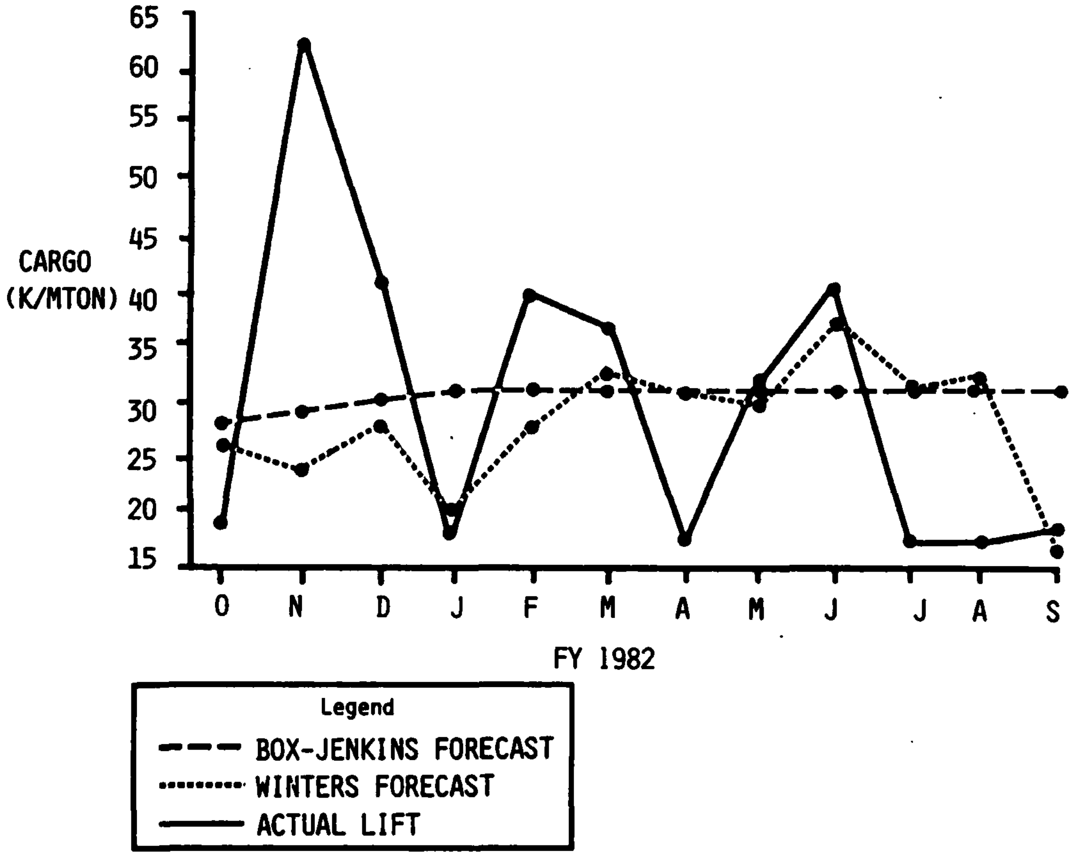

Figure 6-5. Coal Cargo Forecast - FY 82

6-10. AMMUNITION FORECASTING MODEL DEVELOPMENT

a. Ammunition requests fall into two general categories: (1) ammunition to increase war reserve stocks and (2) ammunition to be used for training purposes. The war reserve buildup program is an annually funded program that is reviewed every 6 months to address the manufacturing, transportation, handling, and stockpiling constraints of ammunition buildup. Ammunition dedicated for training purposes is strictly based upon demand and number of combat units in a particular theater. Additionally, safety testing of ammunition complicates the accurate forecasting of ammunition requirements. If manufactured ammunition fails safety tests, then ammunition shipment plans must be rearranged.

b. The ammunition movement planning process consists of two principal agencies: DCSLOG and Armament, Munitions and Chemical Command (AMCCOM). DCSLOG functions as a screening filter for the war reserve buildup program and training ammunition requests from theater commands. Requests are reviewed biannually at Committee on Ammunition Logistic Support (CALS) meetings, where ammunition allocations are determined for each command based upon priority and manufacturing constraints. The approved allocations are then used by AMCCOM to direct movement of ammunition to the selected commands. At the subsequent CALS meeting (every 6 months), the status of ammunition reserves and manufacturing capability is reviewed and adjustments are made to achieve the stated goals. As with coal, annual ammunition forecasts should be based upon mathematical models and inside information regarding the status of ammunition programs.

c. Ammunition data is relatively constant on an annual basis and the monthly data exhibits some seasonality. However, attempts to capture the seasonal aspects of the data were futile since stationarity could not be achieved. Like coal, the ammunition data should be monitored carefully and adjusted with caution. Stationary data was achieved after differencing the original series at a lag of 1 month.

d. The appropriate model for ammunition data was an ARIMA (2,1,4) model:

$$\underset{(-7.33)}{(1+.8418B} + \underset{(-4.59)}{.5399\,B^2)}\,(1-B)\,X_t = (1+\underset{(-3.11)}{.3454B^4} - \underset{(3.86)}{.3689B^5} - \underset{(4.57)}{.3875B^6} - \underset{(2.43)}{.2561B^7})\,\epsilon_t$$

$$x^2\ (6,20) = 17.61$$

All of the estimated coefficients are significant at the 5 percent significance level. The Box-Pierce test for the model indicates that the null hypothesis, estimated residuals are uncorrelated, should not be rejected at the 40 percent significance level. The model forecasted that ammunition shipments during FY 82 would be 189.62 K/MTON versus an actual lift of 179.31 K/MTON of ammunition during FY 82 (see Figure 6-6). The MSE of the ammunition forecast was 119.91 and the annual error was 5.7 percent.

e. When the Winters model was used to forecast ammunition, a forecast of 158.080 K/MTON resulted, which corresponds to an error of -11.8 percent. The fit was quite good, except for the existence of a heavy ammunition shipment (outlier) during July of FY 82. MSE was 107.59.

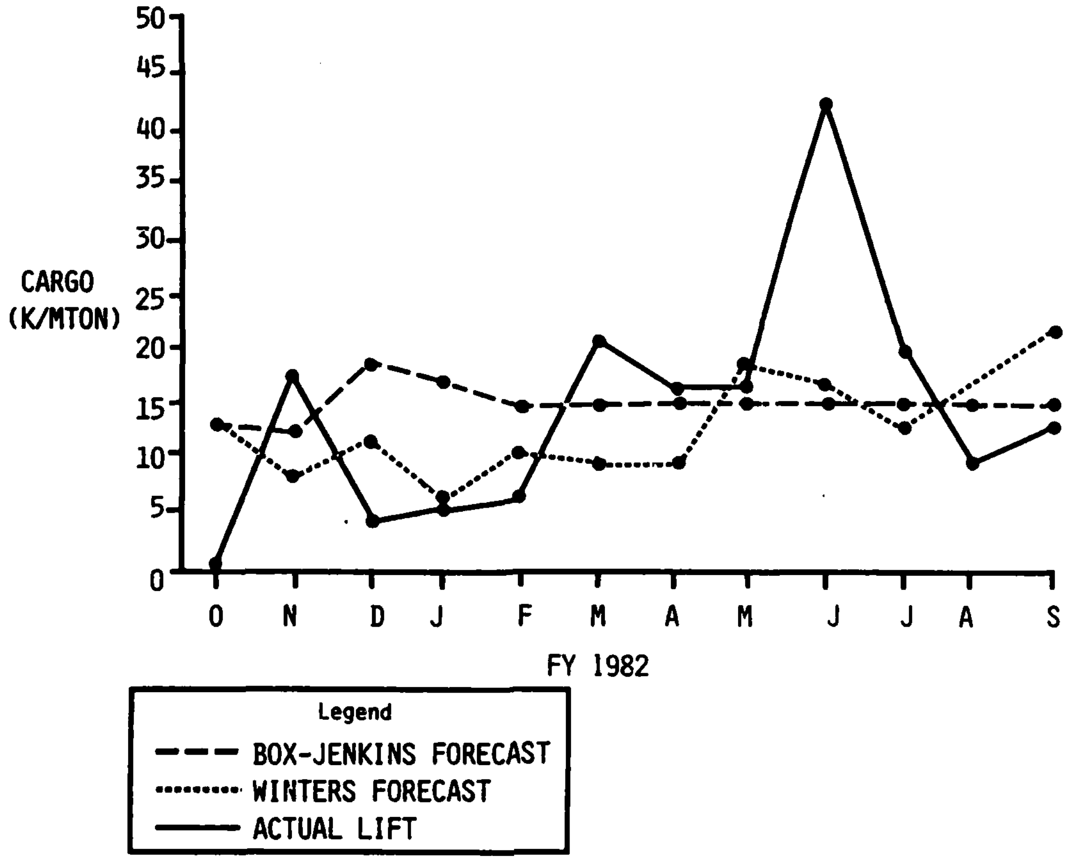

Figure 6-6. Ammunition Cargo Forecast - FY 82

6-11. SPECIAL FORECASTING MODEL DEVELOPMENT

a. The majority of items shipped under commodity code special comprise program items that relate to the Army Modernization Improvement Memorandum (AMIM). They include items such as M1 tanks, 5-ton trucks, and track vehicles. However, there are some program items which are small enough to be shipped in the general cargo category such as force modernization program equipment shipped by Communications and Electronics Command (CECOM). Radios and other electronic items that are shipped by CECOM that are small in size are shipped as general cargo. Items shipped under commodity code special are primarily AMIM program items; however, not all AMIM items are shipped as special cargo. For purposes of this study, AMIM items could not be isolated from the special cargo category due to the current TAC structure. However, with improved data base management and expanded TAC, more accurate forecasts of the special cargo commodity can be made.

b. Special cargo exhibited a trend that could possibly be interpreted as program funding of the defense budget and some aspects of seasonality. To achieve stationary data, the original series was differenced at a lag of 12 months.

c. The appropriate model for special cargo was an ARIMA (2,0,0) non-seasonal model and an ARIMA (0,1,1) model:

$$\underset{(1.21)}{(1 - .1496B} - \underset{(3.16)}{.3875B^2)} (1 - B^{12}) \ln X_t = (1 - \underset{(10.61)}{.801B^{12}} - \underset{(1.65)}{.1503^{14})} \epsilon_t$$

$$\chi^2 (4,20) = 13.15$$

All of the estimated coefficients except ϕ_1 and θ_{14} are significant at the 5 percent significance level. The model was verified using the Box-Pierce test and a visual check of the estimated residuals. The Q statistic for this model with 20 degrees of freedom is 13.15. This diagnostic indicates that the residuals are not significant and that the null hypothesis should not be rejected at the 16 percent significance level. This model forecasted that 559.42 K/MTON of special cargo would be shipped during FY 82 versus an actual amount of 189.83 K/MTON (see Figure 6-7). The annual forecast error was 14.2 percent and the forecast MSE was 159.23. It should be noted that the amount of special cargo tonnage shipped during FY 82 is much lower than any of the preceding years. In fact, the average tonnage of special cargo shipped over the past 5 years was 669.17 K/MTON. In all cases, forecasting methodologies are employed based upon the assumption that the behavior of future observations will not differ greatly from the behavior of past observations. When the future is radically different than the past, as in the case of special cargo tonnage for FY 82, forecasts cannot predict the future with any degree of accuracy.

d. Similarly, the radical change in special cargo shipments during FY 82 caused the Winters model to overestimate the actual lift by 28.1 percent. The forecast MSE was 404.018; the Winters model forecasted a lift of 627.52 K/MTON.

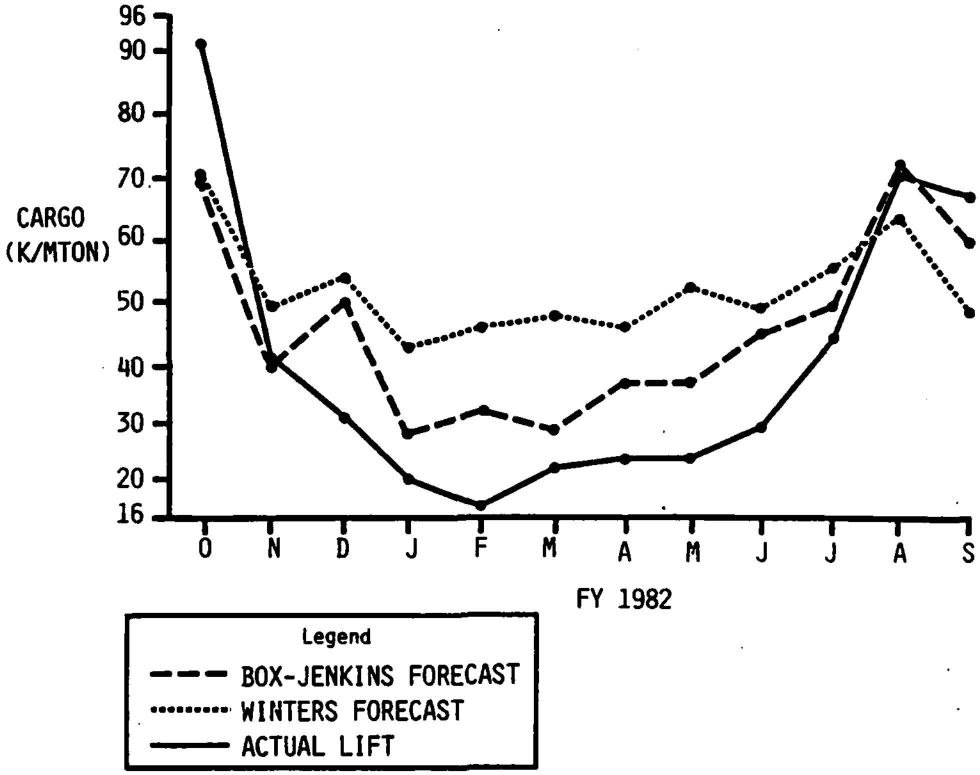

Figure 6-7. Special Cargo Forecast - FY 82

6-12. CARGO TRAILER/CONEX FORECASTING MODEL DEVELOPMENT

a. CONEX shipments, as annotated in the data (commodity 70), were in fact said to be roll on/roll off (RORO) trailer shipments. Empty CONEX data was negligible, therefore, it was combined with trailer data and the resulting series was modeled as cargo trailers. CONEX data demonstrated an upward annual linear trend and the monthly data exhibited seasonality. Stationarity was achieved after differencing the original series at a lag of 12 months.

b. The appropriate model for special cargo data was an ARIMA (0,0,1) nonseasonal model and an ARIMA (0,1,1) seasonal model with a series mean:

$$(1 - B^{12})\, X_t = \underset{(4.09)}{.4057} + (1 + \underset{(-2.32)}{.2912B})\, (1 - \underset{(14.97)}{.8264B^{12}})\, \epsilon_t$$

$$\chi^2\ (2,20) = 12.74$$

The results indicate that all of the estimated coefficients are significant at the 5 percent significance level. The Q statistic for the estimated model residuals at 20 degrees of freedom is 12.74 which is significant at the 16 percent significance level. Therefore, the null hypothesis, uncorrelated residuals, should not be rejected at the 16 percent significance level. The model forecasted CONEX/cargo trailer shipments for FY 82 to be 76.43 K/MTON versus an actual lift for FY 82 of 74.47 K/MTON (see Figure 6-8). The MSE of the CONEX forecast was .81, and the annual forecast error was 2.6 percent.

c. When the Winters model was used to estimate CONEX/cargo trailer shipments, the forecast, 77.03 K/MTON, exceeded the actual lift by 2.56 K/MTON, or about 3.4 percent. The MSE was .78 K/MTON, and the fit was quite good.

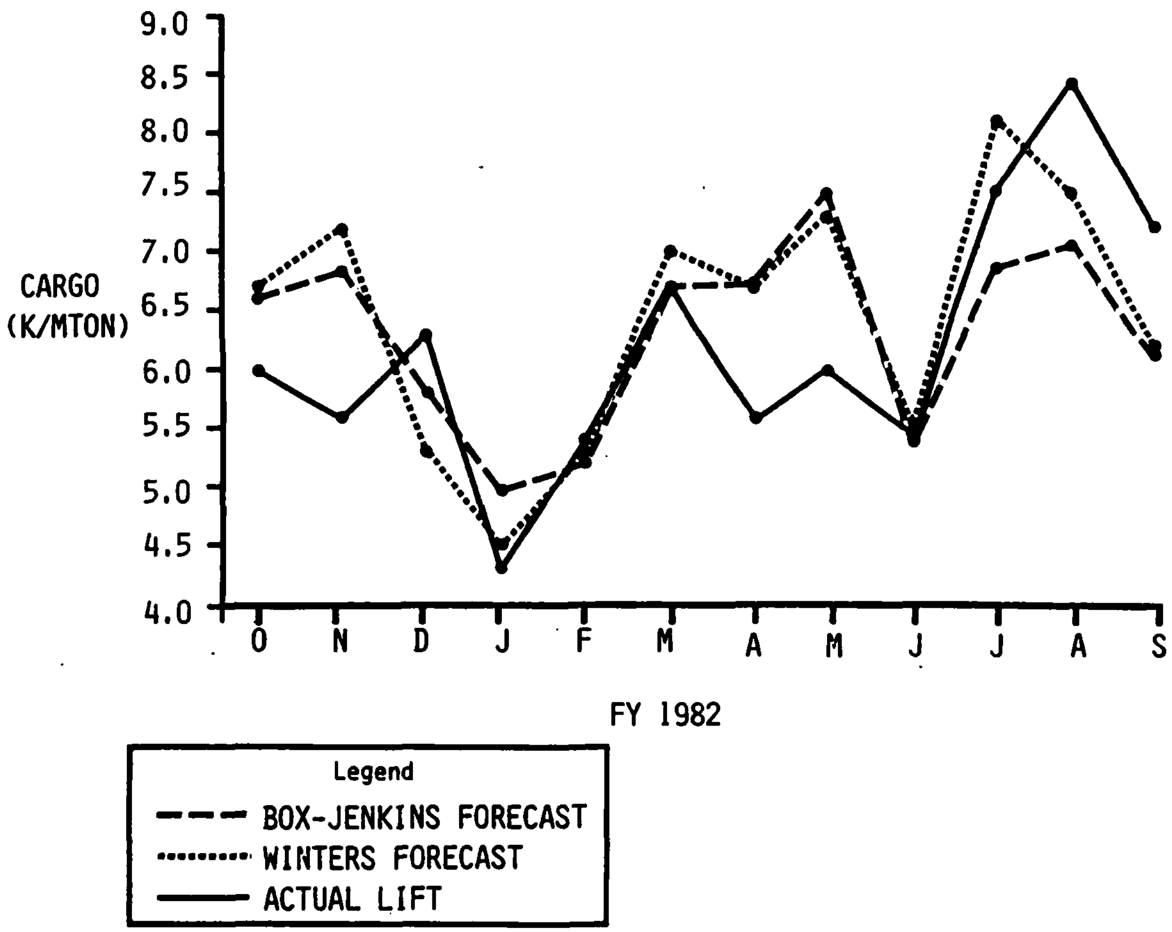

Figure 6-8. CONEX Cargo Forecast - FY 82

6-13. FREEZE FORECASTING MODEL DEVELOPMENT

a. AAFES shipments of freeze goods account for approximately 80 percent of freeze cargo shipped during a given year. Freeze shipments increased 24 percent during FY 82; however, AAFES freeze shipments increased 30 percent during the same period. Thus, like coal and ammunition, program information from AAFES must be integrated into the overall forecast of freeze data.

b. Freeze data depicts a trend and pattern very similar to CONEX data. The trend during the period under study was an upward linear function, and the monthly data exhibited seasonality. Stationarity was achieved after differencing the seasonally adjusted series at a lag of 1 month.

c. The appropriate model for freeze data was an ARIMA (2,1,2) non-seasonal model and a (0,1,1) seasonal model:

$$\underset{(-6.76)}{(1+.7740B} + \underset{(-5.96)}{.6789B^2)}\,(1-B^{12})\,(1-B)\,X_t = (1-\underset{(4.32)}{.4729B} + \underset{(-5.76)}{.5038B^{11}})\,(1-\underset{(12.04)}{.7753B^{12}})\;\epsilon_t$$

$$\chi^2\,(5,20) = 14.66$$

The results indicate that all of the coefficients of the model are significant at the 5 percent significance level. The Q statistic for 20 degrees of freedom is 14.66. Therefore, the null hypothesis, residuals are uncorrelated, should not be rejected at the 20 percent significance level. The freeze seasonal model forecasted that 31.86 K/MTON would be transported during FY 82 versus an actual shipment of 36.42 K/MTON (see Figure 6-9). The MSE of the freeze forecast was .49, and the annual forecast error was -12.5 percent.

d. When the Winters model was used to forecast freeze shipments, a 12.8 percent underforecast resulted. The model forecasted a lift of 31.758 K/MTON, and the MSE of the forecast was 0.458, indicative of a relatively good fit.

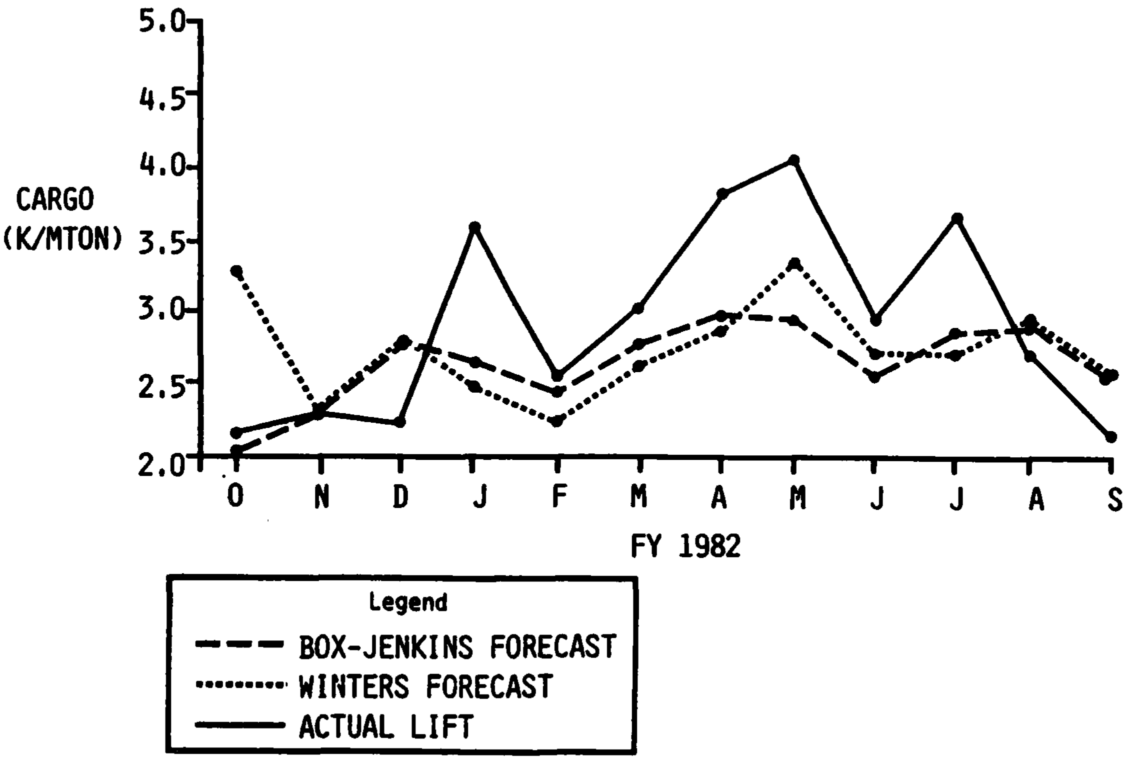

Figure 6-9. Freeze Cargo Forecast - FY 82

6-14. CHILL FORECASTING MODEL DEVELOPMENT

a. As stated previously, raw billing data from MSC were compiled into monthly time series data (cargo shipped monthly). The sorting process used to obtain the monthly time series data was done under the assumption that debits and credits contained in the raw data base would be eliminated by this process. Furthermore, it was assumed that this data manipulation would not produce any negative numbers (i.e., credit balance). This assumption follows from normal accounting practices when a credit is recorded to offset previous debit. However, due to problems with the raw data base, a negative number was generated from this process (November 1976--see Figure D-1, Appendix D). The cause of this negative number can only be resolved after a thorough review of the MSC and Army finance and accounting records which is beyond the scope of this study. Therefore, the first 2 months of the data series were eliminated. Time series data from December 1977 through September 1981 were used to develop forecasting models for the commodity chill.

b. Chill shipments were relatively constant on an annual basis, but monthly data did exhibit seasonality. Stationarity was achieved after transforming the original series using natural logarithms and then differencing the logarithmic series at a lag of 12 months.

c. The appropriate model for chill data was a nonseasonal ARIMA (0,0,2) model and a seasonal ARIMA (1,1,0) model:

$$(1 + \underset{(-5.61)}{.6371}B^{12})(1 - B^{12}) \ln X_t = (1 - \underset{(2.0)}{.3012}B + \underset{(-1.83)}{.2716}B^2)\, \epsilon_t$$

$$\chi^2\ (3,20) = 15.63$$

All of the estimated coefficients except θ_2 are significant at the 5 percent significance level. The Q statistic for 20 degrees of freedom is 15.63, which indicates that the residuals are not significant and that the null hypothesis should not be rejected at the 25 percent significance level. Also, all of the estimated residuals fall within the 95 percent confidence interval and appear to be distributed randomly. The FY 82 forecast for chill using this model was 15.32 K/MTON of cargo shipped versus an actual lift of 14.13 K/MTON (see Figure 6-10). The MSE of the chill forecast was .21, and the annual forecast error was 8.4 percent.

d. Application of Winters model to the chill time series resulted in a forecast of 13.03 K/MTON. This was an aggregate underforecast of 1.094 K/MTON, or -7.7 percent. The fit was good, and the MSE of the forecast was .13.

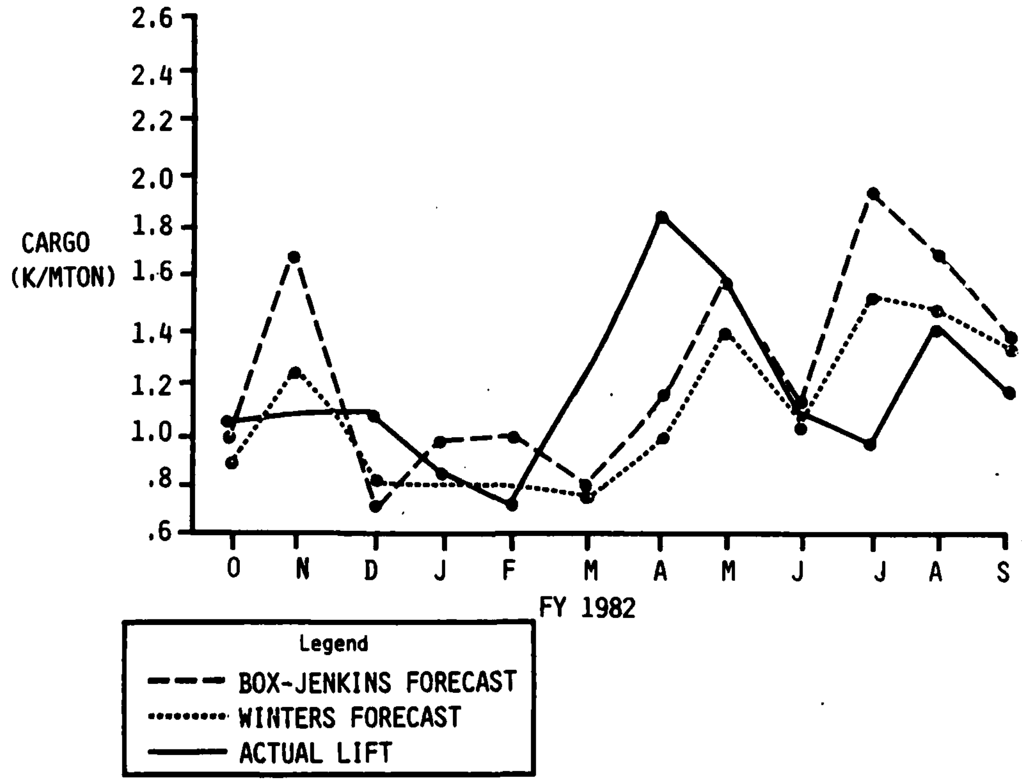

Figure 6-10. Chill Cargo Forecast - FY 82

6-15. SUMMARY OF FORECASTING RESULTS. Table 6-2 portrays the forecasting results of the Box-Jenkins and Winters models for each commodity for FY 82.

Table 6-2. FY 82 Forecasting Results

Commodity	Percent error			
	Present system		Box-Jenkins	Winters
	FY 81	FY 82	FY 82	FY 82
General	22.0	3.5	4.6	7.5
Breakbulk (4.7)	168.0	63.0	9.8	28.6
Container (44.5)	7.8	10.0	8.5	4.9
Nonprogram (33.5)	--	--	2.2	1.4
Special (16.6)	15.0	66.0	14.0	28.0
Coal (10.4)	22.0	13.8	.6	6.4
POV (13.5)	.4	7.3	1.7	5.3
Ammo (3.9)	36.0	3.9	.3	11.8
Household (2.5)	19.0	11.0	8.5	13.2
Cargo tlr (2.1)	30.0	14.6	1.6	2.9
Reefer (1.2)	14.0	39.2	7.0	10.0

( ) Percent of total lift.

CHAPTER 7

SATISFACTION OF ELEMENTS OF ANALYSIS

7-1. GENERAL. The course of the study was, to a significant extent, guided by all the sponsor's designated essential elements of analysis (EEA). However, identification of the variances between forecasts and lift, conditions which contributed to the variances, and effective methods for improving the forecast predominated the study efforts. All of the questions in the EEA were answered during the study, albeit some to a greater degree than others.

7-2. SYNOPSIS OF EEA. Discussion of the EEA is contained throughout the report. A capsule of the EEA and the answers to them follow:

a. **What are the recorded variances between long-range transportation workload forecasts and actual utilization of shipping cargo?** Tables 2-1 and 2-2, Chapter 2, contain the variances by commodity and shipping mode for FY 81 and FY 82.

b. **Do systemic conditions exist which contribute to unrealistic forecasting? If so, what are they?** Paragraph 2-2, Chapter 2, details the conditions observed in the current system. Most significant systemic contributions to the errors are the lack of an effective feedback system, some agency reports based on a limited knowledge of the forecasted commodity, inadequacies in the TAC structure, inadequate program input into the forecast, and separate long- and short-range forecasting systems.

c. **What is the economic and operational impact of long-range forecasts which are at variance with actual utilization?** Table 2-5, Chapter 2, shows the MSC industrial fund FY 82 losses which were directly attributable to errors in Army forecasts. Operationally, the forecasting variance resulted in underutilization of MSC cargo carrying capacity. The MSC-controlled fleet was approximately 40 percent utilized in FY 1982.

d. **Do short-range forecasts impact on long-range forecasting? If so how?** With the exception of CONUS outbound household goods and privately owned vehicles, long-range and short-range forecasts are prepared by the same personnel. In some cases, the long-range forecast impacts the short-range, as opposed to vice versa, as in those cases, the short-range forecasts are derived from the long-range.

e. **What is the impact of the current separation of responsibility for long-range and short-range forecasting?** Separation of the responsibility for long-range and short-range forecasting has created a dual system of reporting which does not contribute to the accuracy of the forecasts. It has produced long-range and short-range forecasts which are usually not in agreement. It requires the maintenance of similar records at LCA and HQDA, and diffuses responsibility for management of the forecasting system.

f. **What methodologies exist in other services which could be applied to the resolution of the Army's problem?** Discussion of USAF and USN forecasting procedures is contained in Chapter 3. The USAF forecasting procedures at AFLC could be used in conjunction with the procedures and models recommended in this report as the basis for an improved Army forecasting system. AFR 75-15, Forecast of Air Force Transportation Requirements, and AFLC Regulation 171-125, Surface Transportation Tonnage and Cost System (00278), contain a description of the USAF system.

g. **What DARCOM activities affect major end items of equipment planned for overseas distribution?** All program and project management decisions affecting the distribution of major end items to overseas locations impact the requirements for surface cargo space. In particular, changes to programs which occur subsequent to the formulation of the annual forecast of space requirements are critical in that the shipping vessel procurement and use is developed from this forecast. If the transportation forecasting activity is not cognizant of the changes to programs, then the match of shipping resources to available cargo is complicated. A major forecasting difficulty has been the information interface between the program decisions and the forecasting process. The analysis of the impact of DARCOM activities was limited by the masking of much of the DARCOM generated cargo within the general and special cargo commodities.

h. **What is the impact of the TAEDP on forecasting of requirements?** The TAEDP is provided to DARCOM Inventory Control Points (ICP) prior to the preparation of the preliminary annual forecast. It is used in conjunction with the Materiel Movement Report (MMR) and judgment to forecast major end-item movement requirements. There is limited confidence in the TAEDP at the ICPs; consequently, there is significant reliance on the MMR and forecaster judgment.

i. **What is the commodity impact of AAFES forecasting procedures?** The AAFES forecasting procedures, per se, do not impact the commodities. AAFES accounted for 30 percent of all cargo, 50 percent of general cargo, and 60 percent of reefer cargo shipped in FY 1982.

j. **What are the effective and cost effective methods for improving forecasting accuracy?** Chapters 5 and 6 identify procedures and methods that would improve the accuracy of the forecasting system.

k. **What, if any, unique commodities are masked as general or special cargo?**

(1) Much of the CECOM force modernization equipment is masked as general cargo and is not currently identifiable. This prevents accurate adjustment of general cargo forecasts to reflect force modernization programs.

(2) Military sedans and smaller military wheeled vehicles are classified as and are masked in special cargo. All special cargo is forecast as transported via MSC breakbulk ships. These vehicles can be transported via breakbulk roll on/roll off (RO/RO) or container vessels, and could be identified as a separate commodity or in a single commodity with POVs.

CHAPTER 8

CONCLUSIONS

8-1. GENERAL. The investigation of the current Army transportation workload forecasting system and the methodologies used within the process indicates that it can be improved. Significant improvements and efficiencies can be gained from refining the Army forecasting system, using accurate forecasting tools, and amending the reporting requirements of the transportation operating authorities. Annual cost avoidance potential should range betwen $30M and $100M.

8-2. FORECASTING SYSTEM

a. The Army transportation workload forecasting system can be improved by using improved forecasting methodologies and revising the forecasting process.

b. A sufficient data base has been created in this study which can be used as a basis with forecasting techniques for making accurate forecasts and for incorporation into a data base used by Army forecasters.

c. The Box-Jenkins and Winters models can provide accurate forecasts of the Army over-ocean surface cargo transportation requirements.

d. When used in conjunction with program information, the forecasts developed using the Box-Jenkins and Winters models should provide the transportation operating agencies (TOA) with accurate forecasts of Army over-ocean surface cargo transportation requirements.

e. The forecasting of Army transportation requirements by the TOA, using a forecasting model and program input from the Army, is considered to be the most efficient, accurate, and cost effective system.

f. Forecasting by a single Army agency would achieve similar accuracy as forecasting by the TOA and would also result in significant cost savings. If forecasting by the TOA is not achieveable in the near term, forecasting by a single Army agency is the most efficient alternative. If forecasting by the TOA is ultimately developed, then the transition from forecasting by a single Army activity to the TOA would require minimal effort.

g. If the present forecasting structure is to be retained, accuracy would be improved by combining long-range and short-range forecasting systems, using an accurate multiyear data base, applying uniform forecasting methods, structuring TACs to identify each shipper and program, upgrading MECHTRAM, and developing an effective feedback program to inform shippers on the cargo shipped.

h. HQ DARCOM is the most appropriate location for the forecasting activity if it is decided that a single activity within the Army will perform the forecasting function. Predominant reasons for this conclusion are:

(1) DARCOM is a major Army shipper.

(2) HQ DARCOM is cognizant of and has a command relationship with the program activities which have the most significant impact on irregular shipping requirements (e.g., force modernization or ammunition program decisions). Consequently, coordination problems would be minimized.

(3) Non-DARCOM shipments are accurately predictable and, for the most part, can be forecasted using a forecasting model.

(4) HQ DARCOM has the capability, with augmentation, to support the forecasting system.

i. HQDA and LCA also have the capability to support the system, and could, if augmented with the appropriate skills, perform the forecasting function.

j. TAC structure revision would allow identification of program specific cargo within the general and special commodity categories and facilitate forecasting of these commodities.

k. Interdependence of the transportation budgets and workload forecasts would be enhanced if they used the same data sources.

l. Accurate and timely program data for force modernization, ammunition, fuels, and personnel related programs would improve forecast accuracy.

m. The automated systems supporting the USAF surface tonnage and cost system, and the forecast of Air Force transportation requirements process is an appropriate paradigm for the Army's ADP system to support transportation workload forecasting when used with the forecasting models developed in this study. It is also an appropriate model for the cost and performance aspects of the system.

n. There are no indications that separation of budget and forecasting responsibilities contribute to forecasting error.

8-3. EXTERNAL FACTORS

a. The requirement to forecast the mode of shipment as breakbulk or container is a significant contributor to forecasting error. Resolution of this problem with MSC and MTMC, resulting in elimination of this forecasting requirement, would eliminate at least one-third of the forecasting error.

b. Short-range forecasts appear to be of minimal value to the TOAs and do not justify the amount of effort required for their preparation. Submission of annual reports and periodic change reports should suffice.

c. MSC billing system appears to contain significant inaccuracies and delays in its reports. Stringent audits of MSC bills, establishment of a history of accuracy and timeliness of the MSC billing system, and development of procedures with MSC to resolve system defects which are identified should result in more accurate costs and an accurate data base for forecast formulation.

d. The amount of household goods processed by MSC is a small proportion of the total household goods shipped. MTMC decides whether household goods will be shipped by a freight forwarder or through MSC. As a small shift from freight forward shipment to MSC would have a major impact on forecast accuracy, MTMC involvement in the forecast formulation should reduce the potential for error in the Army household goods forecast.

CHAPTER 9

ACTIONS TO IMPROVE THE TRANSPORTATION FORECASTING SYSTEM

9-1. GENERAL. This chapter outlines those actions identified in this study that, if taken, should improve the Army's transportation workload forecasting process. Regardless of the system chosen, the actions concerning TAC revision, resolution of mode, household goods and short-range forecasting requirements, refinement of forecasting procedures, and budget and forecast interdependence, if executed, would improve forecast accuracy. It is assumed during the implementation of suggested actions: (1) that the current forecasting system will be maintained until the selected system is totally in place, and (2) that a timetable and responsibilities for the completion of necessary actions will be established.

9-2. SELECT FORECASTING SYSTEM STRUCTURE. Selection, from the proposed forecasting system structures, of that system or combination of systems which most satisfactorily meets the requirements of an improved forecasting system is a necessary prerequisite to the implementation of other changes. Forecasting at a single location, using historic and program information, is considered the most efficient and effective.

9-3. RESOLVE TAC STRUCTURE. Restructuring of the TAC to include TAC identification of the major program under which the commodity is shipped (i.e., Force Modernization) is required to isolate force modernization. If either decentralized forecasting system option is selected, then including identification of the program and the shipping command/agency in the TAC structure is suggested.

9-4. RESOLVE MODE FORECASTING REQUIREMENT. Resolution with the surface transport TOA to eliminate the requirement to forecast whether cargo is to be shipped breakbulk or container and that the forecast state only the commodity and route is necessary to eliminate a significant source of forecasting error.

9-5. RESOLVE SHORT-RANGE FORECASTING REQUIREMENT. Resolving with MSC and MTMC to eliminate the monthly short-range requirements forecast and replacing it with periodic reports of changes to the annual forecast is suggested.

9-6. RESOLVE HOUSEHOLD GOODS FORECASTING PROCEDURE. Establishment of a process whereby MTMC will participate in the development of the household goods forecast to determine what proportion of household goods will be shipped as Code 4 and Code 5 should reduce the potential for forecast error.

9-7. ESTABLISH REPORTING REQUIREMENTS. Establishing reporting requirements, based on the system selected and the resolution of forecasting requirements with the TOA, will ensure understanding of revised reporting responsibilities. The type, content, and frequency of reports should be established in coordination with the forecasting agencies/commands, budget agencies, and the TOA.

9-8. DEFINE LINKAGE BETWEEN FORECAST AND BUDGET. Establishing mechanisms to ensure that the forecasting of transportation requirements and budget processes are coordinated and have access to the same source data will assist both forecast and budget preparation.

9-9. DEVELOP ADP SYSTEM REQUIREMENTS. This action is also a function of the forecasting system selected. If the present system or variations thereof are selected, then modification of the MECHTRAM system to provide a more extensive data base, evaluate the forecasts made by the commands/agencies, produce information of greater utility to the budget process, and provide timely cost and performance data will improve the forecasting process. If a single Army agency is to perform the forecasting, then replacing or overhauling the MECHTRAM system is suggested. In either of these cases, including in the system those capabilities now embodied in the AFLC system and the forecasting models developed in this study will facilitate system improvement. If the forecasts are to be prepared by the TOA, the modification of the MECHTRAM system to accept program input and produce consolidated program reports, accurately process MSC bills, and provide comprehensive cost and performance reports on the surface cargo transportation process will provide necessary forecast and budget information.

9-10. UPDATE FORECASTING MODELS. Depending on the time between completion of the models by the study agency and their use by the forecasters, it may be necessary to refine the forecasting models. The models should be checked by comparing the most recent lift data available to forecasts developed by the model for the time periods in question.

9-11. REVISE REGULATIONS. Changes to AR 55-23 and AR 55-30, reflecting changes to the system, will be necessary to ensure understanding of the revised process. Additionally, change recommendations to JCS Pub 15 should reflect the changes to forecasting procedures which may be developed with the TOA.

APPENDIX A

STUDY CONTRIBUTORS

1. STUDY TEAM

a. Study Director

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LTC G. Tilden, Strategy, Concepts and Plans Directorate

APPENDIX B

STUDY DIRECTIVE

DEPARTMENT OF THE ARMY
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR LOGISTICS
WASHINGTON, D.C. 20310

REPLY TO ATTENTION OF
DALO-TSP-C11 83504941 11 May 1983

SUBJECT: Transportation Workload Forecasting (TWF) Study

Director
U. S. Army Concepts Analysis Agency
8120 Woodmont Avenue
Bethesda, Maryland 20814

1. Purpose of Study Directive. This directive tasks the Concepts Analysis Agency to conduct the subject study.

2. Study Title. Transportation Workload Forecasting (TWF) Study.

3. Background. Current forecasting procedures of Army cargo and mail workload requirements directed by AR 55-30 prescribe input from seventeen major commands/agencies/activities, world-wide. These consolidated requirements are submitted by HQDA to the Military Sealift Command (MSC) and the Military Airlift Command (MAC) in accordance with Joint Chiefs of Staff Publication 15. The MSC provides the Military Traffic Management Command (MTMC) a copy. MTMC, MSC and MAC utilize this data to generate their industrial fund budgets. History reveals significant variances in forecasted requirements versus actual lift, which result in distorted budgets by both the shipper service and MSC/MAC/MTMC. Transportation funds to pay these overseas movements are centrally budgeted at HQDA, with the U. S. Army Finance and Accounting Center (USAFAC) the designated office.

4. Study Proponent and Proponent's Study Director. HQDA ODCSLOG is the study proponent. Director of Transportation, Energy and Troop Support, ODCSLOG (DALO-TSP), will be the Proponent's study representative.

5. Study Agency. U. S. Army Concepts Analysis Agency (CAA).

6. Terms of Reference.

a. Statement of the Problem. Current Army transportation workload forecasting procedures result in unrealistic forecasts of Army lift requirements to MAC, MSC, and MTMC.

b. Purpose. To develop procedures to improve US Army transportation workload forecasting.

c. Scope. This study will focus on the long-range surface transportation workload forecast process and its impact on the Army budget and on transportation costs. Short-range forecasting will be examined to the extent that it impacts on or influences the long-range forecast.

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d. Objectives. Determination of the nature and extent of the TWF problem, exploration of alternative solutions to the problem, evaluation of the alternative solutions in terms of cost and feasibility, and development of an outline plan to manage the TWF system improvements.

e. Tasks.

(1) Identify the nature and extent of U. S. Army transportation workload forecasting variances from actual lift.

(2) Determine the impact of long-range transportation workload forecasts on the Army budget, on the industrial funds of Military Sealift Command (MSC), the Military Airlift Command and Military Traffic Management Command (MTMC), and on rates established for Army second destination cargo movements.

(3) Examine feasible and cost effective methods for increasing accuracy in forecasting.

(4) Examine and evaluate alternative locations for forecasting responsibility.

(5) Recommend an operationally and cost effective transportation workload forecasting methodology.

f. Timeframe. Current.

g. Assumptions. Transportation workload forecasting requirements will remain unchanged for the duration of the study.

h. Essential Elements of Analysis (EEA).

(1) What are the recorded variances between long-range transportation workload forecasting and actual utilization of cargo shipping?

(2) Do systemic conditions exist which contribute to unrealistic forecasting? If so, what are they?

(3) What is the economic and operational impact of long-range forecasts which are at variance with actual utilization?

(4) Do short-range forecasts impact on long-range forecasting? If so how?

(5) What is the impact of the current separation of responsibility for long-range and short-range forecasting?

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(6) What methodologies exist in the other services which could be applied to the resolution of the Army problem?

(7) What DARCOM activities affect major items of equipment planned for oversea distribution?

(8) What is the impact of the Total Army Equipment Distribution Program (TAEDP) on forecasting of requirements.

(9) What is the commodity impact of AAFES forecasting procedures?

(10) What are the feasible and cost effective methods for improving forecasting accuracy?

(11) What, if any, unique commodities are masked as general or special cargo?

7. Responsibilities.

a. The ODCSLOG will:

(1) Provide support as required for its areas of responsibility and interest.

(2) Prepare an evaluation of study results IAW AR 5-5.

(3) Establish and convene a Study Advisory Group (SAG) under provisions of AR 5-5.

b. CAA will:

(1) Establish a study team.

(2) Establish direct communications with ODCSLOG, D/TRETS, and other agencies as required for the conduct of the study.

(3) Provide periodic in-process reviews (IPR) and final study documentation to the study sponsor.

c. USAMSSA will: Provide ADP support as requested.

8. Literature Search.

a. Department of the Army, Office of the Comptroller of the Army, Report on the Army Transportation Study, May 1971.

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b. Evaluation of Second Destination Transportation Funding, U. S. Army Logistics Evaluation Agency, 29 December 1978.

c. Defense Logistics Agency studies and reports.

d. MSC reports.

e. Army Inventory Management Agency studies.

f. USAF and USN transportation workload forecasting methodologies.

g. OSD transportation workload forecasting studies and reports.

9. References.

a. JCS Pub 15, dated 2 June 1975.

b. AR 55-23, dated 17 March 1978.

c. AR 55-30, dated 15 August 1982.

d. AR 55-133, dated 18 February 1977.

e. AR 59-8, dated 20 August 1982.

f. MECHTRAM Users Manual, dated June 1978.

g. AR 11-18, October 1975.

h. DA PAM, May 1976.

i. AR 11-28, December 1975.

10. Administration.

a. Support

(1) Funding for temporary duty (TDY) and travel associated with the study will be provided by each participating agency.

(2) Headquarters or agencies represented in the Study Advisory Group will provide own TDY, per diem, and travel funds.

b. Milestone Schedule

First IPR May 1983

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Second IPR	September 1983
Third IPR	December 1983

c. Control Procedures

(1) Periodic IPRs will be provided to the study sponsor by the study team.

(2) Documentation required by AR 5-5, including DD Form 1498 and DD Form 1473, and a final report to include an Executive Summary will be submitted by CAA.

d. Coordination

(1) Direct coordination between CAA, DALO-TSP, and forecasting activities is authorized. For purposes of any possible data collection, coordination between CAA and the submitting activity is directed. Information copies of all data inputs should be provided to HQDA, DALO-TSP-C11.

(2) This study directive has been coordinated with CAA in accordance with AR 5-5.

FOR THE DEPUTY CHIEF OF STAFF FOR LOGISTICS:

JIMMY D. ROSS
Brigadier General, GS
Director of Transportation,
Energy and Troop Support

APPENDIX C

REFERENCES/BIBLIOGRAPHY

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1. Dry Cargo Sealift Movement Forecasting and Sizing of MSC Fleet Study, OSD Logistics System Analysis Office, 1982

2. Anderson, O. D, Time Series Analysis and Forecasting: The Box Jenkins Approach, Butterworth & Co., Ltd, London, England, 1977

3. Box, George E. P. and Gwilym M. Jenkins, Time Series Analysis: Forecasting and Control, Holden-Day Inc., San Francisco, CA, 1976

4. Dixon, W. J., et al., BMDP Statistical Software, University of California Press, Berkeley, CA, 1981

5. Makridakis, Spyros and Steven C. Wheelwright, Forecasting: Methods and Applications, John Wiley & Sons, New York, NY, 1978

6. Montgomery, Douglas C. and Lywood A. Johnson, Forecasting and Time Series Analysis, McGraw-Hill Book Company, New York, NY, 1976

7. Pindyck, Robert S. and Daniel L. Dubinfeld, Econometric Models and Economic Forecasts, McGraw-Hill Book Company, New York, NY, 1981

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DEPARTMENT OF DEFENSE

Department of Defense (DOD) Publications

DOD Directive 5160.10, Single Manager Assignment for Ocean Transportation

DOD Directive 5160.53, Single Manager Assignment for Military Traffic, Land Transportation, and Common-User Ocean Terminals

Joint Chiefs of Staff (JCS) Publications

JCS Publication 15, Mobility System Policies, Procedures and Considerations

DEPARTMENT OF THE ARMY

Department of the Army (DA) Publications

AR 55-23, Submission of Dry Cargo Requirements and the Assignment and Allocation of Sea Transportation Space

AR 55-30, Space Requirements and Performance Reports for Transportation Movements

AR 59-8, Military Airlift Command: Requirement, Submissions, Space Assignments, and Allocations and Priorities

Report on the Army Transportation Study, Department of the Army, Office of the Comptroller of the Army, 1971

Evaluation of Second Destination Transportation Funding, US Army Logistics Evaluation Agency, 1978

Deputy Chief of Staff for Logistics (DCSLOG)

Integrated Transportation Management Operating System (ITMIS) User's Manual

DEPARTMENT OF THE AIR FORCE

US Air Force Logistics Command (AFLC) Publication

AFLC Regulation 171-125, Surface Transportation Tonnage and Cost System (0027B)

US Air Force (USAF) Publication

AFR 75-15, Reports for Military Transportation Requirements.

DEPARTMENT OF THE NAVY

US Navy Supply Systems Command Publication

NAVSUPINST 4620.7D, Sealift Cargo Requirements and Reporting Instructions.

APPENDIX D

COMMODITY TIME SERIES DATA

D-1. GENERAL. The purpose of this appendix is to provide a list of the aggregate time series data that was used to build the forecasting models and test their accuracy.

D-2. COMMODITY DATA

a. Each figure contains three columns of data: (1) column 1 identifies the year and month, (2) column 2 depicts the amount of measurement tons that were lifted during the month, and (3) column 3 lists the number of records or shipments that were aggregated to develop the lift figure in column 2.

b. As discussed in paragraph 6-2, aggregate time series data was developed for each commodity over all routes as well as each commodity for a particular route. The data contained in this appendix is the commodity data for all routes combined. The specific route data (424 routes) is available upon request.

7610	914.43	32
7611	-446.00	53
7612	929.00	30
7701	773.05	34
7702	1092.00	25
7703	686.00	24
7704	888.50	27
7705	1049.00	28
7706	1569.00	31
7707	1244.00	34
7708	1280.00	37
7709	1536.33	41
7710	1241.66	29
7711	1420.68	37
7712	1034.00	49
7801	966.00	22
7802	665.00	17
7803	973.00	25
7804	1098.05	32
7805	1468.22	36
7806	1147.57	33
7807	1624.08	26
7808	1398.31	35
7809	1932.14	37
7810	1134.12	29
7811	1007.05	30
7812	1100.67	29
7901	679.54	22
7902	898.38	31
7903	803.69	37
7904	953.98	29
7905	1744.64	42
7906	1180.45	43
7907	1536.85	49
7908	1926.72	53
7909	1268.99	41
7910	753.78	33
7911	1781.41	58
7912	907.11	44
8001	962.50	32
8002	1370.28	31
8003	841.68	28
8004	1174.32	32
8005	2064.68	49
8006	1131.43	33
8007	2325.32	36
8008	1861.21	52
8009	1475.91	41
8010	736.55	42
8011	1601.66	50
8012	586.91	38
8101	956.52	47
8102	733.21	38
8103	780.88	45
8104	1111.18	38
8105	1065.04	43
8106	1126.30	37
8107	1462.26	33
8108	1579.98	37
8109	1305.40	52
8110	1029.26	38
8111	1088.42	35
8112	1075.72	50
8201	836.67	22
8202	776.65	24
8203	1258.34	34
8204	1852.16	33
8205	1612.27	37
8206	1083.50	33
8207	941.80	28
8208	1404.23	34
8209	1170.27	26
8210	405.76	21
8211	1199.56	27
8212	1002.46	25
8301	1004.83	27
8302	553.68	21
8303	993.29	24
8304	1160.93	27
8305	1079.12	27
8306	1504.68	27

Figure D-1. Chill Cargo Data

7610	1825.00	24
7611	1377.00	28
7612	1714.40	24
7701	1997.00	22
7702	1020.00	19
7703	1692.00	23
7704	1747.00	23
7705	2105.00	22
7706	2280.00	22
7707	1551.50	24
7708	2168.00	28
7709	2520.63	23
7710	1297.48	21
7711	1432.60	23
7712	3222.00	37
7801	1562.75	27
7802	1620.00	21
7803	2173.00	22
7804	2483.00	23
7805	2575.00	30
7806	2126.25	32
7807	2735.63	27
7808	2248.56	30
7809	2155.63	24
7810	1603.22	23
7811	2065.12	23
7812	2475.95	25
7901	1854.22	25
7902	2620.91	27
7903	1994.23	25
7904	2600.57	27
7905	2807.90	29
7906	2096.05	24
7907	2196.11	35
7908	2678.11	31
7909	1204.67	26
7910	1705.16	28
7911	2509.71	28
7912	1849.35	34
8001	2293.43	26
8002	1658.10	24
8003	2590.96	25
8004	2510.01	27
8005	2622.45	27
8006	2533.26	23
8007	2518.18	22
8008	1856.05	24
8009	2010.77	23
8010	2342.00	27
8011	2053.41	24
8012	1948.56	16
8101	2543.46	32
8102	2366.03	18
8103	2525.21	26
8104	2563.80	26
8105	3742.60	27
8106	2002.94	26
8107	2143.94	25
8108	3240.05	28
8109	2249.00	31
8110	3320.31	26
8111	2346.50	26
8112	2204.62	30
8201	3570.90	20
8202	2564.14	24
8203	3011.91	30
8204	3807.10	32
8205	4076.17	37
8206	2952.83	30
8207	3662.92	39
8208	2713.77	29
8209	2184.09	21
8210	2679.29	30
8211	2333.06	25
8212	2838.82	22
8301	3367.38	27
8302	2709.29	23
8303	3084.59	26
8304	3349.15	30
8305	3489.33	28
8306	1408.76	18

Figure D-2. Freeze Cargo Data

7610	61749.00	[illegible]
7611	39861.00	2
7612	58988.00	3
7701	21934.00	2
7702	42244.00	2
7703	55231.00	2
7704	39902.00	1
7705	40668.00	2
7706	58003.00	2
7707	60925.00	2
7708	59130.00	2
7709	19340.00	2
7710	30267.00	1
7711	18599.00	1
7712	20967.00	6
7801	32448.00	1
7802	17533.00	1
7803	35408.00	2
7804	40275.00	3
7805	41381.00	2
7806	63142.00	5
7807	16423.00	1
7808	17596.00	1
7809	14777.00	1
7810	20450.00	1
7811	21372.00	1
7812	22176.02	8
7901	21521.00	6
7902	45859.00	3
7903	44672.70	4
7904	55623.25	3
7905	56026.63	6
7906	57462.04	6
7907	60851.00	2
7908	56040.00	2
7909	19492.00	1
7910	21564.00	2
7911	42761.00	5
7912	46265.00	6
8001	40735.00	2
8002	41967.00	2
8003	43866.40	3
8004	911.99	4
8005	46137.80	6
8006	57750.40	5
8007	44276.00	3
8008	61943.00	3
8009	44779.00	2
8010	41780.00	3
8011	39949.00	2
8012	41578.00	2
8101	19639.00	1
8102	42924.40	3
8103	43059.73	4
8104	34307.00	2
8105	16040.00	3
8106	17952.00	1
8107	42153.00	4
8108	36490.00	2
8109	19255.00	1
8110	19888.00	4
8111	64116.00	4
8112	41776.00	4
8201	19028.00	1
8202	40916.00	3
8203	38147.00	1
8204	19197.00	1
8205	33085.00	2
8206	41567.00	2
8207	19103.00	1
8208	19405.00	1
8209	19712.00	2
8210	18858.00	1
8211	20783.00	2
8301	3.75	1
8302	42134.00	2
8303	42810.00	2
8304	37096.00	1
8305	42172.15	3
8306	59384.00	2

Figure D-3. Coal Cargo Data

7610	41821.00	661
7611	35966.00	561
7612	36005.45	559
7701	29064.00	477
7702	25607.34	405
7703	34811.90	444
7704	34059.68	459
7705	53170.56	579
7706	64770.59	608
7707	66293.50	685
7708	49268.87	637
7709	52133.99	600
7710	34352.50	523
7711	42229.51	623
7712	32394.77	961
7801	37390.59	494
7802	28335.40	457
7803	30829.73	492
7804	37085.44	509
7805	43438.15	540
7806	48713.32	579
7807	57841.56	742
7808	54899.44	690
7809	37034.26	570
7810	40010.71	590
7811	34677.62	527
7812	34208.30	538
7901	30187.86	542
7902	28548.93	448
7903	35251.63	488
7904	36773.68	517
7905	42298.38	525
7906	57765.56	648
7907	47143.98	742
7908	51880.17	645
7909	37408.39	540
7910	35868.76	573
7911	36811.15	598
7912	34736.91	770
8001	30050.56	466
8002	30936.04	442
8003	38732.92	439
8004	37293.05	435
8005	53344.70	573
8006	70839.85	618
8007	54640.66	642
8008	49141.86	593
8009	39196.46	589
8010	31053.24	495
8011	37337.96	580
8012	32077.74	547
8101	28986.22	549
8102	25622.64	442
8103	34327.40	424
8104	38185.57	553
8105	38301.51	575
8106	60539.24	721
8107	52705.90	667
8108	52652.01	651
8109	38700.91	618
8110	33664.01	626
8111	42015.68	702
8112	35020.40	857
8201	30798.75	476
8202	27999.89	369
8203	38213.67	411
8204	40310.56	451
8205	47200.96	507
8206	57071.23	519
8207	61344.41	547
8208	51192.28	501
8209	45420.13	510
8210	44899.97	504
8211	42950.14	531
8212	40307.49	512
8301	38289.44	495
8302	33096.79	431
8303	36512.30	439
8304	38640.73	483
8305	52182.91	521
8306	52566.11	389

Figure D-4. POV Cargo Data

7610	25277.00	77
7611	16605.38	48
7612	5857.00	32
7701	8430.00	35
7702	21607.00	52
7703	15348.00	40
7704	6696.00	34
7705	14505.00	39
7706	19595.00	43
7707	19071.00	47
7708	11319.05	35
7709	24709.00	51
7710	18633.00	26
7711	7990.00	34
7712	21955.00	82
7801	11073.77	34
7802	12196.40	42
7803	11516.35	43
7804	16017.36	49
7805	16719.70	40
7806	16951.41	36
7807	15443.58	41
7808	14800.04	36
7809	10445.10	42
7810	9797.31	38
7811	16870.93	63
7812	9093.68	32
7901	15901.03	35
7902	19502.37	45
7903	27913.34	62
7904	18948.87	73
7905	39409.91	70
7906	20607.57	34
7907	30392.92	68
7908	19885.99	56
7909	30817.66	75
7910	9624.08	67
7911	9872.81	40
7912	17939.59	79
8001	8619.23	45
8002	515.37	37
8003	6482.14	44
8004	11686.72	54
8005	23455.11	63
8006	16020.10	66
8007	12359.52	47
8008	25878.58	36
8009	22490.53	39
8010	13486.95	49
8011	1627.89	35
8012	9108.96	52
8101	1235.15	35
8102	10908.02	34
8103	5540.86	43
8104	6186.03	54
8105	22260.45	49
8106	24613.14	52
8107	7073.32	47
8108	23843.03	62
8109	27333.09	63
8110	662.05	45
8111	17557.01	51
8112	5482.24	53
8201	6456.22	49
8202	7392.55	49
8203	21027.41	60
8204	17228.07	67
8205	17218.66	63
8206	42902.71	55
8207	20341.87	68
8208	10394.07	51
8209	12649.19	51
8210	4855.21	41
8211	13602.41	54
8212	5045.79	40
8301	6207.98	41
8302	19933.54	51
8303	1578.10	34
8304	23499.36	40
8305	17038.42	46
8306	5246.68	17

Figure D-5. Ammunition Cargo Data

7610	169685.38	929
7611	136598.20	906
7612	137157.17	804
7701	118389.04	798
7702	119138.13	789
7703	156793.38	826
7704	155416.55	861
7705	149079.38	828
7706	151319.13	844
7707	153615.98	915
7708	164439.95	919
7709	175531.69	987
7710	102835.28	731
7711	152121.67	895
7712	155614.20	1492
7801	131867.87	775
7802	127959.98	701
7803	170993.59	746
7804	184455.30	768
7805	195278.54	765
7806	185624.84	836
7807	192765.97	866
7808	183700.29	837
7809	172309.79	701
7810	159271.08	693
7811	152886.07	697
7812	141442.29	694
7901	136876.47	775
7902	132237.18	777
7903	191265.90	841
7904	171987.31	776
7905	163200.71	836
7906	190869.50	807
7907	194245.59	1017
7908	191258.98	945
7909	157422.38	933
7910	146030.71	875
7911	160887.98	1021
7912	162211.08	1272
8001	141571.69	744
8002	140556.16	659
8003	153689.79	732
8004	158969.70	731
8005	171530.99	788
8006	169789.05	772
8007	167376.09	832
8008	171133.33	824
8009	145800.95	728
8010	163019.89	822
8011	130670.76	745
8012	130638.09	810
8101	117417.46	730
8102	136109.29	753
8103	157627.35	879
8104	159745.58	809
8105	164352.00	919
8106	151871.78	845
8107	147996.56	769
8108	153975.55	766
8109	157746.08	910
8110	148297.50	858
8111	148662.02	892
8112	152260.93	1086
8201	141734.41	626
8202	145632.43	583
8203	177477.21	640
8204	207666.50	684
8205	184058.04	703
8206	185248.45	637
8207	190531.74	709
8208	171823.35	624
8209	168166.05	651
8210	163430.32	737
8211	166049.06	690
8212	146563.08	671
8301	165732.53	663
8302	166667.72	600
8303	168058.87	672
8304	170752.73	635
8305	172529.14	593
8306	146634.14	477

Figure D-6. General Cargo Data

AD-A139 872 TRANSPORTATION WORKLOAD FORECASTING (TWF) STUDY(U) ARMY CONCEPTS ANALYSIS AGENCY BETHESDA MD J N KEENAN ET AL. JAN 84 CAA-SR-84-2 2/4

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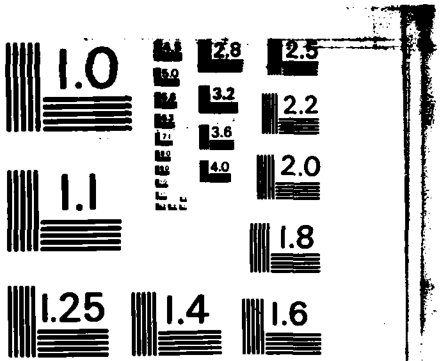


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

7610	6921.13	264
7611	5181.63	238
7612	6843.00	195
7701	9356.00	207
7702	7583.00	179
7703	8284.00	172
7704	7325.00	191
7705	10120.00	215
7706	8517.52	212
7707	11202.84	250
7708	9764.90	257
7709	12922.03	278
7710	51504.44	396
7711	49633.62	479
7712	52162.62	564
7801	13149.16	269
7802	5261.56	186
7803	5141.90	183
7804	4355.41	176
7805	5928.59	201
7806	24223.30	362
7807	38029.99	477
7808	30135.99	451
7809	14979.32	301
7810	8249.93	233
7811	5444.69	231
7812	7036.35	240
7901	5884.55	220
7902	5931.01	183
7903	5718.59	197
7904	7249.50	209
7905	6477.25	184
7906	11968.71	278
7907	13788.33	317
7908	18869.97	338
7909	11953.09	308
7910	7961.36	293
7911	5658.74	271
7912	7884.78	286
8001	5729.89	233
8002	5618.19	228
8003	8103.18	199
8004	5106.35	198
8005	8828.87	225
8006	12187.71	238
8007	13564.19	234
8008	15455.52	297
8009	5887.34	258
8010	7383.61	242
8011	5425.80	208
8012	5455.39	242
8101	12359.36	303
8102	4676.94	197
8103	6081.80	254
8104	5092.21	230
8105	5337.28	223
8106	8152.05	234
8107	10326.22	264
8108	9874.07	264
8109	7502.37	307
8110	6401.19	277
8111	7367.61	254
8112	8732.26	302
8201	6216.15	130
8202	6482.44	191
8203	5433.68	186
8204	4988.23	185
8205	6247.31	197
8206	9819.27	213
8207	10179.44	233
8208	8307.99	255
8209	7502.69	245
8210	6446.26	225
8211	6141.86	225
8212	6296.87	220
8301	7079.59	214
8302	5458.20	191
8303	8368.62	187
8304	6458.20	200
8305	6250.06	192
8306	3572.82	121

Figure D-7. HHG Cargo Data

7610	4566.00	9
7611	4797.00	10
7612	4085.00	10
7701	3835.00	13
7702	3035.00	6
7703	4619.00	12
7704	5403.00	13
7705	6925.00	18
7706	2740.00	18
7707	3436.00	16
7708	5423.00	22
7709	4585.00	22
7710	5332.00	29
7711	7500.00	42
7712	4809.00	40
7801	3008.38	17
7802	4484.00	20
7803	4955.17	23
7804	5312.19	21
7805	4517.80	23
7806	4776.16	22
7807	6890.31	35
7808	4529.79	27
7809	3040.79	17
7810	4992.09	32
7811	4708.84	20
7812	2458.71	20
7901	3536.08	17
7902	4139.14	25
7903	6303.43	30
7904	4566.99	15
7905	5076.56	17
7906	2809.66	20
7907	6961.60	40
7908	6608.23	36
7909	5319.78	27
7910	5151.74	25
7911	5069.07	30
7912	3194.80	38
8001	3464.81	15
8002	3706.79	15
8003	5634.30	11
8004	4547.11	15
8005	5267.77	16
8006	4601.18	15
8007	6358.49	20
8008	6241.42	18
8009	5169.60	16
8010	6699.15	12
8011	6624.96	13
8012	6570.70	11
8101	4320.55	15
8102	5564.29	14
8103	6165.83	19
8104	6695.59	23
8105	6718.39	18
8106	6840.74	13
8107	7962.13	25
8108	6188.26	15
8109	5583.56	28
8110	5967.83	26
8111	5619.88	25
8112	6305.61	24
8201	4289.05	11
8202	5414.74	11
8203	6717.58	14
8204	5628.13	13
8205	6042.79	12
8206	5378.95	10
8207	7499.49	12
8208	8432.05	13
8209	7172.74	12
8210	7097.94	17
8211	7240.69	10
8212	6174.71	18
8301	4912.16	[illegible]
8302	4756.71	11
8303	7660.25	13
8304	6166.17	11
8305	7150.32	14
8306	7339.53	10

Figure D-8. CONEX Cargo Data

7610	103157.00	167
7611	58871.00	122
7612	39460.00	116
7701	26477.00	114
7702	39854.00	131
7703	31793.00	102
7704	41171.00	113
7705	43139.75	135
7706	63514.19	142
7707	71288.75	157
7708	90143.13	151
7709	67335.38	160
7710	81170.00	108
7711	35116.90	136
7712	35683.00	212
7801	35545.37	138
7802	39076.19	114
7803	46139.50	128
7804	39683.84	139
7805	45772.92	133
7806	47049.17	152
7807	48994.29	144
7808	71461.20	146
7809	34868.92	117
7810	86150.90	139
7811	47392.79	110
7812	92161.79	128
7901	61218.57	109
7902	75766.21	116
7903	89700.76	135
7904	71410.28	157
7905	97975.18	141
7906	60328.28	147
7907	51095.70	184
7908	54659.18	156
7909	64187.00	164
7910	34199.90	119
7911	68929.19	180
7912	50715.55	156
8001	62835.93	117
8002	41753.65	94
8003	48868.54	117
8004	35981.60	112
8005	42740.18	103
8006	45385.89	123
8007	79021.29	144
8008	54166.92	106
8009	51748.36	121
8010	72327.59	142
8011	46773.28	110
8012	77300.46	134
8101	39046.16	112
8102	52046.25	105
8103	41809.62	125
8104	64555.04	140
8105	57810.41	115
8106	43339.49	90
8107	40229.12	120
8108	60673.97	119
8109	42064.65	128
8110	91382.88	153
8111	41020.93	110
8112	32728.10	131
8201	21858.81	60
8202	17823.79	52
8203	23526.04	76
8204	24994.10	78
8205	25399.55	71
8206	30089.88	80
8207	44222.43	95
8208	70003.35	73
8209	66826.87	79
8210	56958.69	91
8211	41928.63	84
8212	37710.32	86
8301	33987.13	97
8302	13157.70	60
8303	28412.73	95
8304	40297.05	77
8305	32096.73	76
8306	17622.00	44

Figure D-9. Special Cargo Data

APPENDIX E

BOX-JENKINS METHODOLOGY

E-1. GENERAL

a. Box-Jenkins models are a flexible class of stable linear statistical models that are used to model stochastic time series data. The models are first fitted to historical time series data using parametric estimates. The fitted model is then used to provide forecasts of future observations.

b. This appendix will discuss:

(1) Stochastic properties of time series models and the principle of stationarity.

(2) Basic model autocorrelation and partial autocorrelation functions.

(3) Seasonal models.

(4) The backshift operator.

(5) Model diagnostic checks.

E-2. STOCHASTIC PROPERTIES AND STATIONARITY

a. The assumption of a historical stochastic time series differentiates Box-Jenkins models from other time series models. Some time series models are simple extrapolation formulas which fail to account for the stochastic properties of time series. Box-Jenkins models assume that the historical data evolves stochastically and attempt to model the stochastic properties of the time series for forecasting purposes.[5]

b. A stochastic process assumes that each observation $x_1, x_2, \ldots x_t$ is randomly drawn from a probability distribution. Using Box-Jenkins techniques, an attempt is made to duplicate the stochastic process in hopes of understanding the probability distributions of future observed values and providing accurate predictions of the future. A perfect duplication of the stochastic process is practically impossible. This would require a joint distribution of all possible combinations of time series values $x_1, x_2 \ldots x_t$. If the time series is large, one can quickly see that the resulting probability distribution function would be immense. In view of this impossible task, the next best thing is to model the characteristics of the stochastic process. If the characteristics can be identified, then the randomness of the series can be approximated and used to predict future values.[6]

c. Stochastic properties of time series data affect model development through the principle of stationarity. Stationary data are data whose stochastic processes remain constant over time. If the stochastic process is constant over time, i.e., stationarity exists, then coefficients similar to those used in regression analysis can be estimated to model the data. One of the critical assumptions of regression analysis is the assumption of a constant linear relationship between two variables. If the relationship remains linear over time, then the process is stationary, and the model is adequate. If not, then the process is nonstationary and the model is not correct.

d. The principal of stationarity assumes that the stochastic properties of the data are invariant with respect to time. The data are invariant in that the stochastic processes of the data are constant throughout all intervals of time. The stochastic processes are assumed to be in equilibrium, and any variance from a constant mean is assumed to be the same at any point in time.

e. As mentioned earlier, a stochastic process assumes that each observation is randomly drawn. Future predictions of the stochastic process would be based on the conditional probability distribution for the series. Thus, prediction of x_{T+1} would be made given the probability distribution of the series $x_1 \ldots x_T$. In mathematical terms, this conditional probability would be expressed as:

$$p\ (x_T + 1 \mid x_1,\ x_2\ \ldots\ x_T)$$

If the time series is stationary, the joint distribution and conditional distribution will remain constant throughout time. Thus,

$$p(x_t,\ \ldots,\ x_{t+n}) = p(x_{t+m},\ \ldots,\ x_{t+n+m})$$

$$p(x_t) = p(x_{t+m})$$

Finally, if the series is stationary, the mean, variance, and covariance of the data will remain constant over time.[6]

f. The autocorrelation function is a statistical tool that is used in Box-Jenkins models to describe the stochastic process of a time series and provides an understanding of the probability distributions of the time series. The autocorrelation function ρ_k is defined as:

$$\rho_k = \frac{E\left[(x_t - \mu_x)(x_{t+k} - \mu_x)\right]}{\sqrt{E\left[(x_t - \mu_x)^2\right] E\left[(x_{t+k} - \mu_x)^2\right]}} = \frac{COV(x_t,\ x_{t+k})}{\sigma_{x_t}\ \sigma_{x_{t+k}}}$$

If a stochastic process consists of independently distributed random variables with a mean of zero, then the autocorrelation function for $\rho_0 = 1$ and $\rho_k = 0$ for all lags $k > 0$. This process indicates the existence of white noise, which means that the forecast of $x_{T+l} = 0$ for all $l > 0$. When white noise is achieved, random errors of the modeling process have been eliminated since the predicted value of the error term equals zero.

g. As in other statistical models, Box-Jenkins uses a sample of time series to make predictions about the population. Thus, the sample autocorrelation function $\hat{\rho}_k$ is defined as:

$$\hat{\rho}_k = \frac{\sum_{t=1}^{T-k} (x_t - \bar{x})(x_{t+k} - \bar{x})}{\sum_{t=1}^{T} (x_t - \bar{x})^2}$$

This statistic is used on Box-Jenkins models to compute the autocorrelation function for different values of lag k. If the data are generated by a stationary process, the autocorrelation function estimates $\hat{\rho}_k$ should fall to zero quickly as k increases. A failure of $\hat{\rho}_k$ to drop off quickly to zero indicates the existence of nonstationary data. To test whether successive coefficients of the autocorrelation function are equal to zero, i.e., generated by white noise, one would employ the Bartlett test. Bartlett determined that if the series was generated by white noise, the sample autocorrelation coefficients are approximately distributed with a normal distribution of mean of zero and standard deviation $1/\sqrt{T}$, where T equals the number of observations in the series. Thus, if the sample coefficients fall within the confidence interval, the sample coefficients are assumed to be zero.[6]

h. Finally, if the data are not generated by a stationary process, a technique known as differencing will help achieve stationary data. Differencing is defined as:

$$w_t = x_t - x_{t-1}$$

where the new series w_t is then analyzed for stationarity. If the data do not exhibit stationarity with first order differencing, the series w_t can be differenced again. Additionally, if the variance of the data does not remain constant over time, logarithm transformations of the data and possible differencing of the transformed data should be attempted to achieve stationarity.

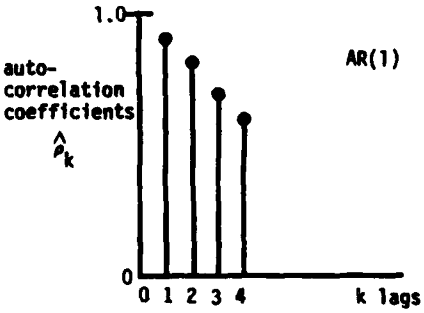
E-3. AUTOCORRELATION AND PARTIAL AUTOCORRELATION FUNCTIONS

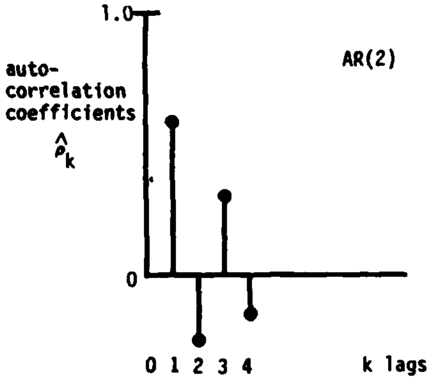
a. Autoregressive (AR) models attempt to describe the process x_t with a weighted sum of past values of the series x_{t-n} and a random disturbance term, ϵ_t.

$$x_t = \phi_1 x_{t-1} + \phi_2 x_{t-2} + \dots + \phi_n x_{t-n} + \delta + \epsilon_t$$

where ϕ_n are the AR parameters δ is the mean of the series.

The autocorrelation function for the AR models is used to help determine the number of lags in the model:





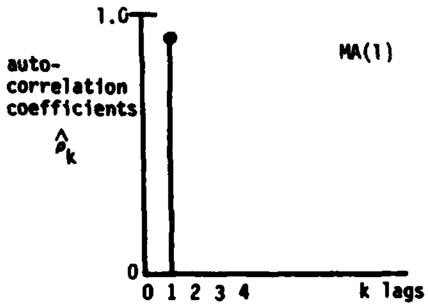
An AR(1) process depicts a function that declines geometrically from $\rho_0 = 1$. An AR(2) process can be portrayed as an oscillating or sinusoidal function that dampens geometrically. The partial autocorrelation functions for AR models closely resemble the pattern for MA model autocorrelation function and vice versa. Thus, to confirm the existence of an AR(1) model, one would expect to find a partial autocorrelation function with a significant coefficient at lag 1 and zeros for all coefficients with lags $k > 1$. Similarly, the AR(2) partial autocorrelation function would depict two significant coefficients and then zeros for all lags $k > 2$.[2]

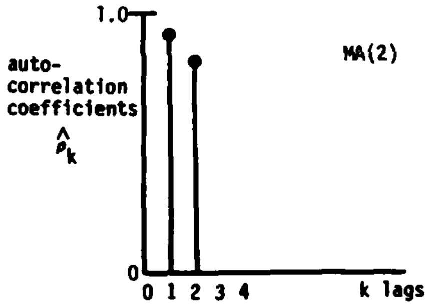
b. Moving average (MA) models attempt to describe the process x_t by a weighted sum of current and lagged disturbance terms, ϵ_{t-n}.

$$x_t = \mu + \epsilon_t - \theta_1 \epsilon_{t-1} - \theta_2 \epsilon_{t-2} - \dots - \theta_n \epsilon_{t-n}$$

where μ is the mean of the series and θ_n are the MA parameters.

The autocorrelation function for MA models will depict how many disturbance terms should be used in the model:





Autocorrelation functions for MA models will portray significant coefficients which correspond to the number of disturbance terms to include in the model. Successive coefficients should decline to zero rapidly. The partial autocorrelation functions for MA models will depict coefficients that dampen exponentially to zero or dampen in an oscillating manner to zero.

c. Autoregressive-moving average (ARMA) models are mixed models which attempt to describe the process x_t as a function of past values, lagged random disturbances, and a current disturbance term.

$$x_t = \phi_1 x_{t-1} + \phi_2 x_{t-2} + \cdots + \phi_n x_{t-n} + \delta + \epsilon_t - \theta_1 \epsilon_{t-1} - \theta_2 \epsilon_{t-2} - \cdots - \theta_n \epsilon_{t-n}$$

The autocorrelation and partial autocorrelation functions for ARMA models can be depicted in many combinations. For more information, reference Box-Jenkins' "Time Series Analysis"[2] for a complete description of possible function portrayals.

E-4. BACKSHIFT OPERATOR

a. The "backshift operator" is the use of a mathematical concept to simplify model building. The backshift operator B is defined as:

$$Bx_t = x_{t-1}$$

In more general terms, the backshift operator is defined as $B^n x_t$, where n relates to the number of past values used.[4] The following will explain the use of the backshift operator:

$$x_{t-1} = Bx_t$$
$$x_{t-2} = B^2x_t$$
$$x_{t-3} = B^3x_t$$
$$\vdots \qquad \vdots$$
$$x_{t-n} = B^nx_t$$

b. All ARMA models can be expressed using the backshift operator. For example, an AR(1) model is depicted as follows:

$$x_t = \phi_1 x_{t-1} + \epsilon_t$$

since $Bx_t = x_{t-1}$ the equation can be written as:

$$x_t = \phi_1 Bx_t + \epsilon_t$$
$$x_t - \phi_1 Bx_t = \epsilon_t$$
$$(1 - \phi_1 B)x_t = \epsilon_t$$

Similarly, an MA model is depicted as follows:

$$x_t = \epsilon_t - \theta_1 \epsilon_{t-1}$$

since $B\,\epsilon_t = \epsilon_{t-1}$, the equation can be written as:

$$x_t = \epsilon_t - \theta_1 B\epsilon_t$$
$$x_t = (1 - \theta_1 B)\epsilon_t$$

c. A more complex model such as an AR(2) is rewritten as follows:

$$x_t = \phi_1 x_{t-1} + \phi_2 x_{t-2} + \epsilon_t$$

since $Bx_t = x_{t-1}$ and $x_{t-2} = Bx_{t-1} = B^2x_t$, the equation can now be written as:

$$x_t = \phi_1 Bx_t + \phi_2 B^2 x_t + \epsilon_t$$
$$x_t - \phi_1 Bx_t - \phi_2 B^2 x_t = \epsilon_t$$
$$(1 - \phi_1 B - \phi_2 B^2)\, x_t = \epsilon_t$$

Similarly, an MA(2) model is depicted as:

$$x_t = (1 - \theta_1 B - \theta_2 B^2)\epsilon_t$$

The use of the backshift operator is especially useful in expressing seasonal models. This will be explained in the next section.

E-5. SEASONAL MODELS

a. Seasonal Box-Jenkins models are a particular class of models which incorporate multiplicative properties. Seasonal data are identified through autocorrelation analysis of the time series data. If seasonality exists, autocorrelation coefficients will peak at lags 12, 24, and 36 and should be correlated with each other. The existence of seasonality in the data violates the principle of stationarity and must be removed through differencing. In this case, the resulting series w_t is a seasonally adjusted series:

$$w_t = x_t - x_{t-12}$$

If the series w_t is stationary, it is modeled, and if it is nonstationary, the series w_t is differenced.

b. Once stationary data is achieved, two distinct models are combined. One model is a seasonal model which captures the seasonal correlation between observations a year apart. The second model is a nonseasonal model which explains the dependency of observations within a given year. The following equations illustrate this process.

(1) A seasonal AR model is described as follows:

$$x_t = \phi_{12} x_{t-12} + \alpha_t$$

$$x_t = \phi_{12} B x_{t-11} + \alpha_t$$

$$\vdots \qquad \vdots \qquad \vdots$$

$$x_t = \phi_{12} B^{12} x_t + \alpha_t$$

$$x_t - \phi_{12} B^{12} x_t = \alpha_t$$

$$(1 - \varphi_{12} B^{12}) x_t = \alpha_t \qquad \text{(E-1)}$$

(2) Likewise, a seasonal MA model is constructed as follows:

$$x_t = \alpha_t - \theta_{12}\alpha_{t-12}$$

$$x_t = \alpha_t - \theta_{12}B\alpha_{t-11}$$

$$\begin{matrix} \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot \end{matrix}$$

$$x_t = \alpha_t - \theta B^{12}\alpha_t$$

$$x_t = (1 - \theta_{12}B^{12})\alpha_t \qquad \text{(E-2)}$$

c. The two seasonal models above now explain the relationship between the observations separated by a year (i.e., October 1978, October 1979). However, a nonseasonal relationship exists between the months within a year (i.e., October 1978, November 1978). Thus, the error term α_t in the seasonal model would not be totally independent. A relationship exists between the seasonal model error terms that must also be explained in order to completely analyze the data. Nonseasonal MA or AR models are used to explain this relationship.

$$(1 - \phi_1 B)\alpha_t = \epsilon_t \qquad \text{(E-3) AR nonseasonal model}$$

$$\alpha_t = (1 - \theta_1 B)\epsilon_t \qquad \text{(E-4) MA nonseasonal model}$$

Combining seasonal (E-1) and nonseasonal (E-3) components provides the following:

$$(1 - \phi_1 B)(1 - \phi_{12}B^{12})x_t = \epsilon_t$$

where seasonal (E-2) and nonseasonal (E-4) components are AR.

$$x_t = (1 - \theta_1 B)(1 - \theta_{12}B^{12})\epsilon_t$$

where seasonal and nonseasonal components are MA. Models may also be mixed where the seasonal and nonseasonal components are opposite.

$$(1 - \phi_{12}B^{12})\, x_t = (1 - \theta_1 B)\epsilon_t \quad \text{seasonal AR, nonseasonal MA}$$

$$(1 - \phi_1 B)\, x_t = (1 - \theta_{12}B^{12})\epsilon_t \quad \text{seasonal MA, nonseasonal AR}$$

E-6. MODEL DIAGNOSTICS

a. The next-to-last step in model building is diagnostic checks on the fit of the model. There are two basic diagnostic checks that are performed once the Box-Jenkins model is estimated.

b. The first test involves a visual comparison of the autocorrelation function of the model to the autocorrelation function of the original series. This particular check is a very subjective test. If the autocorrelation functions are similar, then the model is assumed to be valid. If the autocorrelation functions are different, then the model adequacy is suspect.

c. The second test involves a quantitative analysis of the residuals of the model. Box-Jenkins model building assumes that the error terms are normally distributed with a mean of zero and a variance 1/T. If the residuals of the model are characterized by those properties, the residuals closely resemble the properties of white noise. Statistical results by G. E. P. Box and D. A. Pierce have developed the Box-Pierce statistic Q:

$$Q = T \sum_{k=1}^{K} \hat{\rho}_k^{\,2}$$

where T is the number of observations, k is the number of lags, and $\hat{\rho}_k$ is the estimated residual at each lag k. The statistic is approximately distributed as a chi-square distribution with k - p - q degrees of freedom (p is the AR order and q is the MA order). Although any lag greater than 5 is sufficient for this test, the normal rule of thumb is to include enough lags to have at least 20 degrees of freedom.[6]

d. The null hypothesis H_0 for the Box-Pierce statistic is that the residuals are not correlated with each other, have a mean of zero and a variance 1/T, i.e., the properties of the residuals resemble white noise. Once calculated, the Q statistic is compared to values of a chi-square distribution for a given number of degrees of freedom. If the Q statistic is less than the value in the chi-square table, the null hypothesis is not rejected for a given significance level. If the Q statistic is greater than the chi-square value, the null hypothesis is rejected for a given significance level. For example, if the Q statistic is 11.1 for 20 degrees of freedom, then the null hypothesis would not be rejected at the 95 percent confidence level, since 11.1 is less than 12.4.

APPENDIX F

BOX-JENKINS COMMODITY ANALYSIS

F-1. GENERAL. The purpose of this appendix is to detail the steps of analysis that were performed during the Box-Jenkins model development for each commodity. The analysis discussion will consist of: (1) a visual examination of the raw data patterns and moving average patterns, (2) the achievement of stationarity through differencing or transformations, (3) an identification of model type through analysis of the autocorrelation and partial autocorrelation functions, (4) the estimation of model parameters, and (5) the verification of model fit for each commodity. The analysis discussion of commodities appears in this appendix as follows:

F-2. POV

a. The raw data for POVs is depicted in Figure F-1. In its raw form, the series exhibits a seasonal trend with the peaks occurring in the summer months (June-July) and the troughs occurring in the winter months (January-February). This pattern is more pronounced in the 3-month and 6-month moving average schematics (Figures F-2 and F-3). However, the mean of the series is fairly constant over time as displayed in Figure F-4.

b. Autocorrelation function analysis of the raw series confirms the seasonality of the series as noted by the large autocorrelation coefficients at lags 6, 12, 18, 24, 30, and 36 (Figures F-5 and F-6). The strong seasonal trend violates the principle of data stationarity; therefore, the series was differenced at a lag of 12 months to eliminate the seasonal trend. Figure F-7 depicts the seasonally adjusted series.

c. The autocorrelation function of the seasonally differenced series is depicted in Figure F-8. Aside from the high autocorrelation coefficients at lags 12 and 24, the series exhibits random behavior and is considered to be stationary. The significant autocorrelation coefficients at lags 12 and 24 suggest an MA seasonal model. Examination of the partial autocorrelation function (Figure F-9) identifies a possible AR nonseasonal model. Again, without considering the autocorrelation coefficients at lags 12 and 24, the autocorrelation pattern is similar to an AR process. In sum, the specific model applicable to the POV seasonally adjusted series is a non-seasonal ARIMA (2,0,0) model and a seasonal ARIMA (0,1,1) model:

$$(1 - \phi_1 B - \phi_2 B^2)(1 - B^{12}) X_t = (1 - \theta_{12} B^{12})\epsilon_t$$

d. The results of this model (Figure F-10) are as follows:

$$\underset{(.19)}{(1 - .0221B} - \underset{(3,05)}{.3554 B^2)} (1 - B^{12}) X_t = (1 - \underset{(16.77)}{.8581 B^{12})}\epsilon_t$$

$$\chi^2 (3,20) = 16.35$$

The results indicate that all the estimated parameters of the model, except ϕ_1 are significant at the 5 percent significance level. Verification of the model's adequacy using the Box-Pierce test indicates that the autocorrelations of the estimated model residuals are not significantly different from zero at the 32 percent significance level (Figure F-11). Thus, the null hypothesis, residuals are uncorrelated, should not be rejected at the 32 percent significance level.

e. However, the significant autocorrelation coefficent at lag 24 of the estimated autocorrelation function suggests that the model is not correctly specified. Attempts to adjust the seasonal model to an ARIMA (0,1,2) resulted in a nonstationary model since $\theta_1 > 1.0$. Adding another seasonal model to the original model resulted in the following:

$$(1 - \phi_1 B - \phi_2 B^2)(1 - B^{12}) X_t = (1 - \theta_{12} B^{12})(1 - \theta_{24} B^{24})\epsilon_t$$

This model eliminated the significant coefficient at lag 24, however this model is more restrictive and the MSE of the FY 82 forecast was larger than the (2,0,0) x (0,1,1) seasonal model. These model adjustments should be tracked during future forecasts to determine if they are warranted.

f. Using this model to forecast FY 82 resulted in a forecast of 501.37 K/MTON versus an actual shipment of 510.252 K/MTON. The MSE of the POV forecast for FY 82 was 8.54 (Figure F-12), and the annual forecast error is -1.7 percent.

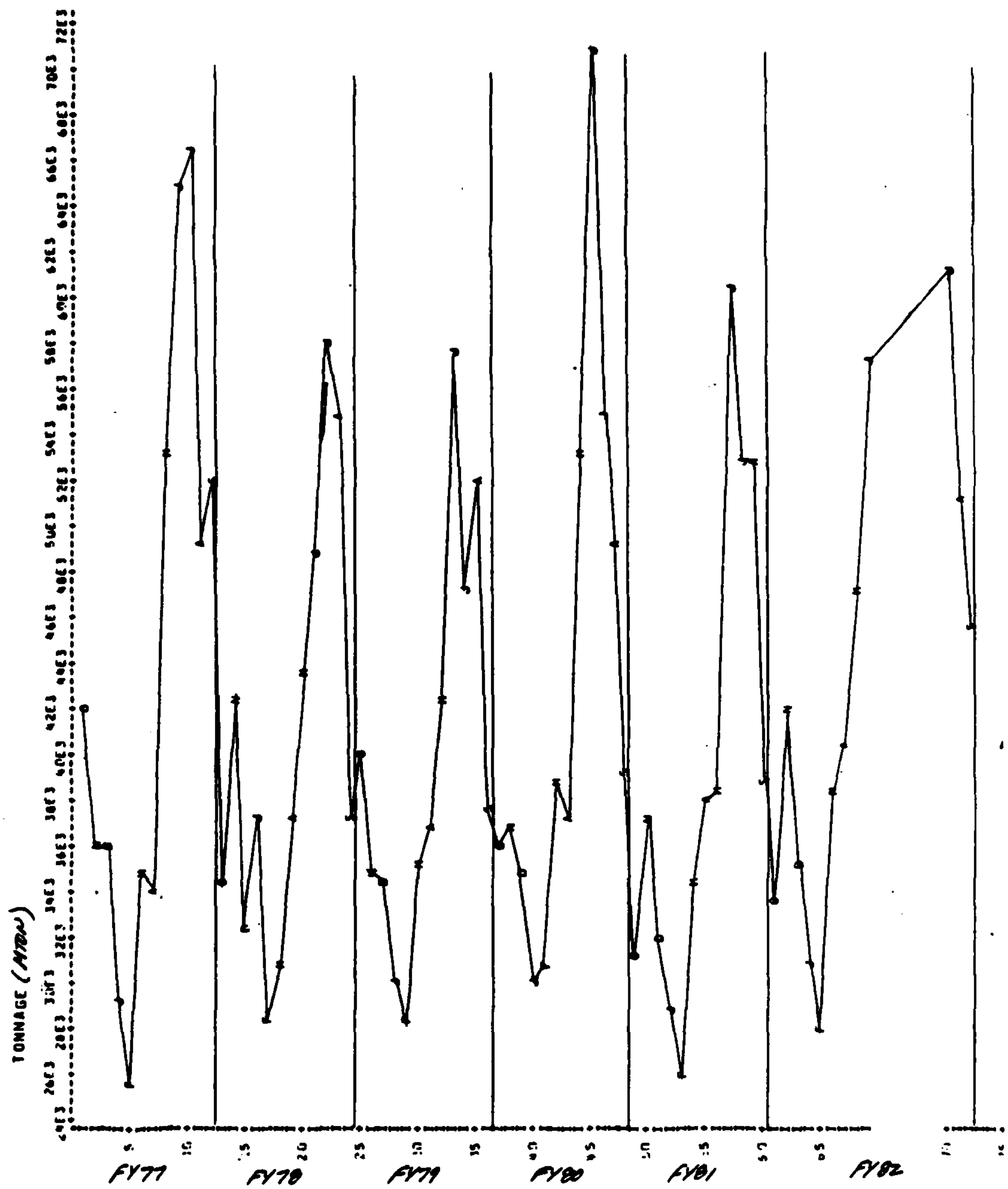
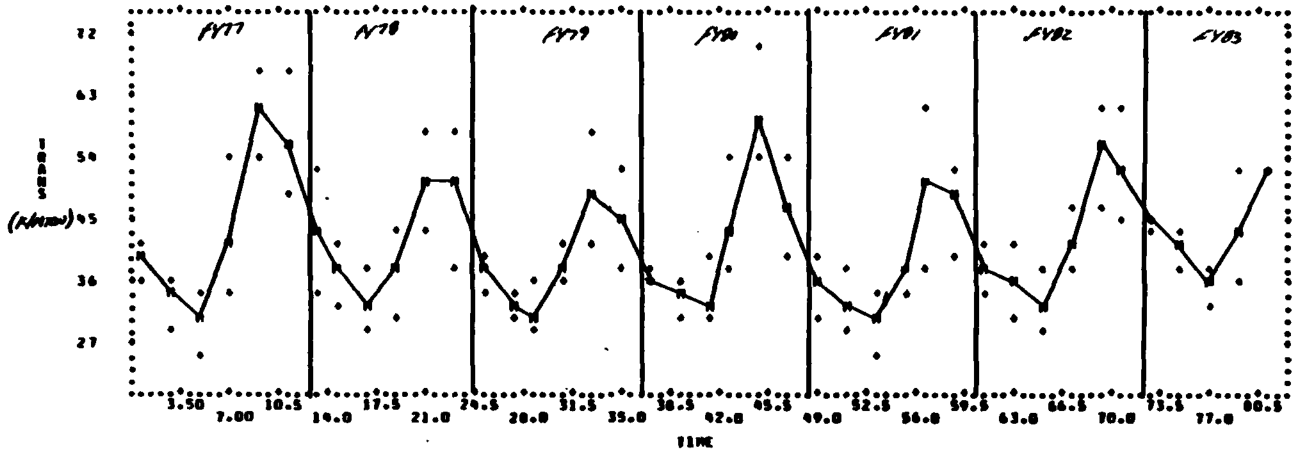
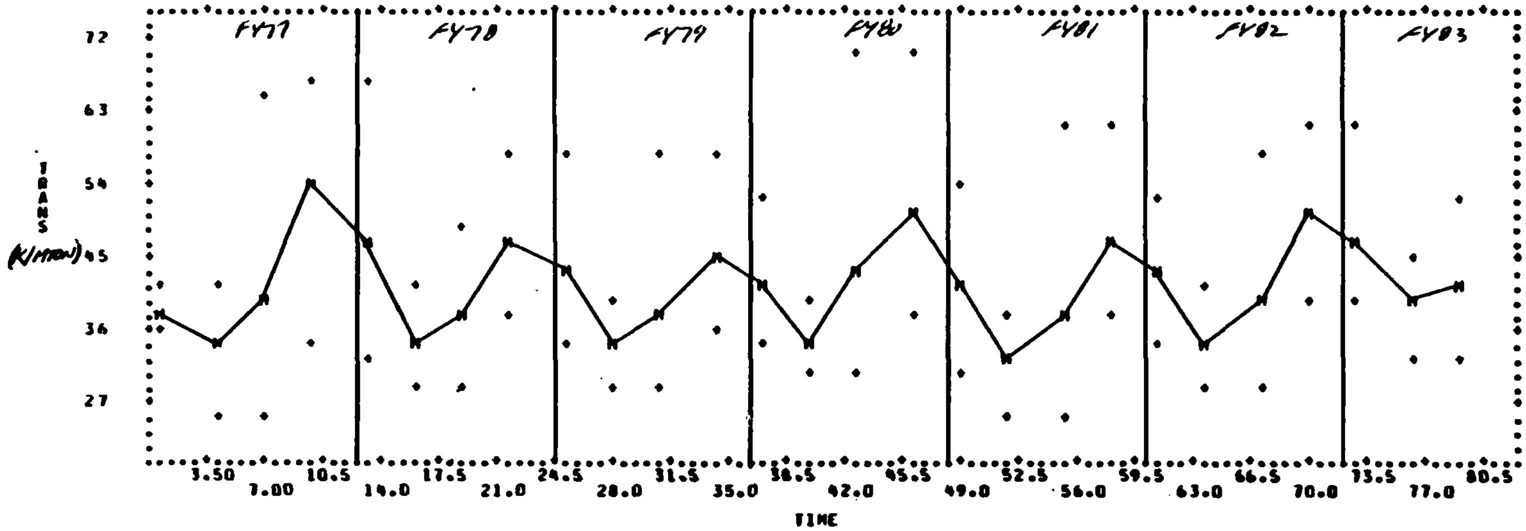


Figure F-1. POV Cargo, FY 77 - FY 82



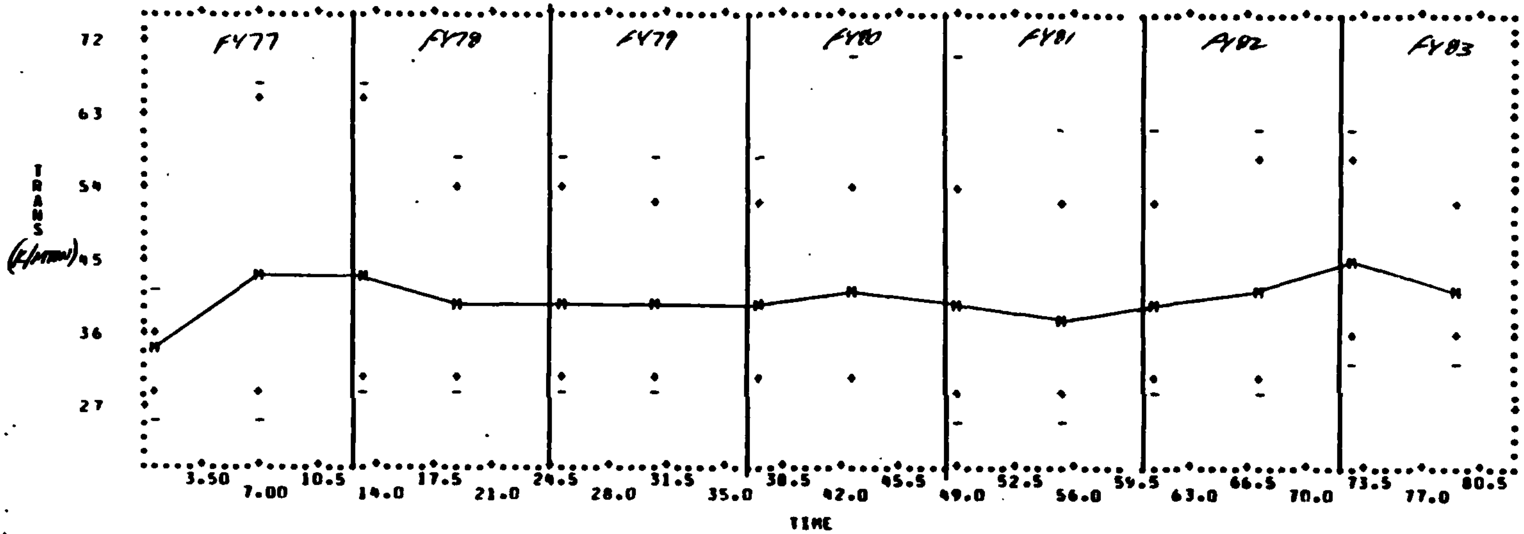
TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	2	35.9660	38.8935	41.8210
3.000	3	29.0690	35.6185	36.0054
5.000	3	25.6073	29.8277	34.0119
7.000	3	34.0597	40.6807	53.1706
9.000	3	53.1706	61.4115	66.2935
11.000	3	49.2689	55.0980	66.2935
13.000	3	34.3525	42.9053	52.1340
15.000	3	32.3998	37.3303	43.2295
17.000	3	28.3354	32.1852	37.3906
19.000	3	30.0297	37.1170	43.4381
21.000	3	43.4381	49.9977	57.8416
23.000	3	37.0343	49.9251	57.8416
25.000	3	34.6776	37.2409	40.0107
27.000	3	30.1079	33.0246	34.6776
29.000	3	28.5989	31.3295	35.2516
31.000	3	35.2516	38.1080	42.2984
33.000	3	42.2984	49.0693	57.7656
35.000	3	37.4084	45.4775	51.8882
37.000	3	35.8888	36.7028	37.4084
39.000	3	30.0506	33.8662	36.8111
41.000	3	30.0506	33.2398	38.7379
43.000	3	37.2930	43.1236	53.3447
45.000	3	53.3447	59.6089	70.0398
47.000	3	39.1965	47.6597	54.6407
49.000	3	31.0532	35.0626	39.1965
51.000	3	28.9862	32.8006	37.3380
53.000	3	25.0226	29.7121	34.3274
55.000	3	34.3274	36.9382	38.3015
57.000	3	38.3015	50.5155	60.5392
59.000	3	38.7009	48.0196	52.7059
61.000	3	33.4490	38.1269	42.0157
63.000	3	30.7987	35.9449	42.0157
65.000	3	27.9999	32.3374	38.2137
67.000	3	38.2137	41.9084	47.2009
69.000	3	47.2009	55.2055	61.3444
71.000	3	45.4201	52.6523	61.3444
73.000	3	42.9501	44.4234	45.4201
75.000	3	38.2094	40.5157	42.9501
77.000	3	33.0960	35.9662	38.2094
79.000	3	36.5123	42.4453	52.1829
81.000	2	52.1829	52.3745	52.5661

Figure F-2. Three-month Moving Average - POV



TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	3	35.9660	37.9300	41.8210
4.000	6	25.6073	33.8793	41.8210
7.000	6	25.6073	40.2473	64.7706
10.000	6	34.0597	53.2829	66.2935
13.000	6	32.3948	46.1122	66.2935
16.000	6	28.3354	34.2554	42.2295
19.000	6	28.3354	37.6321	48.7133
22.000	6	37.0343	46.5020	57.8416
25.000	6	34.2083	43.1120	57.8416
28.000	6	28.5489	33.8142	40.0107
31.000	6	28.5489	38.4710	57.7656
34.000	6	36.7739	45.5451	57.7656
37.000	6	34.7369	40.6449	51.8802
40.000	6	30.0506	34.5261	38.7329
43.000	6	30.0506	43.5329	70.8398
46.000	6	37.2930	50.7428	70.8398
49.000	6	31.0532	40.5747	54.6407
52.000	6	25.8226	31.6009	37.3380
55.000	6	25.8226	37.6938	60.5392
58.000	6	38.1856	46.8475	60.5392
61.000	6	33.6640	42.4598	52.7059
64.000	6	27.9999	34.6187	42.0157
67.000	6	27.9999	40.2658	57.0712
70.000	6	40.3106	50.4232	61.3444
73.000	6	40.3075	47.6857	61.3444
76.000	6	33.0968	39.3427	44.9000
79.000	6	33.0968	41.8814	52.5661

Figure F-3. Six-month Moving Average - POV



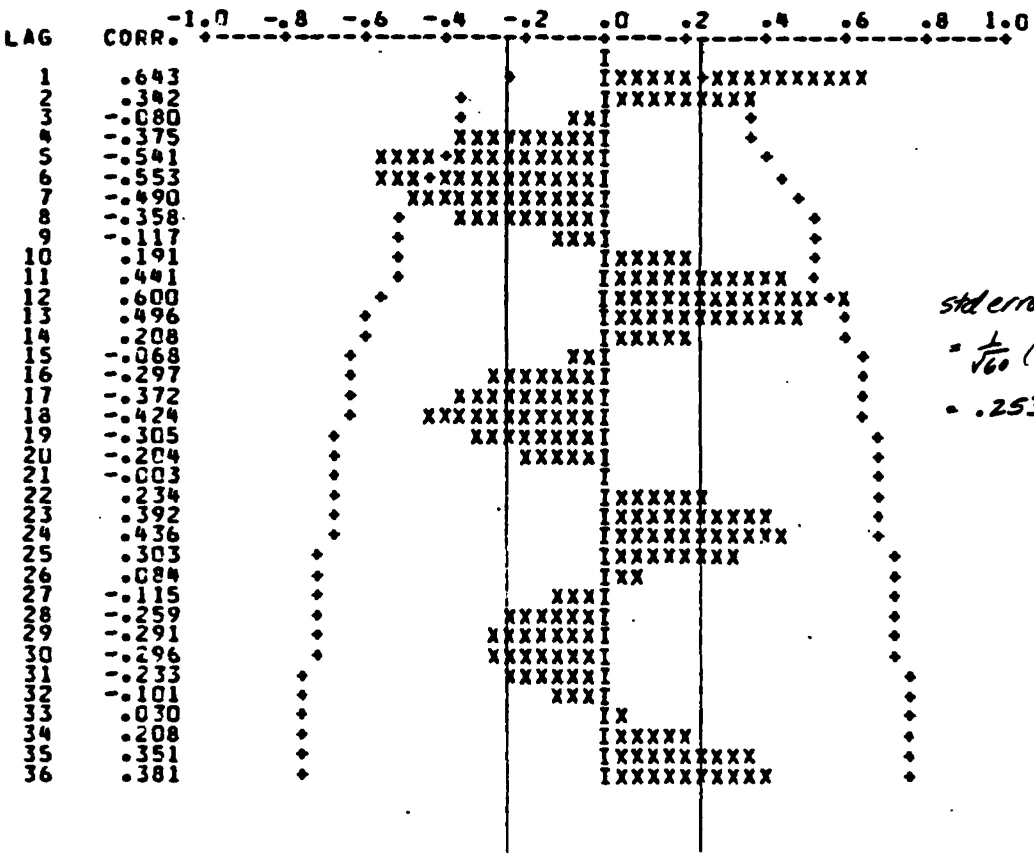
TIME VALUE	NO. OF CASES	MINIMUM VALUE	TRIMMED MINIMUM	TRIMMED MEAN	TRIMMED MAXIMUM	MAXIMUM VALUE
1.000	6	25.6073	29.0640	33.9618	36.0054	41.8210
7.000	12	25.6073	29.0640	43.1072	64.7706	66.2935
13.000	12	28.3354	30.8297	43.0601	64.7706	66.2935
19.000	12	28.3354	30.8297	39.8368	54.8994	57.8416
25.000	12	28.5489	30.1879	39.5507	54.8994	57.8416
31.000	12	28.5489	30.1879	38.9841	51.8802	57.7656
37.000	12	30.0506	30.9360	39.2611	51.8802	57.7656
43.000	12	30.0506	30.9360	41.0722	54.6407	70.8398
49.000	12	25.8226	28.9862	39.7399	54.6407	70.8398
55.000	12	25.8226	28.9862	38.4328	52.7059	60.5392
61.000	12	27.9999	30.7987	40.0258	52.7059	60.5392
67.000	12	27.9999	30.7987	42.0908	57.0712	61.3444
73.000	12	33.0968	36.5123	44.4154	57.0712	61.3444
79.000	9	33.0968	36.5123	41.9690	52.1829	52.5661

Figure F-4. Twelve-month Moving Average - POV

AUTOCORRELATIONS

1- 12	.64	.34	-.08	-.37	-.54	-.55	-.49	-.36	-.12	.19	.44	.60
ST.E.	.13	.17	.19	.19	.20	.22	.24	.26	.27	.27	.27	.28
13- 24	.50	.21	-.07	-.30	-.37	-.42	-.31	-.20	0.0	.23	.39	.44
ST.E.	.30	.32	.32	.32	.32	.33	.34	.34	.35	.35	.35	.36
25- 36	.30	.08	-.12	-.26	-.29	-.30	-.23	-.10	.03	.21	.35	.38
ST.E.	.36	.37	.37	.37	.37	.38	.38	.38	.38	.38	.38	.39

PLOT OF AUTOCORRELATIONS



std error
$= \frac{1}{\sqrt{60}} (1.96)$
$= .253$

Figure F-5. ACF - Raw Data - POV

PARTIAL AUTOCORRELATIONS

1- 12	.64	-.12	-.43	-.23	-.15	-.15	-.25	-.28	-.07	.13	.06	.09
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
13- 24	-.14	-.29	-.04	-.01	.03	-.23	-.01	-.01	.02	.05	-.10	-.11
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
25- 36	-.13	-.02	.07	-.05	-.09	-.09	-.05	.04	-.08	-.13	.07	.08
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13

PLOT OF PARTIAL AUTOCORRELATIONS

```
             -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG     CORR.  +----+----+----+----+----+----+----+----+----+----+
                                        I
  1      .643                  +     IXXXXX+XXXXXXXXXX
  2     -.122                  +  XXXI     +
  3     -.430             XXXXX+XXXXXI     +
  4     -.231                  XXXXXXI     +
  5     -.147                  + XXXXI     +
  6     -.150                  + XXXXI     +
  7     -.254                  XXXXXXI     +
  8     -.275                 X+XXXXXI     +
  9     -.065                  +   XXI     +
 10      .130                  +     IXXX  +
 11      .063                  +     IXX   +
 12      .091                  +     IXX   +
 13     -.137                  +  XXXI     +
 14     -.286                 X+XXXXXI     +
 15     -.038                  +    XI     +
 16     -.007                  +     I     +
 17      .027                  +     IX    +
 18     -.235                  XXXXXXI     +
 19     -.013                  +     I     +
 20     -.012                  +     I     +
 21      .017                  +     I     +
 22      .054                  +     IX    +
 23     -.096                  +   XXI     +
 24     -.106                  +  XXXI     +
 25     -.129                  +  XXXI     +
 26     -.025                  +    XI     +
 27      .072                  +     IXX   +
 28     -.048                  +    XI     +
 29     -.092                  +   XXI     +
 30     -.090                  +   XXI     +
 31     -.049                  +    XI     +
 32      .042                  +     IX    +
 33     -.080                  +   XXI     +
 34     -.134                  +  XXXI     +
 35      .068                  +     IXX   +
 36      .082                  +     IXX   +
```

Figure F-6. PACF - Raw Data - POV

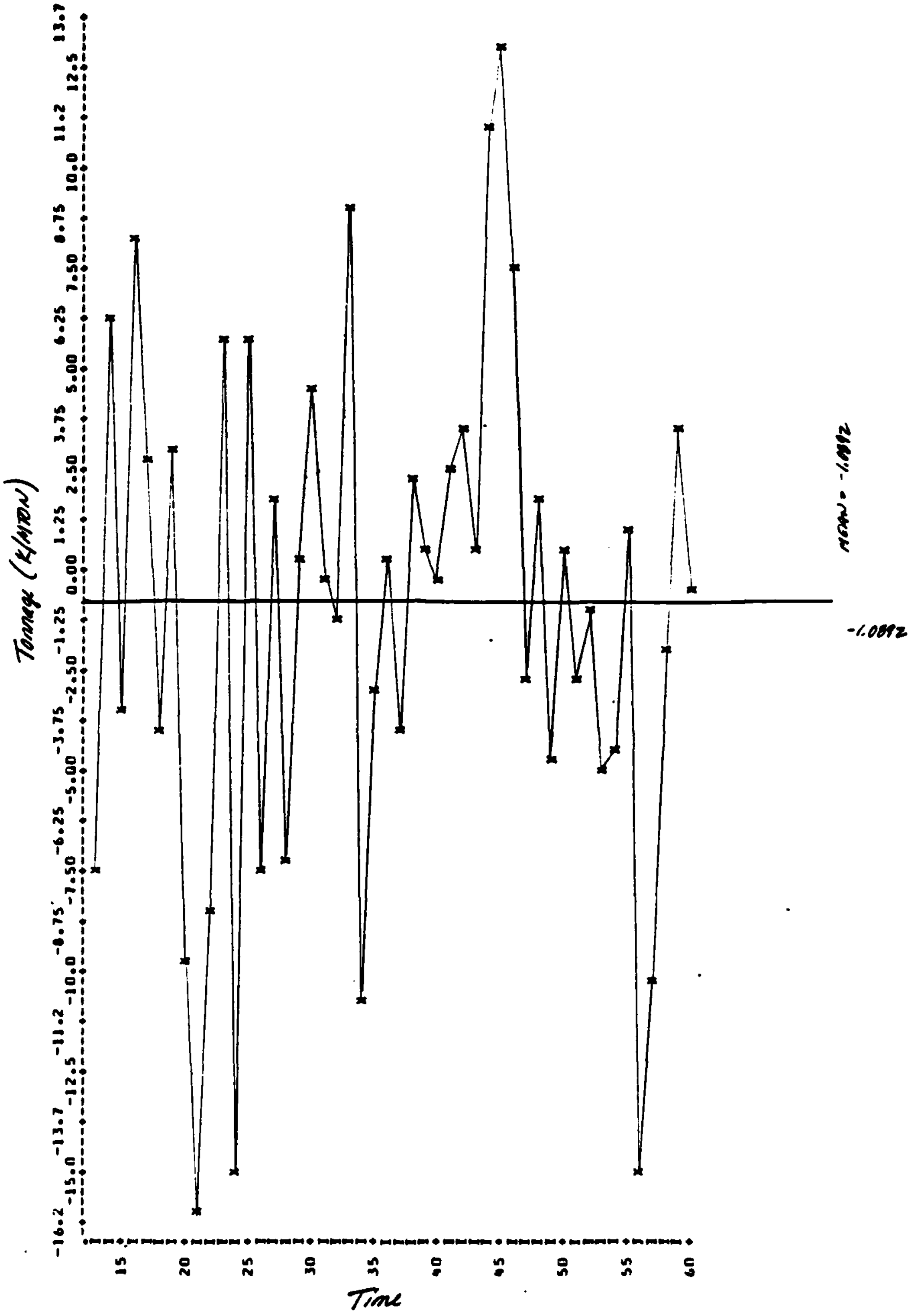


Figure F-7. Differenced Series (12-month lag) - POV

AUTOCORRELATIONS

1- 12	.07	.22	.10	.02	-.11	.04	-.05	-.02	-.10	-.17	-.10	-.27
ST.E.	.14	.15	.15	.15	.15	.15	.16	.16	.16	.16	.16	.16
13- 24	.11	.04	.05	0.0	-.02	-.18	.07	-.18	-.06	0.0	-.12	-.26
ST.E.	.17	.17	.17	.17	.17	.17	.18	.18	.18	.18	.18	.18
25- 36	-.05	-.05	.02	.11	.11	.11	-.03	.11	-.01	.06	.06	.16
ST.E.	.19	.19	.19	.19	.19	.19	.19	.20	.20	.20	.20	.20

PLOT OF AUTOCORRELATIONS

```
               -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG    CORR.    +----+----+----+----+----+----+----+----+----+----+
                                          I
  1     .068                       +      IXX    +
  2     .223                       +      IXXXXXX+
  3     .096                       +      IXX    +
  4     .023                      +       IX      +
  5    -.108                      +    XXXI       +
  6     .045                      +       IX      +
  7    -.051                      +      XI       +
  8    -.020                      +      XI       +
  9    -.097                      +     XXI       +
 10    -.167                      +   XXXXI       +
 11    -.100                      +     XXI       +
 12    -.268                      +XXXXXXXI       +
 13     .106                      +       IXXX    +
 14     .040                      +       IX      +
 15     .045                      +       IX      +
 16     .002                      +       I       +
 17    -.016                      +       I       +
 18    -.184                      +  XXXXXI       +
 19     .068                     +        IXX      +
 20    -.179                     +     XXXXI       +
 21    -.063                     +       XXI       +
 22     .002                     +         I       +
 23    -.120                     +      XXXI       +
 24    -.261                     + XXXXXXXXI       +
 25    -.046                     +        XI       +
 26    -.050                     +        XI       +
 27     .018                     +         I       +
 28     .110                     +         IXXX    +
 29     .106                     +         IXXX    +
 30     .105                     +         IXXX    +
 31    -.026                    +         XI        +
 32     .111                    +          IXXX     +
 33    -.013                    +          I        +
 34     .055                    +          IX       +
 35     .062                    +          IXX      +
 36     .162                    +          IXXXX    +
```

Std error
$= \frac{1}{\sqrt{48}}(1.96)$
$= .283$

Figure F-8. ACF - Lagged 12 Months

PARTIAL AUTOCORRELATIONS

1- 12	.07	.22	.07	-.04	-.15	.05	.01	-.02	-.10	-.18	-.03	-.20
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14
13- 24	.21	.14	-.01	-.10	-.14	-.14	.13	-.13	-.15	-.04	-.10	-.28
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14
25- 36	.07	.14	.02	-.03	-.08	-.05	-.01	.02	-.09	-.01	-.07	0.0
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14

PLOT OF PARTIAL AUTOCORRELATIONS

```
          -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR.  +----+----+----+----+----+----+----+----+----+----+
                                      I
  1     .068                  +      IXX    +
  2     .220                  +      IXXXXX +
  3     .073                  +      IXX    +
  4    -.035                  +     XI      +
  5    -.153                  +  XXXXI      +
  6     .054                  +      IX     +
  7     .006                  +      I      +
  8    -.015                  +      I      +
  9    -.104                  +   XXXI      +
 10    -.179                  +  XXXXI      +
 11    -.033                  +     XI      +
 12    -.199                  + XXXXXI      +
 13     .210                  +      IXXXXX +
 14     .140                  +      IXXXX  +
 15    -.014                  +      I      +
 16    -.103                  +   XXXI      +
 17    -.141                  +  XXXXI      +
 18    -.141                  +  XXXXI      +
 19     .128                  +      IXXX   +
 20    -.133                  +   XXXI      +
 21    -.154                  +  XXXXI      +
 22    -.038                  +     XI      +
 23    -.104                  +   XXXI      +
 24    -.275                  XXXXXXXI      +
 25     .069                  +      IXX    +
 26     .143                  +      IXXXX  +
 27     .024                  +      IX     +
 28    -.032                  +     XI      +
 29    -.081                  +    XXI      +
 30    -.051                  +     XI      +
 31    -.013                  +      I      +
 32     .021                  +      IX     +
 33    -.086                  +    XXI      +
 34    -.012                  +      I      +
 35    -.066                  +    XXI      +
 36     .001                  +      I      +
```

Figure F-9. PACF - Lagged 12 Months

```
ESTIMATION BY BACKCASTING METHOD
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN  .1000-004


SUMMARY OF THE MODEL

OUTPUT VARIABLE -- TRANS
INPUT VARIABLES -- NOISE

VARIABLE  VAR. TYPE  MEAN      TIME     DIFFERENCES
                                                12
TRANS       RANDOM             1-  60  (1-B   )

PARAMETER VARIABLE   TYPE  FACTOR  ORDER ESTIMATE         ST. ERR.  T-RATIO
      1   TRANS       MA      1     12     .8581            .0512     16.77
      2   TRANS       AR      1      1     .2208-001        .1159       .19
      3   TRANS       AR      1      2     .3554            .1165      3.05

RESIDUAL SUM OF SQUARES   =       806.252357 (BACKCASTS EXCLUDED)
DEGREES OF FREEDOM        =               43
RESIDUAL MEAN SQUARE      =        18.750055
```

Figure F-10. Model Parameters - POV

```
AUTOCORRELATIONS

  1- 12     -.02 -.03  .12 -.02 -.20  .05  .07 -.06 -.07 -.04 -.20 -.18
  ST.E.      .13  .13  .13  .13  .13  .14  .14  .14  .14  .14  .14  .14

 13- 24      .16  .04  .13  .05 -.03 -.12  .10 -.10 -.06  .17 -.10 -.27
  ST.E.      .15  .15  .15  .15  .15  .15  .15  .15  .16  .16  .16  .16

 25- 36      .02 -.07 -.03  .12  .13  .01 -.02  .14 -.02  .01  .13  .11
  ST.E.      .17  .17  .17  .17  .17  .17  .17  .17  .17  .17  .17  .17

PLOT OF AUTOCORRELATIONS

            -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8   1.0
LAG     CORR. +----+----+----+----+----+----+----+----+----+----+
                                       I
  1    -.015                   +     I     +
  2    -.026                   +    XI     +
  3     .121                   +     IXXX  +
  4    -.017                   +     I     +
  5    -.202                   +XXXXXI     +
  6     .055                  +      IX     +
  7     .067                  +      IXX    +
  8    -.062                  +    XXI      +
  9    -.066                  +    XXI      +
 10    -.038                  +     XI      +
 11    -.199                  + XXXXXI      +
 12    -.179                  +  XXXXI      +
 13     .164                  +      IXXXX  +
 14     .037                  +      IX     +
 15     .128                  +      IXXX   +
 16     .053                  +      IX     +
 17    -.035                  +     XI      +
 18    -.120                  +   XXXI      +
 19     .103                 +       IXXX    +
 20    -.101                 +    XXXI       +
 21    -.061                 +     XXI       +
 22     .170                 +       IXXXX   +
 23    -.103 .272(60)=1635   +    XXXI       +
 24    -.266                 +XXXXXXXI       +
 25     .024                 +       IX      +
 26    -.067                 +     XXI       +
 27    -.027                 +      XI       +
 28     .121                 +       IXXX    +
 29     .130                 +       IXXX    +
 30     .005                 +       I       +
 31    -.025                 +      XI       +
 32     .137                 +       IXXX    +
 33    -.023                 +      XI       +
 34     .007                 +       I       +
 35     .126                 +       IXXX    +
 36     .113                +        IXXX     +
```

Figure F-11. Estimated Residuals - POV

FORECAST ON VARIABLE TRANS FROM TIME PERIOD 61

PERIOD	FORECASTS	ST. ERR.	ACTUAL	ERROR
61	35.36769	6.27085	33.664	-1.703
62	37.17831	6.27237	42.016	4.838
63	33.60430	6.65760	35.02	1.416
64	30.16449	6.65832	30.779	.615
65	26.42352	6.70566	28.0	1.577
66	34.95272	6.70587	38.214	3.262
67	35.44728	6.71187	40.311	4.864
68	49.08484	6.71192	47.201	-1.883
69	62.68552	6.71269	57.041	-5.644
70	60.19025	6.71269	61.344	1.154
71	50.49294	6.71279	51.192	.7
72	45.75998	6.71279	45.420	-.339
	501.37		510.26	MSE = 8.54

STANDARD ERROR = 6.27085 (BY CONDITIONAL METHOD)

Figure F-12. Forecast FY 82 - POV

F-3. GENERAL CARGO

a. The raw data for general cargo is depicted in Figure F-13. The raw data appears to follow a seasonal pattern which falls in the early part of the fiscal year and rises at the end of the fiscal year. This seasonal pattern is more clearly manifested in the 3-month and 6-month moving average diagrams (Figures F-14 and F-15). However, it should be noted that the seasonal pattern is not repeated regularly and that a general trend exists in the data. This fact is verified by the 12-month moving average diagram (Figure F-16) which depicts a possible 5-year cycle in the data. Currently, there is not enough data to confirm the existence of this cycle throughout time; thus, this hypothesis requires continued analysis.

b. Autocorrelation function analysis of the data confirms the existence of seasonality in the data (Figures F-17 and F-18) as noted by the large autocorrelation coefficients at lags 6, 12, 18, 24, 30, and 36. To eliminate seasonality in the data, the raw series was differenced at a lag of 12 months. The plot of the new series is shown in Figure F-19. It is readily obvious that this series is not stationary, as noted by the downward trend of observations over time. Nonstationarity in the data is more clearly evidenced by the autocorrelation function (Figure F-20) which fails to fall quickly to zero. In an effort to achieve stationarity, the seasonally adjusted series was differenced at a lag of 1 month. The resulting autocorrelation function (Figure F-21) indicates that a weak stationary series has been generated.

c. Analysis of the autocorrelation function identifies a possible mixed ARMA nonseasonal model and a possible MA seasonal model. The nonseasonal mixed ARMA model is suggested based upon the gradual decline (except lag 3) of the autocorrelation and partial autocorrelation coefficients (Figures F-21 and F-22). The autocorrelation function suggests a MA seasonal process as manifested by the gradual decay of autocorrelations at lags 12 and 24. Thus, the data suggest a multiplicative seasonal with a mixed ARIMA nonseasonal (1,1,1) model and a seasonal ARIMA (0,1,1) model:

$$(1 - \phi_1 B)\ (1 - B^{12})\ (1 - B)\ X_t = (1 - \theta_1 B)\ (1 - \theta_{12} B^{12})\epsilon_t$$

d. The results of the model (Figure F-23) are as follows:

$$\underset{(2.5)}{(1 - .3579\ B)}\ (1 - B^{12})\ (1 - B)\ X_t = \underset{(8.31)}{(1 - .7962\ B)}\ \underset{(13.43)}{(1 - .7753\ B^{12})}\epsilon_t$$

$$\chi^2\ (3,20) = 12.8$$

The results indicate that all of the estimated parameters are signficant of the 5 percent significance level. The Q statistic for 20 degrees of freedom is 12.8 (Figure F-24). Thus, the null hypothesis, estimated model residuals are uncorrelated, should not be rejected at the 13 percent significance level.

e. The general cargo seasonal model forecasted that 1856.61 K/MTON would be transported during FY 82 versus an actual shipment of 2021.55 K/MTON The MSE of the general cargo forecast for FY 82 was 318.54 (Figure F-25), and the annual forecast error was -8.2 percent. As stated in paragraph 6-7, another model for general cargo forecasted FY 82 shipments with a -4.6 percent error. Both models should be tracked into the future for forecasting accuracy and model fit.

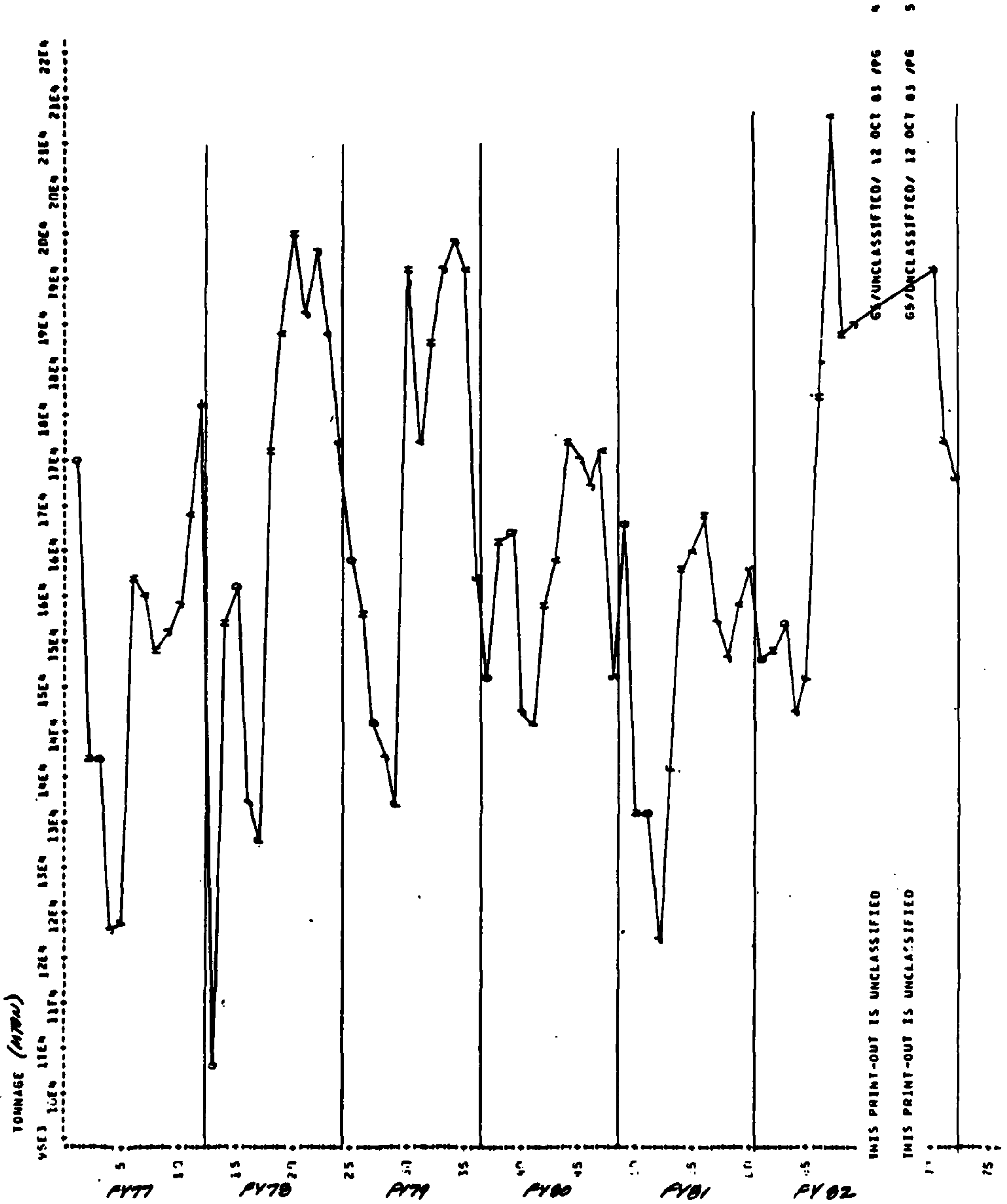
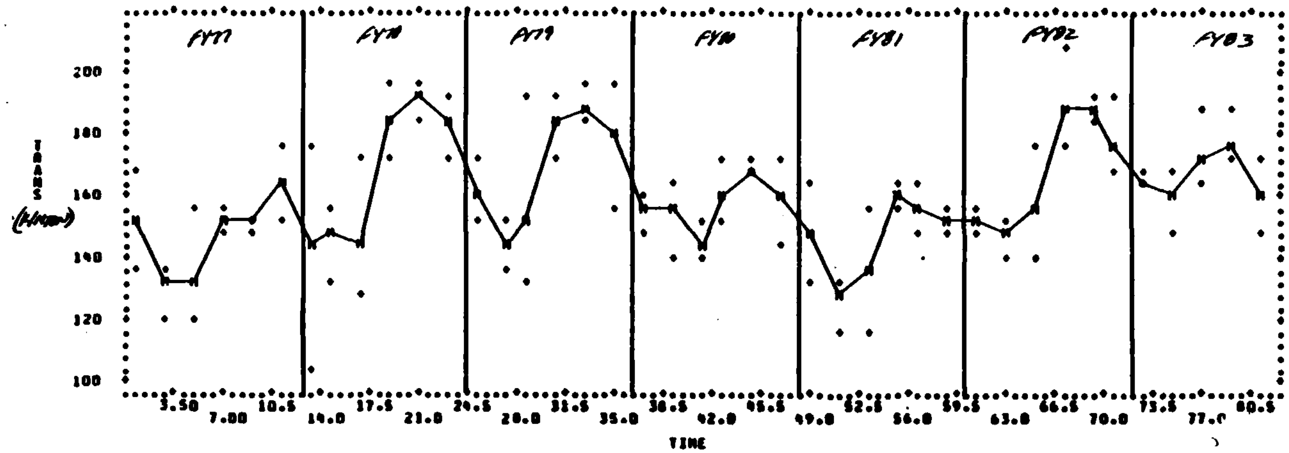
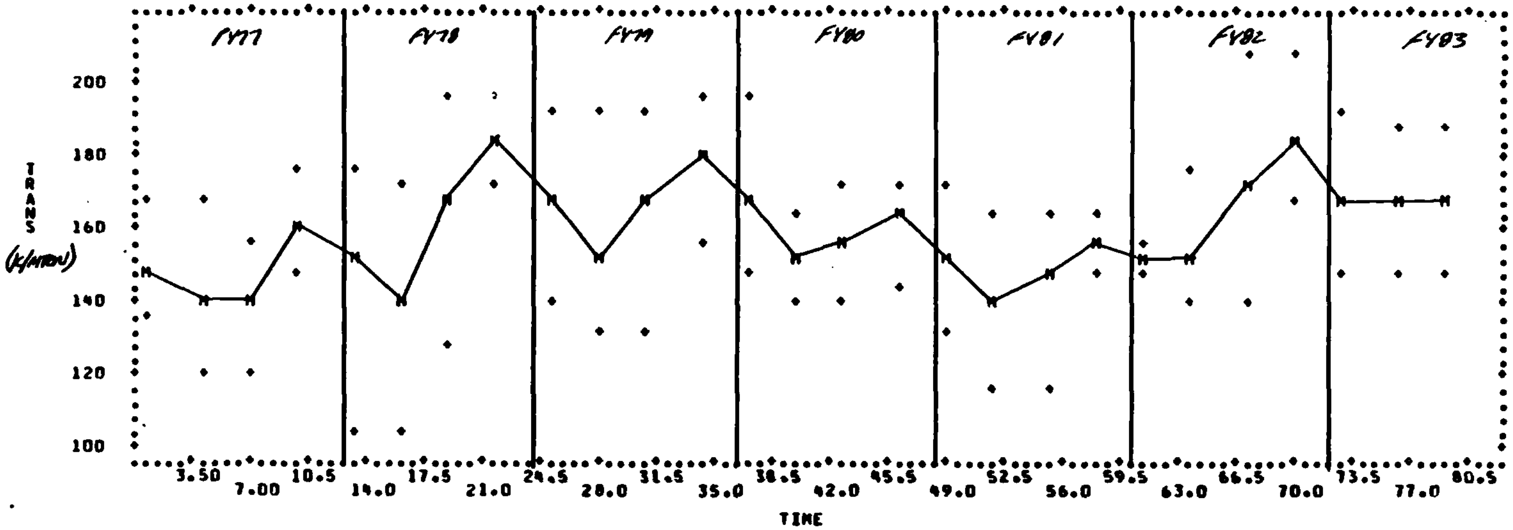


Figure F-13. General Cargo, FY 77 - FY 82



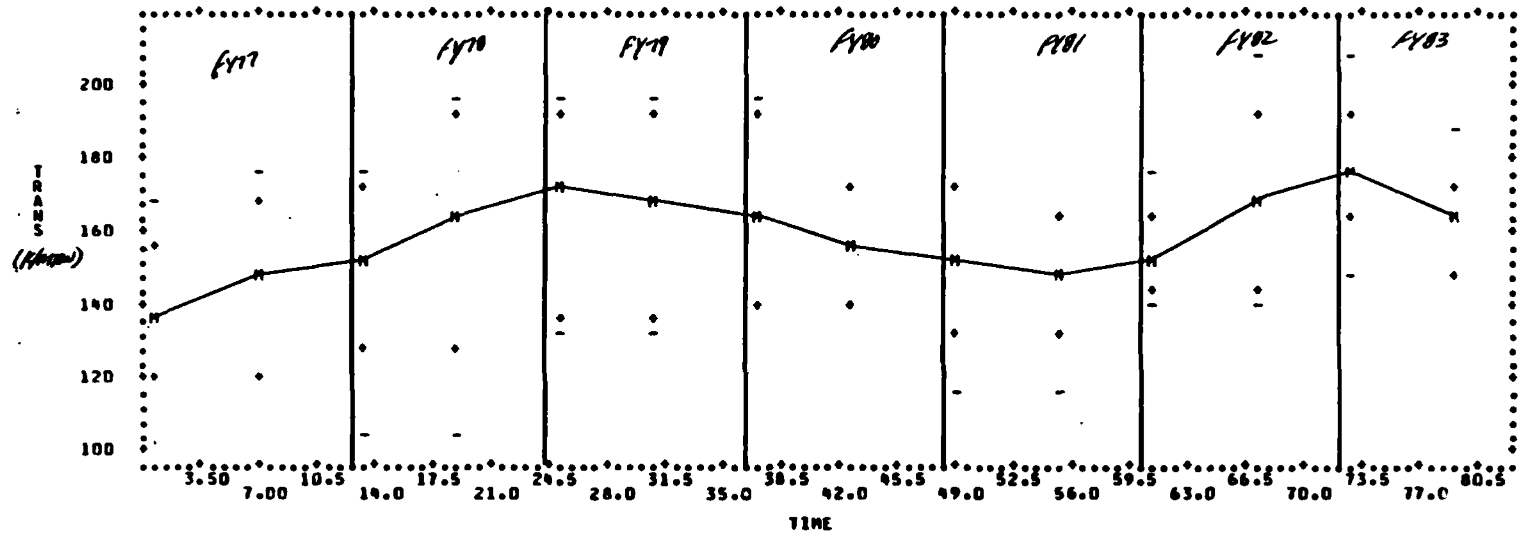
TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	2	136.5982	153.1918	169.6855
3.000	3	118.3890	130.7198	137.3572
5.000	3	118.3890	131.4402	156.7934
7.000	3	149.0794	153.7631	156.7934
9.000	3	149.0794	151.3382	153.6160
11.000	3	153.6160	164.5297	178.5317
13.000	3	102.8353	143.4963	175.5317
15.000	3	131.8679	146.5346	155.6142
17.000	3	127.9600	143.6071	170.9936
19.000	3	170.9936	183.5750	195.2785
21.000	3	185.6248	191.2231	195.2785
23.000	3	172.3098	182.9253	192.7660
25.000	3	152.8061	161.4890	172.3098
27.000	3	136.8765	143.7349	152.8061
29.000	3	132.2372	153.4594	191.2659
31.000	3	171.9873	182.1513	191.2659
33.000	3	183.2007	189.4386	194.2456
35.000	3	157.4224	180.9756	194.2456
37.000	3	146.0307	159.7809	160.0000
39.000	3	141.5717	154.0902	162.2111
41.000	3	140.5562	145.2725	153.6098
43.000	3	153.6098	161.3968	171.5310
45.000	3	157.3161	164.5654	171.5310
47.000	3	145.8009	161.4360	171.1333
49.000	3	130.6708	146.4977	163.0198
51.000	3	117.4175	126.2421	130.6708
53.000	3	117.4175	137.0519	157.6273
55.000	3	157.6273	160.5750	164.3520
57.000	3	147.9966	154.7401	164.3520
59.000	3	147.9966	153.2394	157.7461
61.000	3	148.2975	151.5685	157.7461
63.000	3	141.7344	147.5524	152.2678
65.000	3	141.7344	154.9482	177.4772
67.000	3	177.4772	189.7339	207.6665
69.000	3	184.0580	186.6127	190.5317
71.000	3	168.1660	176.8404	190.5317
73.000	3	163.4303	165.8818	168.1660
75.000	3	146.5631	159.4482	166.0491
77.000	3	165.7325	173.4964	180.0589
79.000	3	170.7527	177.1136	180.0589
81.000	2	146.6341	159.5816	172.5291

Figure F-14. Three-month Moving Average - General



TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	3	136.5982	147.8136	169.6854
4.000	6	118.3890	139.6269	169.6854
7.000	6	118.3890	141.6893	156.7934
10.000	6	149.0794	158.2338	175.5317
13.000	6	102.8353	150.6932	175.5317
16.000	6	102.8353	140.2321	170.9936
19.000	6	127.9600	166.0300	195.2785
22.000	6	172.3098	185.6891	195.2785
25.000	6	141.4423	167.0626	192.7660
28.000	6	132.2372	152.3298	191.2659
31.000	6	132.2372	167.7395	191.2659
34.000	6	157.4224	181.4974	194.2456
37.000	6	146.0307	168.6761	194.2456
40.000	6	140.5562	150.8246	162.2111
43.000	6	140.5562	156.0179	171.5310
46.000	6	145.8009	164.1000	171.5310
49.000	6	130.6381	151.4398	171.1333
52.000	6	117.4175	139.2471	163.0189
55.000	6	117.4175	147.8539	164.3520
58.000	6	147.9966	155.9479	164.3520
61.000	6	147.9966	151.4899	157.7461
64.000	6	141.7344	152.3442	177.4772
67.000	6	141.7344	173.6363	207.6665
70.000	6	168.1660	184.5824	207.6665
73.000	6	146.5631	167.7606	190.5317
76.000	6	146.5631	166.0836	188.0589
79.000	6	146.6341	168.3959	188.0589

Figure F-15. Six-month Moving Average - General



TIME VALUE	NO. OF CASES	MINIMUM VALUE	TRIMMED MINIMUM	TRIMMED MEAN	TRIMMED MAXIMUM	MAXIMUM VALUE
1.000	6	118.3890	119.1381	137.4217	156.7934	169.6854
7.000	12	118.3890	119.1381	149.3243	169.6854	175.5317
13.000	12	102.8353	127.9600	151.2428	170.9936	175.5317
19.000	12	102.8353	127.9600	165.7414	192.7660	195.2785
25.000	12	132.2372	136.8765	170.0598	192.7660	195.2785
31.000	12	132.2372	136.8765	167.6481	191.2659	194.2456
37.000	12	140.5562	141.5717	165.9130	191.2590	194.2456
43.000	12	140.5562	141.5717	157.7460	171.1333	171.5310
49.000	12	117.4175	130.6381	153.1134	171.1333	171.5310
55.000	12	117.4175	130.6381	148.9401	163.0199	164.3520
61.000	12	141.7344	145.6329	153.0541	164.3520	177.4772
67.000	12	141.7344	145.6329	167.2158	193.5317	207.6665
73.000	12	146.5631	163.4303	174.9766	190.5317	207.6665
79.000	9	146.5631	146.6341	164.5472	172.5291	188.0589

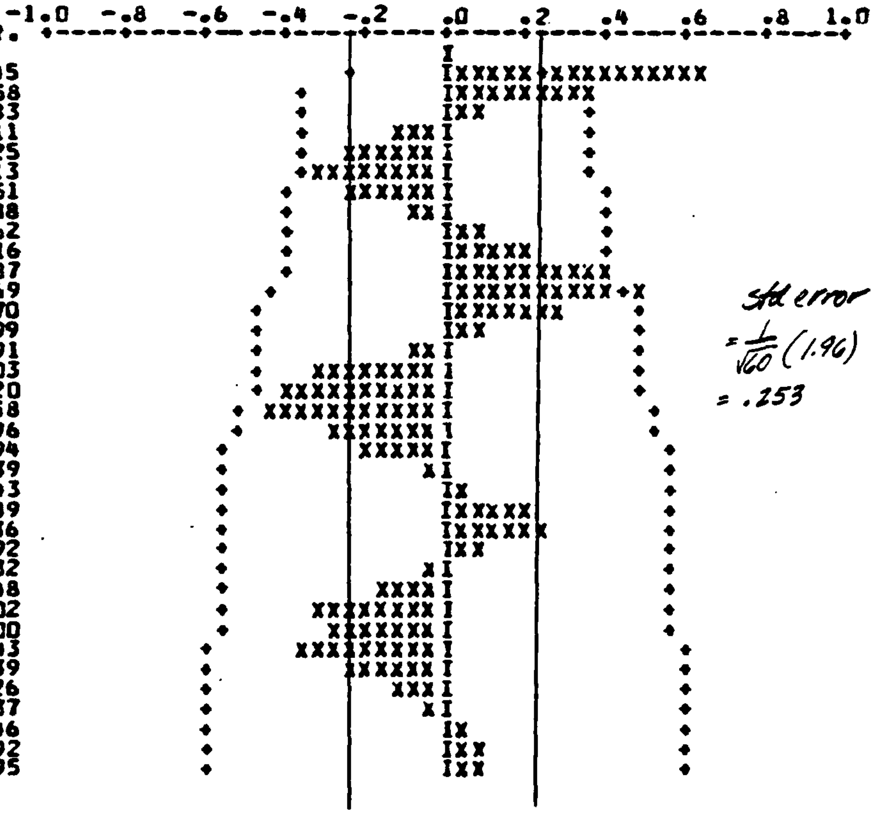
Figure F-16. Twelve-month Moving Average - General

AUTOCORRELATIONS

1- 12	.65	.36	.08	-.11	-.23	-.31	-.25	-.09	.06	.22	.39	.47
ST.E.	.13	.17	.19	.19	.19	.19	.20	.21	.21	.21	.21	.22
13- 24	.27	.10	-.09	-.30	-.42	-.46	-.30	-.19	-.04	.04	.19	.24
ST.E.	.24	.24	.24	.24	.25	.26	.28	.28	.28	.28	.28	.29
25- 36	.09	-.03	-.15	-.30	-.30	-.34	-.24	-.13	-.04	.05	.09	.10
ST.E.	.29	.29	.29	.29	.30	.30	.31	.31	.31	.31	.31	.31

PLOT OF AUTOCORRELATIONS

LAG	CORR.
1	.645
2	.358
3	.083
4	-.111
5	-.225
6	-.313
7	-.251
8	-.088
9	.062
10	.216
11	.387
12	.469
13	.270
14	.099
15	-.091
16	-.303
17	-.420
18	-.458
19	-.296
20	-.194
21	-.039
22	.043
23	.189
24	.236
25	.092
26	-.032
27	-.148
28	-.302
29	-.300
30	-.343
31	-.239
32	-.126
33	-.037
34	.046
35	.092
36	.095



std error $= \frac{1}{\sqrt{60}}(1.96)$ $= .253$

Figure F-17. ACF - Raw Data - General

PARTIAL AUTOCORRELATIONS

1- 12	.65	-.10	-.18	-.11	-.08	-.15	.07	.14	.04	.12	.25	.13
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
13- 24	-.30	.03	-.03	-.29	-.09	.02	.05	-.27	.12	-.12	-.03	.06
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
25- 36	-.07	-.10	.07	-.04	.08	-.18	.01	.03	-.18	-.06	-.09	-.04
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13

PLOT OF PARTIAL AUTOCORRELATIONS

```
             -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR.  +----+----+----+----+----+----+----+----+----+----+
                                          I
  1    .645                        +     IXXXXX+XXXXXXXXXX
  2   -.100                        +  XXXI     +
  3   -.184                        +XXXXXI     +
  4   -.108                        +  XXXI     +
  5   -.080                        +   XXI     +
  6   -.148                        + XXXXI     +
  7    .067                        +     IXX   +
  8    .141                        +     IXXXX +
  9    .043                        +     IX    +
 10    .117                        +     IXXX  +
 11    .248                        +     IXXXXXX
 12    .126                        +     IXXX  +
 13   -.295                       X+XXXXXI     +
 14    .032                        +     IX    +
 15   -.030                        +    XI     +
 16   -.286                       X+XXXXXI     +
 17   -.086                        +   XXI     +
 18    .024                        +     IX    +
 19    .048                        +     IX    +
 20   -.267                       X+XXXXXI     +
 21    .119                        +     IXXX  +
 22   -.121                        +  XXXI     +
 23   -.034                        +    XI     +
 24    .056                        +     IX    +
 25   -.067                        +   XXI     +
 26   -.097                        +   XXI     +
 27    .069                        +     IXX   +
 28   -.037                        +    XI     +
 29    .078                        +     IXX   +
 30   -.180                        + XXXXI     +
 31    .007                        +     I     +
 32    .026                        +     IX    +
 33   -.175                        + XXXXI     +
 34   -.064                        +   XXI     +
 35   -.087                        +   XXI     +
 36   -.041                        +    XI     +
```

Figure F-18. PACF - Raw Data - General

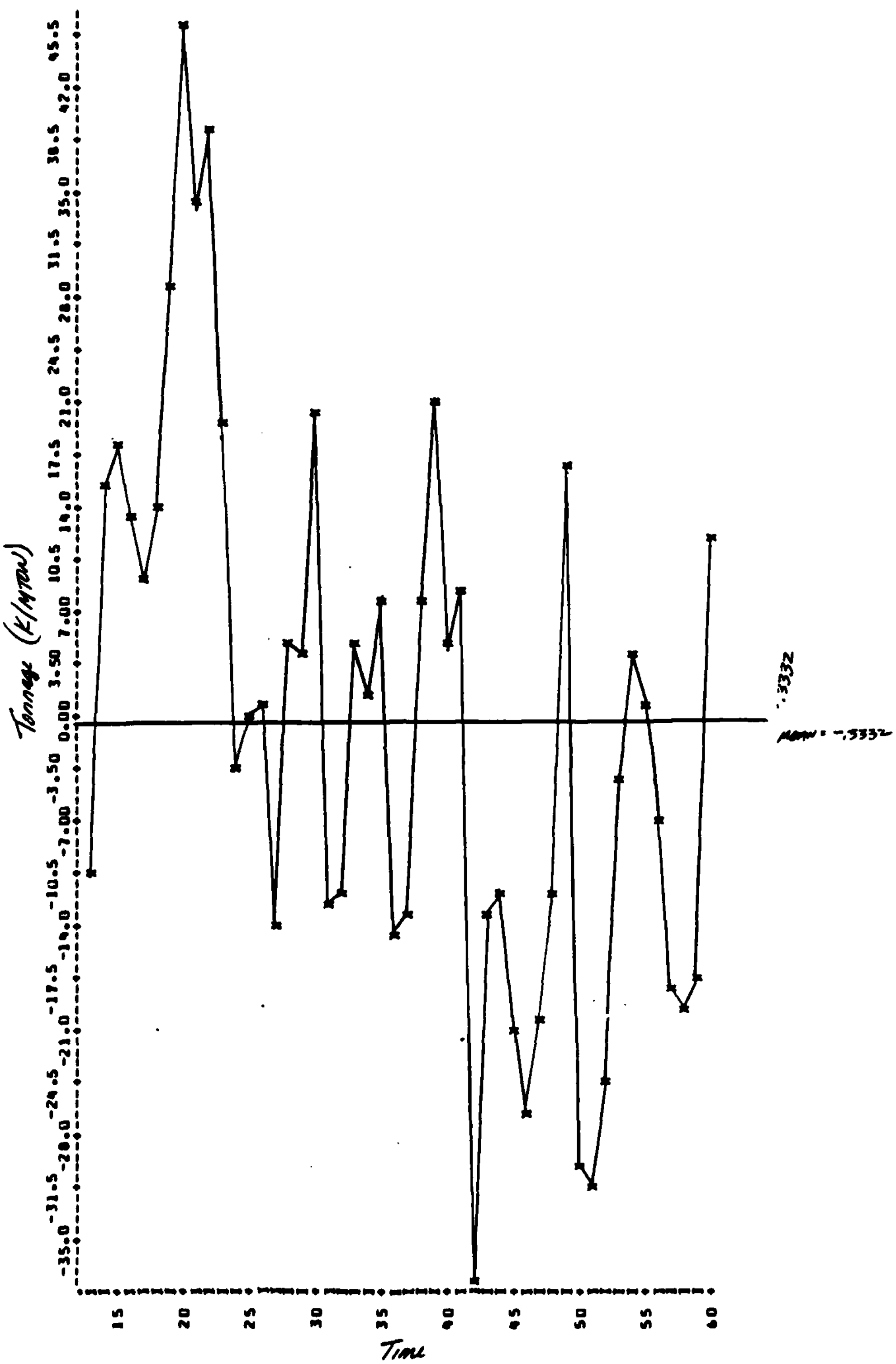
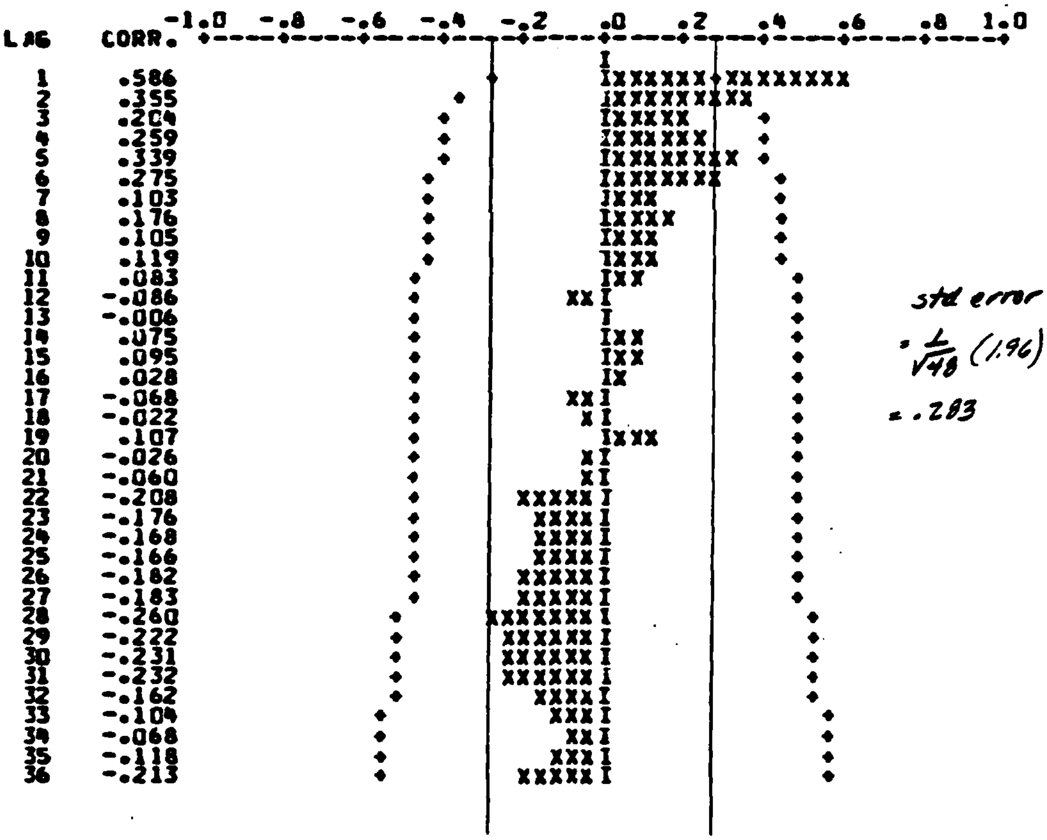


Figure F-19. Differenced Series (12-month lag) - General

AUTOCORRELATIONS

1- 12	.59	.35	.20	.26	.34	.27	.10	.18	.11	.12	.08	-.09
ST.E.	.14	.19	.20	.21	.21	.22	.23	.23	.23	.23	.24	.24
13- 24	-.01	.07	.10	.03	-.07	-.02	.11	-.03	-.06	-.21	-.18	-.17
ST.E.	.24	.24	.24	.24	.24	.24	.24	.24	.24	.24	.24	.25
25- 36	-.17	-.18	-.18	-.26	-.22	-.23	-.23	-.16	-.10	-.07	-.12	-.21
ST.E.	.25	.25	.25	.26	.26	.27	.27	.27	.28	.28	.28	.28

PLOT OF AUTOCORRELATIONS



std error

$= \frac{1}{\sqrt{48}}(1.96)$

$= .283$

Figure F-20. ACF - Lagged 12 Months

AUTOCORRELATIONS

1- 12	-.18	-.09	-.26	-.04	.18	.14	-.28	.19	-.09	.05	.10	-.28
ST.E.	.15	.15	.15	.16	.16	.16	.17	.18	.18	.18	.18	.18
13- 24	.01	.07	.12	.03	-.16	-.10	.28	-.11	.12	-.21	.03	.01
ST.E.	.19	.19	.19	.19	.19	.20	.20	.21	.21	.21	.21	.21
25- 36	.02	0.0	.08	-.12	.02	-.02	-.07	.01	.04	.09	.06	-.15
ST.E.	.21	.21	.21	.21	.22	.22	.22	.22	.22	.22	.22	.22

PLOT OF AUTOCORRELATIONS

```
             -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR.   +----+----+----+----+----+----+----+----+----+----+
                                         I
  1   -.179                       +  XXXXI         +
  2   -.094                       +    XXI         +
  3   -.256                       +XXXXXXI         +
  4   -.045                      +      XI          +
  5    .175                      +       IXXXX      +
  6    .141                      +       IXXXX      +
  7   -.280                      +XXXXXXXI          +
  8    .187                     +        IXXXXX      +
  9   -.090                     +      XXI           +
 10    .047                     +        IX          +
 11    .103                     +        IXXX        +
 12   -.278                     + XXXXXXXI           +
 13    .007                     +        I           +
 14    .071                     +        IXX         +
 15    .117                     +        IXXX        +
 16    .026                    +         IX           +
 17   -.161                    +     XXXXI            +
 18   -.103                    +      XXXI            +
 19    .281                    +         IXXXXXXX     +
 20   -.107                    +      XXXI            +
 21    .123                    +         IXXX         +
 22   -.206                    +    XXXXXI            +
 23    .032                    +         IX           +
 24    .011                    +         I            +
 25    .016                    +         I            +
 26   -.003                    +         I            +
 27    .078                    +         IXX          +
 28   -.124                   +       XXXI             +
 29    .024                   +          IX            +
 30   -.023                   +         XI             +
 31   -.074                   +        XXI             +
 32    .005                   +          I             +
 33    .041                   +          IX            +
 34    .095                   +          IXX           +
 35    .062                   +          IXX           +
 36   -.152                   +      XXXXI             +
```

std error

$= \frac{1}{\sqrt{47}}(1.96)$

$= .286$

Figure F-21. ACF - Lagged 12 Months and 1 Month

```
PARTIAL AUTOCORRELATIONS

  1- 12     -.18 -.13 -.31 -.21  .04  .10 -.29  .19  .02 -.09  .16 -.22
  ST.E.      .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15

 13- 24     -.11 -.03  .13 -.12 -.11  .07  .12 -.12  .15 -.04 -.02 -.09
  ST.E.      .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15

 25- 36     -.06  .03 -.02  .03 -.16 -.01 -.07 -.17  .10 -.03  .06 -.10
  ST.E.      .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15

PLOT OF PARTIAL AUTOCORRELATIONS

           -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG  CORR.  +----+----+----+----+----+----+----+----+----+----+
                                     I
  1  -.179                    +  XXXXI      +
  2  -.130                    +   XXXI      +
  3  -.313                   X+XXXXXXI      +
  4  -.211                    + XXXXXI      +
  5   .036                    +      IX     +
  6   .099                    +      IXX    +
  7  -.293                    XXXXXXXI      +
  8   .188                    +      IXXXXX +
  9   .024                    +      IX     +
 10  -.090                    +    XXI      +
 11   .158                    +      IXXXX  +
 12  -.218                    + XXXXXI      +
 13  -.112                    +   XXXI      +
 14  -.026                    +     XI      +
 15   .132                    +      IXXX   +
 16  -.123                    +   XXXI      +
 17  -.114                    +   XXXI      +
 18   .074                    +      IXX    +
 19   .124                    +      IXXX   +
 20  -.116                    +   XXXI      +
 21   .147                    +      IXXXX  +
 22  -.043                    +     XI      +
 23  -.020                    +      I      +
 24  -.093                    +    XXI      +
 25  -.064                    +    XXI      +
 26   .033                    +      IX     +
 27  -.020                    +     XI      +
 28   .033                    +      IX     +
 29  -.160                    +  XXXXI      +
 30  -.013                    +      I      +
 31  -.072                    +    XXI      +
 32  -.166                    +  XXXXI      +
 33   .097                    +      IXX    +
 34  -.026                    +     XI      +
 35   .062                    +      IXX    +
 36  -.099                    +    XXI      +
```

Figure F-22. PACF - Lagged 12 Months and 1 Month

```
ESTIMATION BY BACKCASTING METHOD
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN  .1000-004

SUMMARY OF THE MODEL
OUTPUT VARIABLE -- TRANS
INPUT VARIABLES -- NOISE

VARIABLE   VAR. TYPE   MEAN      TIME      DIFFERENCES
                                                 12       1
TRANS        RANDOM              1-  60   (1-B  ) (1-B  )

PARAMETER VARIABLE    TYPE   FACTOR   ORDER ESTIMATE          ST. ERR.   T-RATIO
    1    TRANS         MA       1        1      .7962           .0959       8.31
    2    TRANS         MA       2       12      .7753           .0577      13.43
    3    TRANS         AR       1        1      .3579           .1432       2.50

RESIDUAL SUM OF SQUARES  =        6104.701843 (BACKCASTS EXCLUDED)
DEGREES OF FREEDOM       =                 43
RESIDUAL MEAN SQUARE     =         141.969809
```

Figure F-23. Model Parameters - General

AUTOCORRELATIONS

1- 12	0.0	.06	-.14	.04	.01	.15	-.11	.14	-.08	-.05	.05	-.12
ST.E.	.13	.13	.13	.13	.13	.13	.14	.14	.14	.14	.14	.14
13- 24	-.14	.03	.04	-.06	-.13	-.06	.15	-.04	.13	-.12	.07	-.20
ST.E.	.14	.15	.15	.15	.15	.15	.15	.15	.15	.15	.16	.16
25- 36	-.07	-.03	.07	-.16	.04	-.12	-.09	0.0	.02	.08	.01	-.18
ST.E.	.16	.16	.16	.16	.16	.16	.17	.17	.17	.17	.17	.17

PLOT OF AUTOCORRELATIONS

```
              -1.0  -.8   -.6   -.4   -.2    .0    .2    .4    .6    .8   1.0
LAG   CORR.    +----+----+----+----+----+----+----+----+----+----+
                                           I
  1   .004                           +     I     +
  2   .059                           +     IX    +
  3  -.137                           +  XXXI     +
  4   .043                          +      IX     +
  5   .010                          +      I      +
  6   .153                          +      IXXXX  +
  7  -.112                          +   XXXI      +
  8   .144                          +      IXXXX  +
  9  -.081                          +    XXI      +
 10  -.045                          +     XI      +
 11   .052                          +      IX     +
 12  -.119                          +   XXXI      +
 13  -.145                          +  XXXXI      +
 14   .033                          +      IX     +
 15   .043                          +      IX     +
 16  -.058                          +     XI      +
 17  -.128                          +   XXXI      +
 18  -.058                          +     XI      +
 19   .154                          +      IXXXX  +
 20  -.037                          +     XI      +
 21   .131                          +      IXXX   +
 22  -.117                         +    XXXI       +
 23   .065  .213(60)=12.8          +       IXX     +
 24  -.197                         +  XXXXXI       +
 25  -.071                         +     XXI       +
 26  -.030                         +      XI       +
 27   .071                         +       IXX     +
 28  -.158                         +   XXXXI       +
 29   .045                         +       IX      +
 30  -.119                         +    XXXI       +
 31  -.088                         +     XXI       +
 32  -.002                         +       I       +
 33   .024                         +       IX      +
 34   .082                         +       IXX     +
 35   .009                         +       I       +
 36  -.182                         +  XXXXXI       +
```

Figure F-24. Estimated Residuals - General

FORECAST ON VARIABLE TRANS FROM TIME PERIOD 61

PERIOD	FORECASTS	ST. ERR.	ACTUAL	ERROR
61	149.60000	15.16543	148.297	-1.303
62	140.33198	17.39390	146.662	6.331
63	142.79956	18.44542	152.261	9.462
64	127.50204	19.18827	141.734	14.232
65	131.17248	19.82463	145.633	14.461
66	164.52803	20.41488	177.477	12.949
67	164.28495	20.97950	207.666	43.382
68	167.88490	21.52618	184.058	16.174
69	165.61838	22.05823	185.248	19.63
70	166.36350	22.57737	190.532	24.169
71	170.92077	23.08469	171.823	.903
72	165.60065	23.58106	168.166	2.566

STANDARD ERROR = 15.1654 (BY CONDITIONAL METHOD)

1856.61 2021.55 MSE = 318.54

Figure F-25. Forecast FY 82 - General

F-4. HHG

a. The raw series for HHG shipments is depicted in Figure F-26. The raw data depicts the volatility of HHG shipments when MSC is required to transport normal Code 4 shipments. During FY 78 HHG shipments by MSC were more than three-times as large as any other fiscal year in the data set. Due to this distortion in the data, only data from October 1978 through September 1981 was used to develop the models. The HHG time series has only 36 observations, much less than is normally required to achieve satisfactory results from time series analysis.

b. Aside from the distortion during FY 78, the raw data depict a seasonal trend with peaks during the summmer months and troughs during the winter months. Evidence of seasonality in the data is also seen in the 6-month moving average (Figure F-27). However, the 12-month moving average (Figure F-28) suggests that the mean of the series is fairly constant over the latter years and appears to exhibit a slight downtrend.

c. Autocorrelation function analysis (Figures F-29 and F-30) confirms the existence of seasonality in the data as manifested by the significant autocorrelation coefficient at lags 12 and 24. The series was differenced at a lag of 12 months to eliminate the seasonality and achieve stationary data. The plot of the seasonally adjusted series is depicted in Figure F-31. Autocorrelation and partial autocorrelation function analysis of the data (Figures F-32 and F-33) indicate that stationarity has been achieved.

d. Analysis of Figures F-32 and F-33 suggest that the data be modeled with a seasonal and nonseasonal model. In contrast to all of the other models, the seasonal model for HHG was AR in nature. This was discovered after comparing the results of AR and MA seasonal models. The nonseasonal model was identified as an MA process. The resulting model was a nonseasonal ARIMA (0,0,1) model and a seasonal ARIMA (1,1,0) model:

$$(1-\ \phi_{12}\ B^{12})\ (1-B^{12})\ X_t = \mu + (1-\ \theta_4\ B^4)\epsilon_t$$

The nonseasonal model was built with only one parameter rather than four since the first three coefficients lacked any statistical significance. Also, the mean of the seasonally adjusted series was significant at the 6 percent significance level.

e. The results of the model (Figure F-34) were as follows:

$$\underset{(-2.33)}{(1 + .3198B^{12})}\ (1-B^{12})\ X_t = \underset{(-3.67)}{-1.163} + \underset{(1.88)}{(1-.3397B^4)}\epsilon_t$$

$$\chi^2\ (2,20) = 6.26$$

All of the estimated parameters except θ_4, are significant at the 5 percent significance level. θ_4 is significant at the 7 percent significance level. Verification of the model's adequacy, using the Box-Pierce test with 20 degrees of freedom, indicates that the null hypothesis (uncorrelated residuals) should not be rejected at the .5 percent significance level (Figure F-35).

f. This model forecasted FY 82 HHG shipments to be 80.2 K/MTON versus an actual lift of 87.7 K/MTON (Figure F-36). The MSE of the HHG forecast was 5.24 percent, and the annual forecast error was -8.5 percent.

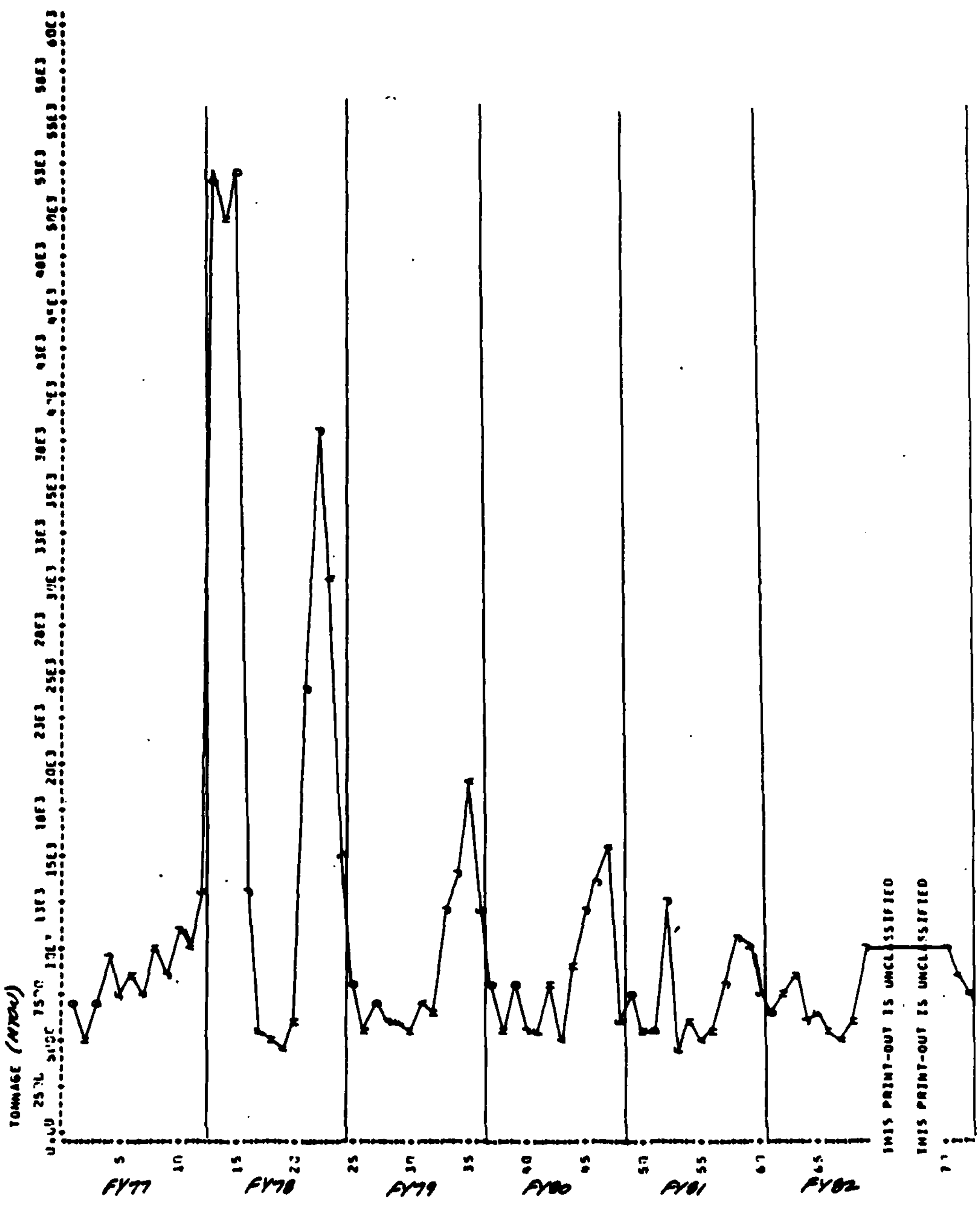
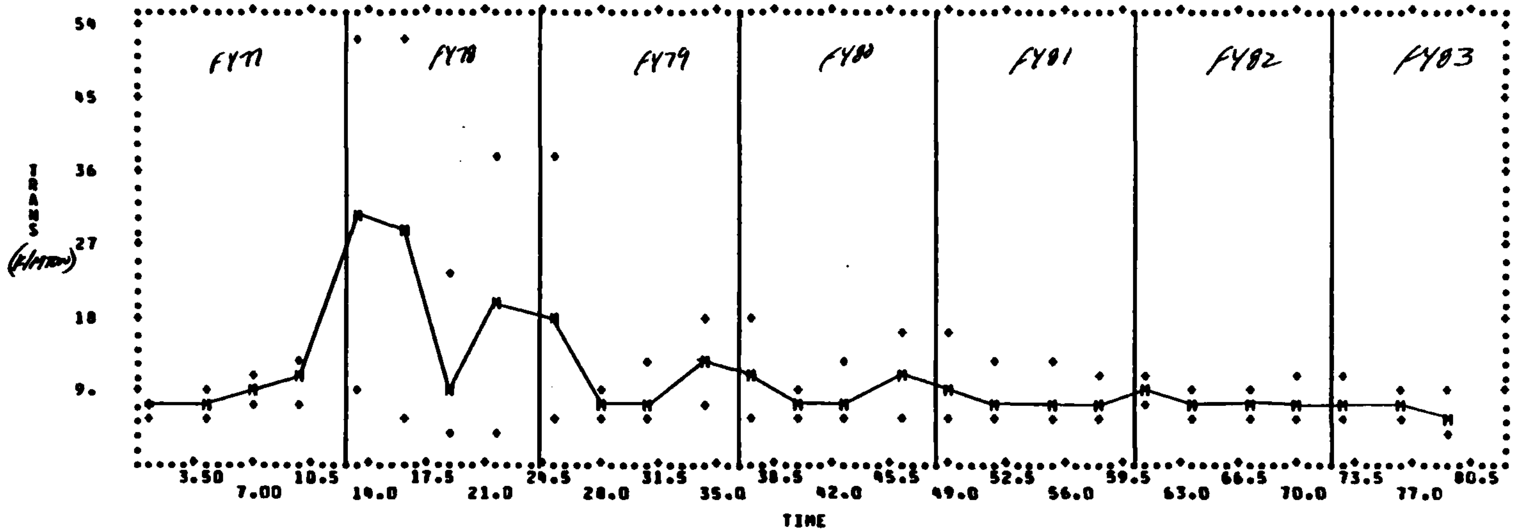
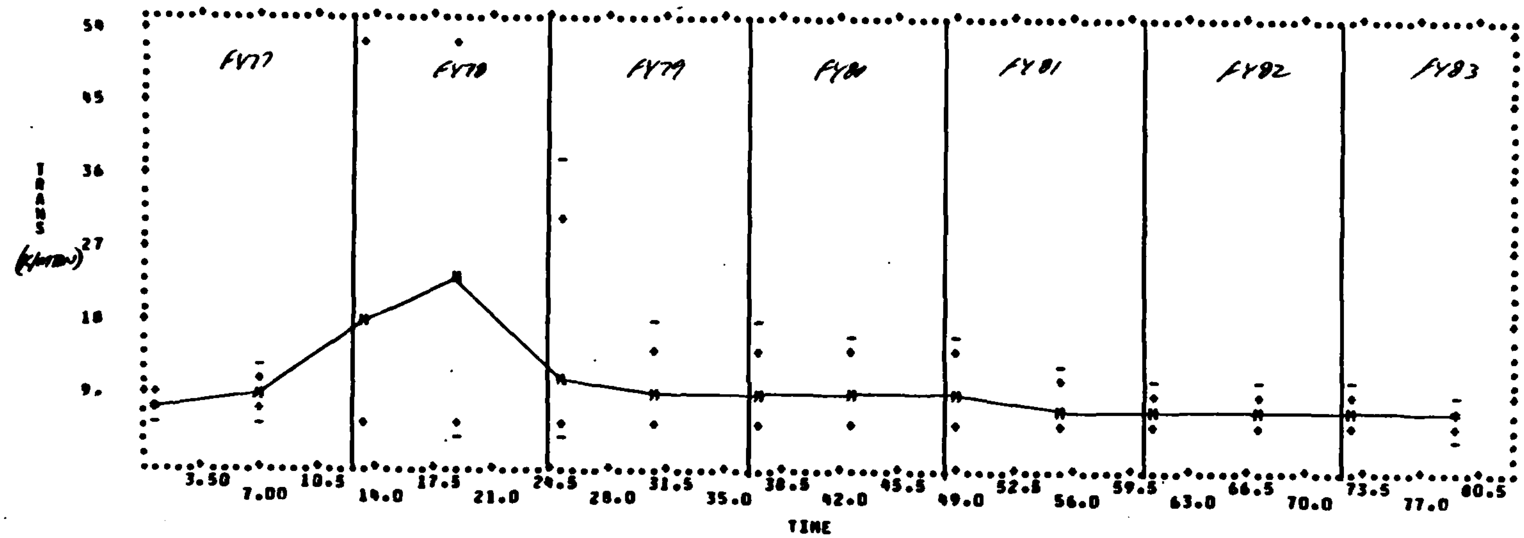


Figure F-26. HHG Cargo, FY 77 - FY 82



TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	3	5.1816	6.3153	6.9211
4.000	6	5.1816	7.3615	9.3560
7.000	6	7.3250	8.5309	10.1200
10.000	6	7.3250	9.9759	12.9220
13.000	6	9.7649	31.1989	52.1626
16.000	6	5.1419	29.4756	52.1626
19.000	6	4.3554	9.6767	24.2233
22.000	6	4.3554	19.6088	38.0300
25.000	6	5.4447	17.3077	38.0300
28.000	6	5.4447	6.3725	8.2499
31.000	6	5.7186	7.2049	11.9687
34.000	6	6.4772	11.7178	18.8700
37.000	6	5.6587	11.0194	18.8700
40.000	6	5.6182	6.8260	8.1032
43.000	6	5.1063	7.5957	12.1877
46.000	6	5.1063	10.1717	15.4558
49.000	6	5.4258	8.8620	15.4558
52.000	6	4.6769	6.8971	12.3594
55.000	6	4.6769	6.9499	12.3594
58.000	6	5.0922	7.7140	10.3262
61.000	6	6.4012	8.3673	10.3262
64.000	6	5.4337	6.7722	8.7323
67.000	6	4.9882	6.5312	9.8193
70.000	6	4.9882	7.8408	10.1794
73.000	6	6.1419	7.4792	10.1794
76.000	6	5.4582	6.6319	8.3686
79.000	6	3.5728	6.1979	8.3686

Figure F-27. Six-month Moving Average - HHG



TIME VALUE	NO. OF CASES	MINIMUM VALUE	TRIMMED MINIMUM	TRIMMED MEAN	TRIMMED MAXIMUM	MAXIMUM VALUE
1.000	6	5.1816	6.8930	7.9078	8.2850	9.3560
7.000	12	3.1816	6.8930	8.5917	11.2028	12.9220
13.000	12	5.1419	5.2616	17.9401	51.5044	52.1626
19.000	12	4.3554	5.1419	23.7988	51.5044	52.1626
25.000	12	4.3554	5.4447	11.3502	30.1360	38.0300
31.000	12	5.4447	5.7186	8.4227	13.7883	18.8700
37.000	12	5.6182	5.6587	8.6775	13.7883	18.8700
43.000	12	5.1063	5.6182	8.1424	13.5642	15.4558
49.000	12	4.6769	5.1063	8.2280	13.5642	15.4558
55.000	12	4.6769	5.0922	7.0631	13.3262	12.3594
61.000	12	5.0922	5.3373	7.1499	9.8741	10.3262
67.000	12	4.9882	5.4337	7.2511	9.8193	10.1794
73.000	12	4.9882	5.4582	7.1669	9.8193	10.1794
79.000	9	3.5728	5.4582	6.3044	7.0796	8.3686

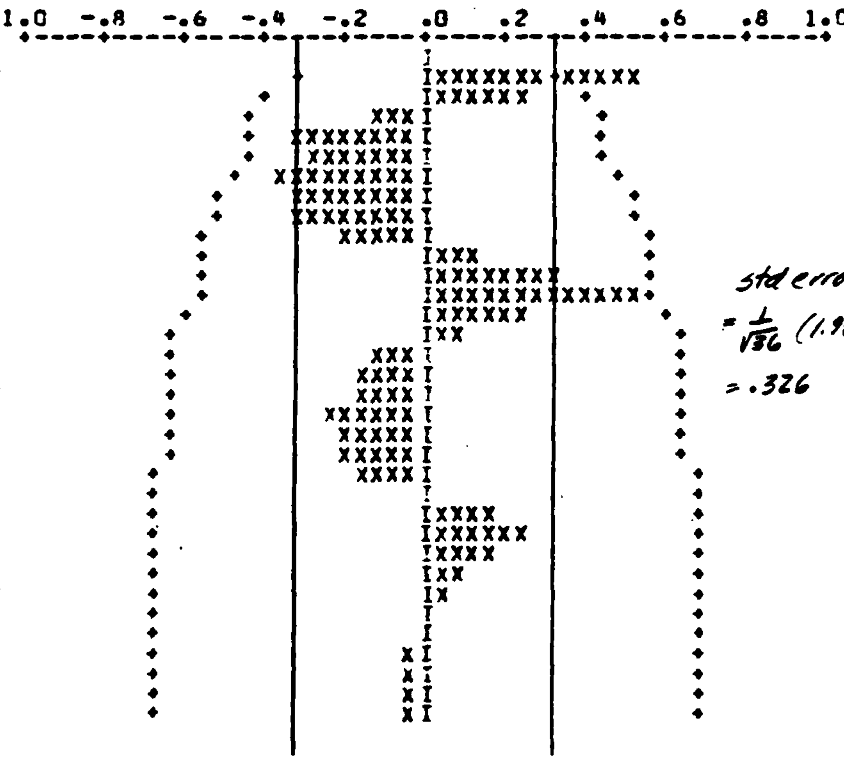
Figure F-28. Twelve-month Moving Average - HHG

AUTOCORRELATIONS

1- 12	.54	.24	-.14	-.30	-.29	-.38	-.30	-.31	-.21	.12	.31	.51
ST.E.	.17	.21	.22	.22	.23	.24	.26	.27	.28	.28	.28	.29
13- 24	.26	.09	-.11	-.18	-.15	-.22	-.21	-.19	-.16	.02	.15	.26
ST.E.	.31	.32	.32	.32	.33	.33	.33	.33	.34	.34	.34	.34
25- 33	.16	.10	.03	.02	-.02	-.02	-.04	-.03	-.04			
ST.E.	.35	.35	.35	.35	.35	.35	.35	.35	.35			

PLOT OF AUTOCORRELATIONS

LAG	CORR.
1	.537
2	.237
3	-.135
4	-.305
5	-.288
6	-.376
7	-.305
8	-.309
9	-.213
10	.116
11	.313
12	.509
13	.258
14	.086
15	-.111
16	-.179
17	-.147
18	-.221
19	-.205
20	-.188
21	-.160
22	.018
23	.150
24	.257
25	.158
26	.097
27	.027
28	.017
29	-.017
30	-.021
31	-.036
32	-.023
33	-.040



std error = $\frac{1}{\sqrt{36}}(1.96)$ = .326

Figure F-29. ACF - Raw Data - HHG

PARTIAL AUTOCORRELATIONS

1- 12	.54	-.07	-.33	-.13	.02	-.32	-.13	-.20	-.19	.24	.09	.10
ST.E.	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17
13- 24	-.28	-.02	-.07	.01	-.04	-.12	-.05	.03	-.19	-.19	.01	-.09
ST.E.	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17
25- 33	-.10	0.0	-.09	-.05	-.08	.03	-.03	.08	-.01			
ST.E.	.17	.17	.17	.17	.17	.17	.17	.17	.17			

PLOT OF PARTIAL AUTOCORRELATIONS

```
             -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
 LAG    CORR. +----+----+----+----+----+----+----+----+----+----+
                                       I
   1     .537                 +        IXXXXXXX+XXXXX
   2    -.071                 +      XXI       +
   3    -.329                 XXXXXXXXI       +
   4    -.129                 +     XXXI       +
   5     .024                 +        IX      +
   6    -.325                 XXXXXXXXI       +
   7    -.129                 +     XXXI       +
   8    -.196                 +   XXXXXI       +
   9    -.189                 +   XXXXXI       +
  10     .243                 +        IXXXXXX +
  11     .086                 +        IXX     +
  12     .100                 +        IXX     +
  13    -.282                 +XXXXXXXI       +
  14    -.020                 +        I       +
  15    -.070                 +      XXI       +
  16     .014                 +        I       +
  17    -.040                 +       XI       +
  18    -.117                 +     XXXI       +
  19    -.054                 +       XI       +
  20     .029                 +        IX      +
  21    -.195                 +   XXXXXI       +
  22    -.192                 +   XXXXXI       +
  23     .013                 +        I       +
  24    -.092                 +      XXI       +
  25    -.097                 +      XXI       +
  26     .001                 +        I       +
  27    -.090                 +      XXI       +
  28    -.047                 +       XI       +
  29    -.076                 +      XXI       +
  30     .032                 +        IX      +
  31    -.031                 +       XI       +
  32     .080                 +        IXX     +
  33    -.005                 +        I       +
```

Figure F-30. PACF - Raw Data - HHG

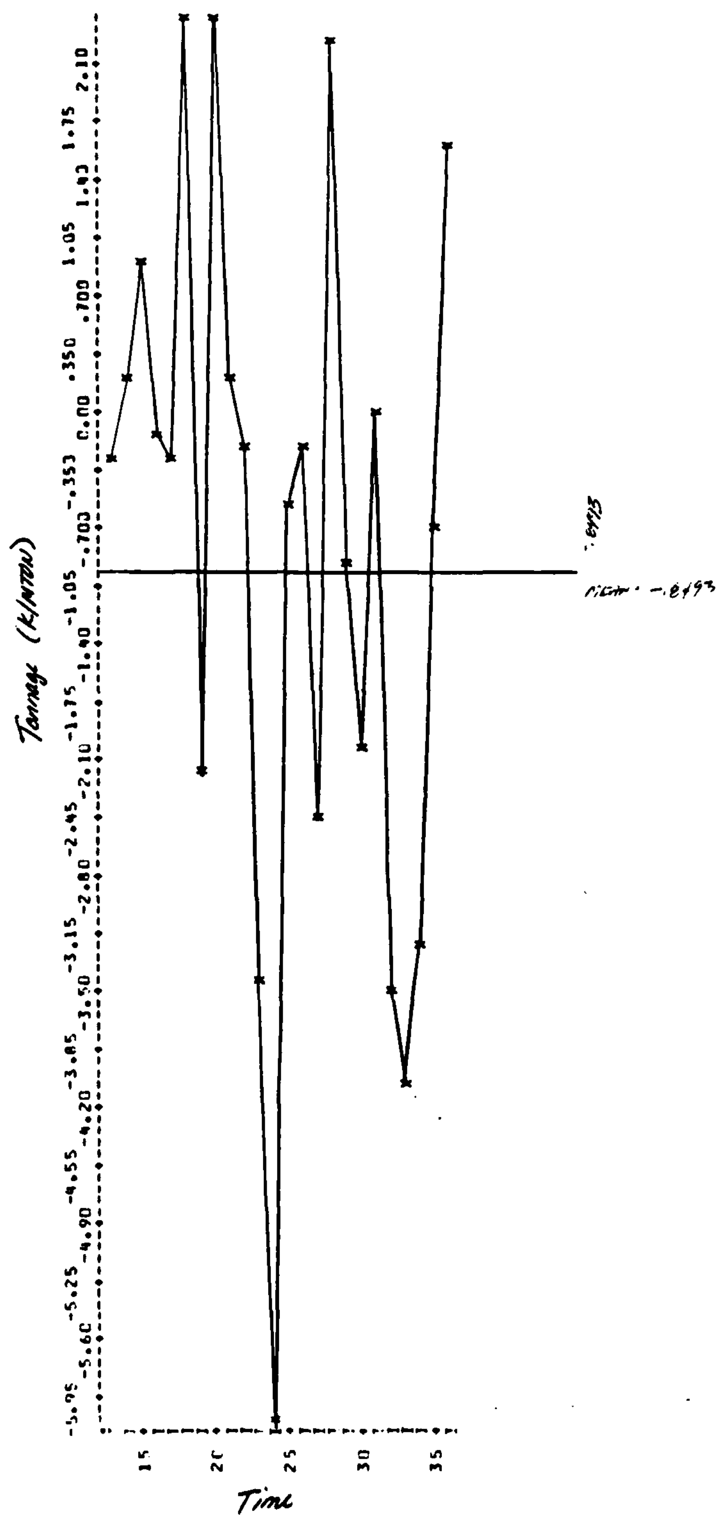


Figure F-31. Differenced Series (12-month lag) - HHG

```
AUTOCORRELATIONS

 1- 12      .18  .03  .02 -.30 -.05 -.11 -.02  .22 -.02  .20  .04 -.29
 ST.E.      .20  .21  .21  .21  .23  .23  .23  .23  .24  .24  .25  .25

 13- 22    -.09 -.08 -.05 -.03 -.10 -.01 -.07 -.02  .03  .03
 ST.E.      .26  .26  .26  .26  .26  .26  .26  .27  .27  .27

PLOT OF AUTOCORRELATIONS

             -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR.  +----+----+----+----+----+----+----+----+----+----+
                                      I
  1    .177                 +         IXXXX     +
  2    .034                 +         IX        +
  3    .020                 +         I         +
  4   -.302                 + XXXXXXXXI         +
  5   -.046               +          XI           +
  6   -.110               +        XXXI           +
  7   -.022               +          XI           +
  8    .219               +           IXXXXX      +
  9   -.020              +            I            +
 10    .196              +            IXXXXX       +
 11    .040              +            IX           +
 12   -.293              +     XXXXXXXI            +
 13   -.089             +           XXI             +
 14   -.080             +           XXI             +
 15   -.051             +            XI             +
 16   -.032             +            XI             +
 17   -.100             +           XXI             +
 18   -.014             +             I             +
 19   -.071             +           XXI             +
 20   -.022             +            XI             +
 21    .029             +             IX            +
 22    .025             +             IX            +
```

std error

$= \frac{1}{\sqrt{24}}(1.96)$

$= .400$

Figure F-32. ACF - Lagged 12 Months

```
PARTIAL AUTOCORRELATIONS

  1- 12      .18  0.0  .01 -.32  .07 -.12  .06  .13 -.08  .18 -.07 -.23
  ST.E.      .20  .20  .20  .20  .20  .20  .20  .20  .20  .20  .20  .20

 13- 22     -.05  .10 -.05 -.18 -.08 -.10 -.07  .02 -.05  .10
  ST.E.      .20  .20  .20  .20  .20  .20  .20  .20  .20  .20

PLOT OF PARTIAL AUTOCORRELATIONS

                -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG      CORR.  +----+----+----+----+----+----+----+----+----+----+
                                         I
  1       .177                 +         IXXXX     +
  2       .003                 +         I         +
  3       .014                 +         I         +
  4      -.318                 + XXXXXXXXI         +
  5       .072                 +         IXX       +
  6      -.121                 +      XXXI         +
  7       .055                 +         IX        +
  8       .134                 +         IXXX      +
  9      -.080                 +       XXI         +
 10       .184                 +         IXXXXX    +
 11      -.063                 +       XXI         +
 12      -.227                 +   XXXXXXI         +
 13      -.048                 +        XI         +
 14       .097                 +         IXX       +
 15      -.048                 +        XI         +
 16      -.181                 +    XXXXXI         +
 17      -.078                 +       XXI         +
 18      -.103                 +      XXXI         +
 19      -.065                 +       XXI         +
 20       .022                 +         IX        +
 21      -.051                 +        XI         +
 22       .098                 +         IXX       +
```

Figure F-33. PCAF - Lagged 12 Months

```
ESTIMATION BY BACKCASTING METHOD
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN  .1000-004

SUMMARY OF THE MODEL

OUTPUT VARIABLE -- TRANS
INPUT VARIABLES -- NOISE

VARIABLE   VAR. TYPE   MEAN       TIME      DIFFERENCES
                                                 12
TRANS        RANDOM               1-  36   (1-B   )

PARAMETER VARIABLE    TYPE  FACTOR   ORDER ESTIMATE         ST. ERR.  T-RATIO
     1    TRANS        MA      1        4      .3397          .1811     1.86
     2    TRANS        AR      1       12     -.3198          .1371    -2.33
     3    TRANS       TRND     1        0    -1.163           .3173    -3.67

RESIDUAL SUM OF SQUARES   =        24.269138 (BACKCASTS EXCLUDED)
DEGREES OF FREEDOM        =                9
RESIDUAL MEAN SQUARE      =         2.696571
```

Figure F-34. Model Parameters - HHG

AUTOCORRELATIONS

1- 12	.16	.03	-.02	-.02	-.10	-.13	-.10	.10	-.09	.15	-.02	-.10
ST.E.	.17	.17	.17	.17	.17	.17	.18	.18	.18	.18	.18	.18
13- 24	-.12	-.10	-.14	-.05	-.02	-.05	-.10	-.01	.02	0.0	.02	.02
ST.E.	.18	.19	.19	.19	.19	.19	.19	.19	.19	.19	.19	.19
25- 33	0.0	.03	.05	.03	.01	.01	.01	0.0	0.0			
ST.E.	.19	.19	.19	.19	.19	.19	.19	.19	.19			

PLOT OF AUTOCORRELATIONS

```
              -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG    CORR.  +----+----+----+----+----+----+----+----+----+----+
                                       I
  1    .163                   +        IXXXX    +
  2    .031                   +        IX       +
  3   -.016                   +        I        +
  4   -.018                   +        I        +
  5   -.102                   +     XXXI        +
  6   -.132                   +     XXXI        +
  7   -.096                  +       XXI         +
  8    .099                  +         IXX       +
  9   -.088                  +       XXI         +
 10    .147                  +         IXXXX     +
 11   -.019                  +         I         +
 12   -.097                  +       XXI         +
 13   -.122                  +      XXXI         +
 14   -.097                  +       XXI         +
 15   -.133                  +      XXXI         +
 16   -.045                  +        XI         +
 17   -.022                  +        XI         +
 18   -.050                  +        XI         +
 19   -.105                  +      XXXI         +
 20   -.014                  +         I         +
 21    .018                  +         I         +
 22    .003 (.173)36=6.26    +         I         +
 23    .022                  +         IX        +
 24    .024                  +         IX        +
 25    .005                  +         I         +
 26    .035                  +         IX        +
 27    .050                  +         IX        +
 28    .032                 +          IX         +
 29    .009                 +          I          +
 30    .012                 +          I          +
 31    .013                 +          I          +
 32    .003                 +          I          +
 33   -.003                 +          I          +
```

Figure F-35. Estimated Residuals - HHG

FORECAST ON VARIABLE TRANS FROM TIME PERIOD 37

PERIOD	FORECASTS	ST. ERR.	ACTUAL	ERROR
37	7.32353	1.71159	6.401	-.922
38	5.03787	1.71159	7.368	2.33
39	5.27541	1.71159	8.732	3.456
40	5.86943	1.71159	6.216	.346
41	3.81461	1.80766	6.482	2.667
42	5.56495	1.80766	5.434	-.131
43	3.93335	1.80766	4.988	1.055
44	5.29067	1.80766	6.247	.956
45	8.27946	1.80766	9.819	1.539
46	10.19849	1.80766	10.179	-.019
47	13.80086	1.80766	8.308	-5.492
48	5.82243	1.80766	7.503	1.681

STANDARD ERROR = 1.71159 (BY CONDITIONAL METHOD)

80.19 87.68 MSE = 5.24

Figure F-36. Forecast FY 82 - HHG

F-5. COAL

a. The raw series for commodity coal is depicted in Figure F-37. The raw data do not depict a recurring pattern or seasonal trend. Examination of the 3-month and 6-month moving average diagrams (Figures F-38 and F-39) affirms the absence of a predictable pattern. The 12-month moving average diagram (Figure F-40) suggests the possibility of a 5-year cycle; however, there is not enough data to verify this hypothesis.

b. Autocorrelation function analysis of the data confirms the absence of seasonality in the data (see Figures F-41 and F-42). However, the autocorrelation function of the raw series indicates that a trend does exist in the data and that stationarity is not present. To achieve stationarity, the raw series was differenced at a lag of one month. The plot of the differenced series is illustrated in Figure F-43. Figures F-44 and F-45 depict the autocorrelation and partial autocorrelation functions of the differenced series. These functions as well as a visual examination of the plot of the differenced series indicate the existence of stationary data.

c. The autocorrelation and partial autocorrelation functions of the differenced series suggest that the data could be modeled using an ARIMA (0,1,1) process. Only the first lag of the autocorrelation function is significant, and the remaining coefficients are distributed randomly within the 95 percent confidence interval. The partial autocorrelations decay exponentially to zero as the lags increase. Besides an ARIMA (0,1,1) model, the data could also be modeled using an ARIMA (1,1,1) model. Thus, the appropriate models are:

$$(1 - B)\, X_t = (1 - \theta_1)\epsilon_t$$

or

$$(1 - \phi_1 B)\,(1 - B)\, X_t = (1 - \theta_1)\epsilon_t$$

d. Test of both models indicated that the ARIMA (1,1,1) model was the most appropriate model. Thus, the resulting forecast model (Figure 6-46) is:

$$\underset{(9.46)}{(1 - .3461B)}\,(1 - B)\, X_t = \underset{(2.06)}{(1 - .859B)}\epsilon_t$$

$$X^2\,(2,20) = 10.87$$

e. All of the estimated parameters were significant at the 5 percent significance level. The model was verified using the Box-Pierce test and a visual examination of the estimated residuals of the model. The Q statistic test is 10.87, which indicates that the null hypothesis, uncorrelated residuals, should not be rejected at the 5 percent significance level (Figure F-47). Also, all of the estimated residuals fall within the 95 percent confidence interval and do not depict any noticeable trend or pattern.

f. The ARIMA (1,1,1) model forecasted the FY 82 coal tonnage shipped to be 406.51 K/MTON (Figure F-48) as compared to the historical FY 82 lift of 375.94 K/MTON and the actual FY 82 DLA coal contract of 440.67 K/MTON. The MSE of the coal forecast was 192.60, and the annual forecast error was -.6 percent (actual FY 82) and 15.2 percent (DLA).

g. As discussed earlier, several external factors have affected coal shipments during October 1977 to September 1981. A close examination of the raw data indicates that contract negotiation delays have seriously affected coal shipments and that a detailed adjustment of coal data is needed to develop an accurate forecasting model. The need for data adjustment is clearly identified by the large outlier observations contained in the differenced series (Figure F-43).

h. In particular, the data point for April 1980 is a large outlier that affects the model-building process. The observation for April 1980 was adjusted to the average shipment for April during the 5-year period. The autocorrelation and partial autocorrelation functions (Figures F-49 and F-50) of the adjusted series again depict a trend in the data. Also, it should be noted that almost all of the autocorrelation coefficients for the adjusted data are greater than the autocorrelation coefficients for the original series (Figure F-41). Thus, the data are very sensitive to data manipulation, and further data adjustments should be done with extreme caution.

i. The differenced adjusted series is illustrated in Figure F-51. The autocorrelation and partial autocorrelation functions (Figures F-52 and F-53) indicate the existence of weak stationarity in the data. Again, it should be noted that although the autocorrelation function of the differenced adjusted series indicates a possible ARIMA (1,1,1) model, the function varies from the differenced unadjusted series. In particular, lags 10, 17, and 24 are more significant than before. This would suggest that additional parameters need to be added to the original model. To retain some parsimony in the model only one parameter was added. The form of the model is:

$$(1 - \phi_1 B)(1 - B) X_t = (1 - \theta_1 B - \theta_{10} B^{10}) \epsilon_t$$

j. The results of the model (Figure F-54) are as follows:

$$\underset{(1.46)}{(1 - .2168B)}\,(1 - B) X_t = (1 - \underset{(9.69)}{.7693B} + \underset{(-3.8)}{.2705B^{10}}) \epsilon_t$$

$$\chi^2\ (3,20) = 10.51$$

All of the estimated parameters are significant at the 5 percent significance level except ${}_1$. The Q statistic indicates a good fit for the model, thus the null hypothesis should not be rejected at the 5 percent significance level (Figure F-55). It should be noted that the "goodness of fit" test accounts for the significant residual coefficient at lag 17. Attempts to reduce the significance of this coefficient added further complication and restriction to the original model. Also, until all of the data are adjusted correctly, additional modifications to the original model should not be attempted.

k. The adjusted model forecasted that 398.80 K/MTON of coal would be shipped during FY 82 (Figure 6-56) which corresponds to an annual forecast error of 6.1 percent.

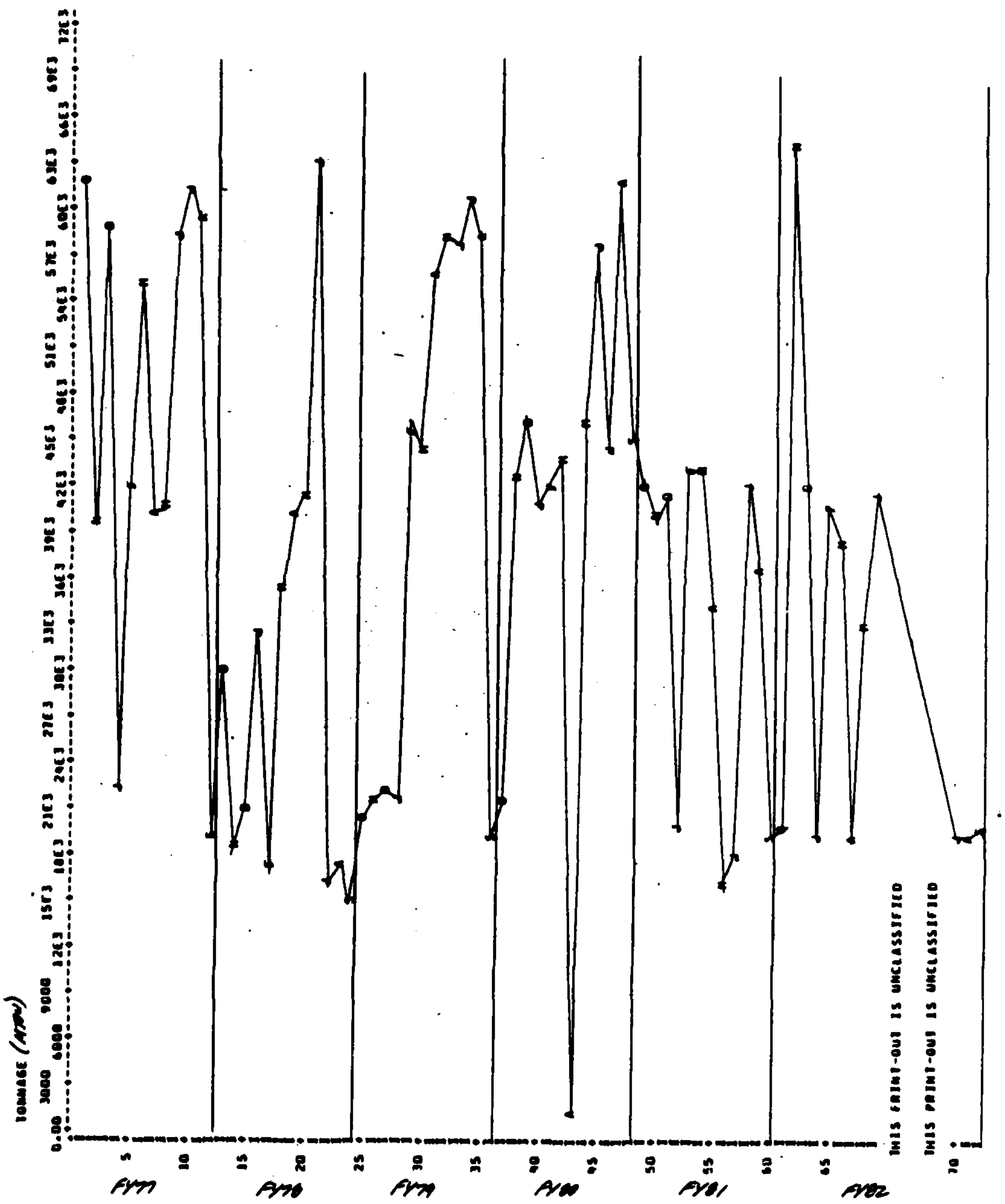
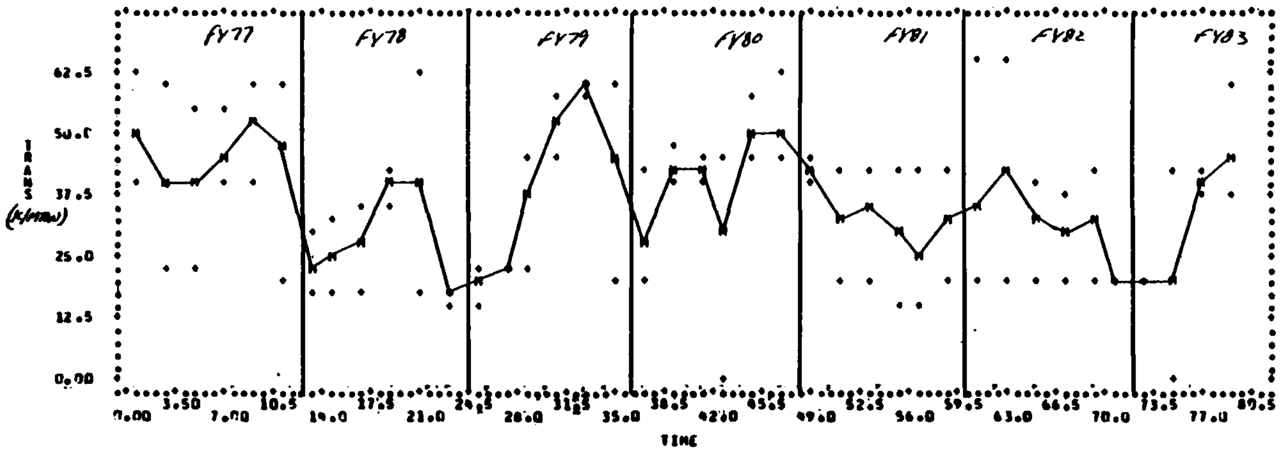
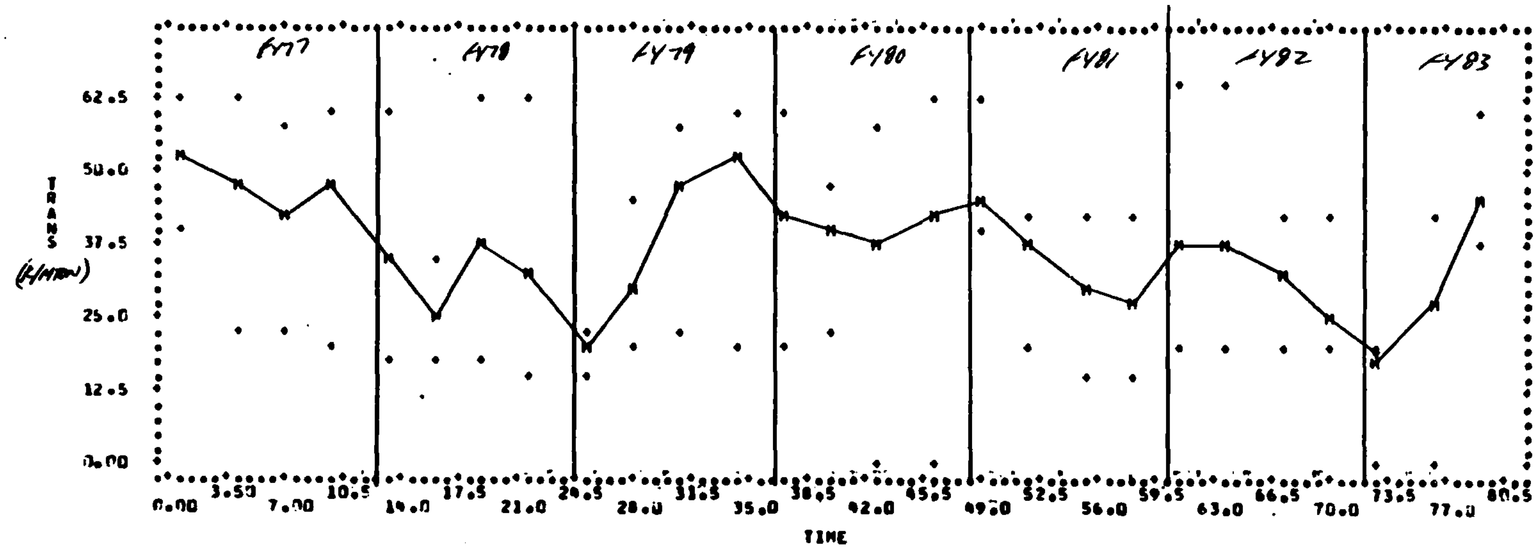


Figure F-37. Coal Cargo FY 77 - FY 82



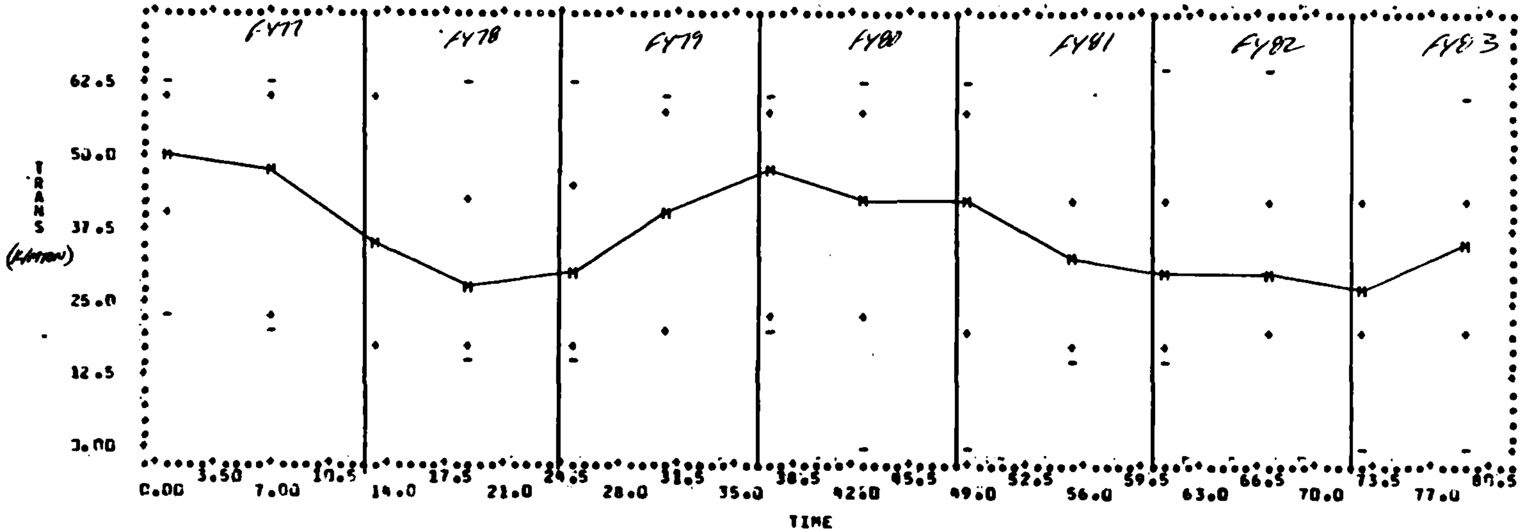
TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	2	39.8610	50.8050	61.7490
3.000	3	21.9340	46.2610	58.9880
5.000	3	21.9340	39.8070	55.2310
7.000	3	31.9026	45.2670	55.2310
9.000	3	47.6680	53.1987	60.9250
11.000	3	19.3400	44.9450	60.9250
13.000	3	18.5990	22.7353	30.2670
15.000	3	18.5990	24.0047	32.4960
17.000	3	17.5330	28.4630	35.9080
19.000	3	35.4080	39.0213	41.3010
21.000	3	16.9730	40.3353	61.1920
23.000	3	16.7770	16.2653	17.5960
25.000	3	14.7770	18.8663	21.3720
27.000	3	21.3720	21.6097	22.1760
29.000	3	21.5210	31.3509	45.8590
31.000	3	44.6727	52.7742	58.0266
33.000	3	57.4620	58.7799	60.8510
35.000	3	19.4920	46.1277	60.8510
37.000	3	19.4920	27.9390	42.7610
39.000	3	40.7350	43.2537	46.2650
41.000	3	40.7350	42.1895	43.8664
43.000	3	.9120	30.3754	46.1370
45.000	3	44.2760	49.3081	57.7550
47.000	3	44.2760	50.3327	61.9430
49.000	3	39.9990	42.1693	44.7790
51.000	3	19.6390	33.7220	41.5780
53.000	3	19.6390	35.2077	41.0597
55.000	3	16.0470	31.1356	41.0597
57.000	3	16.0470	25.3817	42.1530
59.000	3	19.2550	32.6327	42.1530
61.000	3	19.2550	34.4197	64.1160
63.000	3	19.0280	41.6430	64.1160
65.000	3	19.0280	32.6970	43.9160
67.000	3	19.1970	30.1410	38.1970
69.000	3	19.1030	31.2517	41.5670
71.000	3	19.1030	19.4767	19.7120
73.000	3	18.0580	19.7893	20.7850
75.000	3	.0037	20.9736	42.1390
77.000	3	37.0960	42.6809	42.8170
79.000	3	37.0960	46.2174	59.3840

Figure F-38. Three-month Moving Average - Coal



TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	3	39.8610	53.5327	61.7490
4.000	6	21.9340	46.6678	61.7490
7.000	6	21.9340	42.9970	58.0030
10.000	6	19.3400	46.3280	60.9250
13.000	6	18.5990	34.8713	60.9250
16.000	6	17.5330	25.8703	35.4080
19.000	6	17.5330	38.3645	63.1920
22.000	6	14.7770	32.2657	63.1920
25.000	6	14.7770	18.7997	22.1760
28.000	6	20.4530	29.3418	45.8590
31.000	6	21.5210	47.1941	58.0266
34.000	6	19.4920	51.5825	60.8510
37.000	6	19.4920	41.4955	60.8510
40.000	6	21.5640	39.5264	46.2650
43.000	6	.9120	38.5614	57.7504
46.000	6	.9120	42.6330	61.9430
49.000	6	39.9490	45.7175	61.9430
52.000	6	19.6390	38.1550	43.0597
55.000	6	16.0400	28.9870	43.0597
58.000	6	16.0470	27.6995	42.1530
61.000	6	19.2550	37.2797	64.1160
64.000	6	19.0280	37.3118	64.1160
67.000	6	19.0280	31.9930	41.5670
70.000	6	19.1030	25.3448	41.5670
73.000	6	.0037	16.3108	20.7810
76.000	6	.0037	26.9475	42.8100
79.000	5	37.0960	44.7192	59.3840

Figure F-39. Six-month Moving Average - Coal



TIME VALUE	NO. OF CASES	MINIMUM VALUE	TRIMMED MINIMUM	TRIMMED MEAN	TRIMMED MAXIMUM	MAXIMUM VALUE
1.000	6	21.9340	39.8610	49.0810	58.9880	61.7490
7.000	12	19.3400	21.9340	47.6886	60.9250	61.7490
13.000	12	17.5330	18.5990	35.4732	59.1300	60.9250
19.000	12	14.7770	16.4230	27.0897	41.3810	63.1420
25.000	12	14.7770	16.4230	29.1726	45.8590	63.1420
31.000	12	19.4920	20.4500	40.5203	58.0400	60.8510
37.000	12	19.4920	21.5640	46.6310	58.0400	60.8510
43.000	12	.9120	21.5640	43.0102	57.7504	61.9433
49.000	12	.9120	19.6390	42.1873	57.7504	61.9430
55.000	12	16.0400	17.9520	33.6027	42.9244	43.0597
61.000	12	16.0400	17.9520	30.9912	42.1530	64.1160
67.000	12	19.0280	19.1030	29.2796	41.7760	64.1160
73.000	12	.0037	18.8580	27.0940	42.1340	42.8100
79.000	8	.0037	18.8580	33.9755	42.8100	59.3840

Figure F-40. Twelve-month Moving Average - Coal

AUTOCORRELATIONS

1- 12	.34	.16	.07	-.07	-.07	-.14	-.15	-.06	-.06	.06	-.05	0.0
ST.E.	.13	.14	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15
13- 24	.08	.02	-.06	-.15	-.22	-.13	-.09	0.0	-.11	-.21	-.08	.04
ST.E.	.15	.15	.15	.15	.16	.16	.16	.16	.16	.17	.17	.17
25- 36	-.10	-.01	-.09	.06	.12	.04	.03	.06	.02	.03	.01	.03
ST.E.	.17	.17	.17	.17	.17	.17	.17	.18	.18	.18	.18	.18

PLOT OF AUTOCORRELATIONS

```
            -1.0 -.8  -.6  -.4  -.2  .0   .2   .4   .6   .8  1.0
LAG  CORR.   +----+----+----+----+----+----+----+----+----+----+
                                      I
  1   .341                      +     IXXXXX+XXX
  2   .156                     +      IXXXX  +
  3   .069                     +      IXX    +
  4  -.065                     +    XXI      +
  5  -.069                     +    XXI      +
  6  -.140                     +  XXXXI      +
  7  -.150                     +  XXXXI      +
  8  -.060                     +     XI      +
  9  -.059                     +     XI      +
 10   .057                    +       IX      +
 11  -.051                    +      XI       +
 12   .005                    +       I       +
 13   .076                    +       IXX     +
 14   .021                    +       IX      +
 15  -.055                    +      XI       +
 16  -.148                    +   XXXXI       +
 17  -.223                    + XXXXXXI       +
 18  -.132                    +    XXXI       +
 19  -.068                    +     XXI       +
 20   .004                    +       I       +
 21  -.108                    +    XXXI       +
 22  -.214                    +  XXXXXI       +
 23  -.080                    +     XXI       +
 24   .039                    +       IX      +
 25  -.096                    +     XXI       +
 26  -.013                    +       I       +
 27  -.092                    +     XXI       +
 28   .057                    +       IX      +
 29   .120                    +       IXXX    +
 30   .035                   +        IX       +
 31   .029                   +        IX       +
 32   .061                   +        IXX      +
 33   .024                   +        IX       +
 34   .035                   +        IX       +
 35   .009                   +        I        +
 36   .026                   +        IX       +
```

std error
$= \frac{1}{\sqrt{60}}(1.96)$
$= .253$

Figure F-41. ACF - Raw Data - Coal

```
PARTIAL AUTOCORRELATIONS

  1- 12      .34  .05  0.0 -.11 -.02 -.11 -.07  .C3 -.C3  .09 -.13  .C4
  ST.E.      .13  .13  .13  .13  .13  .13  .13  .13  .13  .13  .13  .13

 13- 24      .05 -.02 -.10 -.13 -.14 -.01  .01  .C4 -.17 -.26 -.03  .11
  ST.E.      .13  .13  .13  .13  .13  .13  .13  .13  .13  .13  .13  .13

 25- 36     -.17 -.03 -.19  .06  .07 -.04 -.06 -.C4 -.14 -.04  .11 -.C2
  ST.E.      .13  .13  .13  .13  .13  .13  .13  .13  .13  .13  .13  .13

FLCT OF PARTIAL AUTOCORRELATIONS

            -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG    CORR. +----+----+----+----+----+----+----+----+----+----+
                                                            I
  1    .341                                           +     IXXXXX+XXX
  2    .C45                                           +     IX    +
  3    .C03                                           +     I     +
  4   -.1C9                                           +  XXXI     +
  5   -.C23                                           +    XI     +
  6   -.1C8                                           +  XXXI     +
  7   -.067                                           +   XXI     +
  8    .C29                                           +     IX    +
  9   -.030                                           +    XI     +
 1C    .086                                           +     IXX   +
 11   -.126                                           +  XXXI     +
 12    .C36                                           +     IX    +
 13    .C54                                           +     IX    +
 14   -.018                                           +     I     +
 15   -.1C1                                           +  XXXI     +
 16   -.126                                           +  XXXI     +
 17   -.142                                           + XXXXI     +
 18   -.011                                           +     I     +
 19    .CC9                                           +     I     +
 2C    .043                                           +     IX    +
 21   -.172                                           + XXXXI     +
 22   -.258                                           XXXXXXI     +
 23   -.033                                           +    XI     +
 24    .1C8                                           +     IXXX  +
 25   -.174                                           + XXXXI     +
 26   -.030                                           +    XI     +
 27   -.187                                           +XXXXXI     +
 28    .C57                                           +     IX    +
 29    .066                                           +     IXX   +
 3C   -.040                                           +    XI     +
 31   -.061                                           +   XXI     +
 32   -.C40                                           +    XI     +
 33   -.144                                           + XXXXI     +
 34   -.040                                           +    XI     +
 35    .115                                           +     IXXX  +
 36   -.022                                           +    XI     +
```

Figure F-42. PACF - Raw Data - Codl

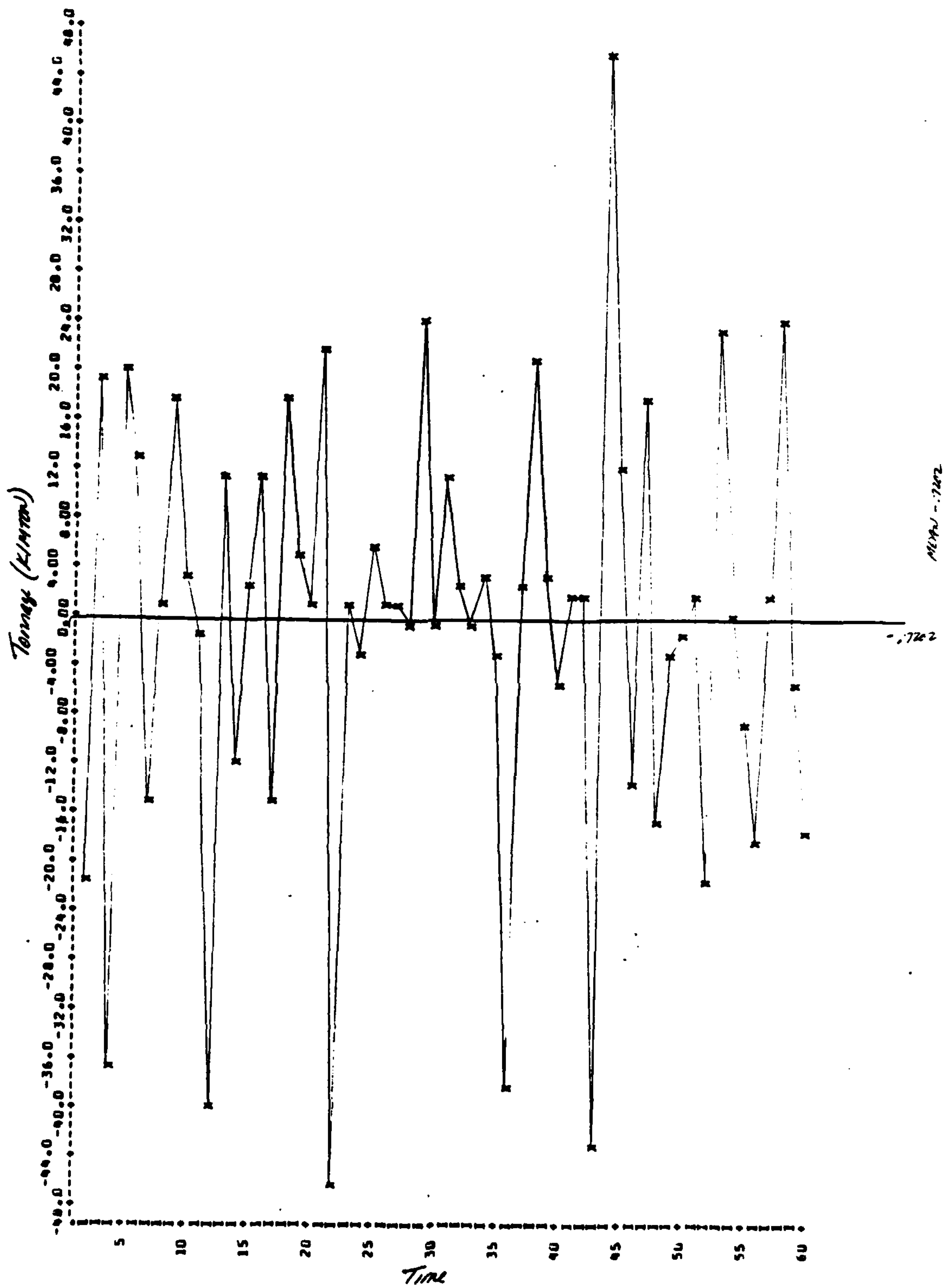


Figure F-43. Differenced Series (1-month lag) - Coal

AUTOCORRELATIONS

1- 12	-.33	-.10	.06	-.13	.05	-.02	-.08	.02	-.07	.18	-.08	-.02
ST.E.	.13	.14	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15
13- 24	.14	0.0	.01	-.01	-.20	.08	-.04	.13	.06	-.19	-.01	.19
ST.E.	.15	.16	.16	.16	.16	.16	.16	.16	.16	.16	.17	.17
25- 36	-.14	.13	-.18	.04	.12	-.09	-.03	.03	-.04	.03	.01	-.02
ST.E.	.17	.17	.17	.18	.18	.18	.18	.18	.18	.18	.18	.18

PLOT OF AUTOCORRELATIONS

```
              -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR.  +----+----+----+----+----+----+----+----+----+----+
                                      I
  1   -.333                   XX+XXXXXI     +
  2   -.097                    +    XXI      +
  3    .061                    +      IXX    +
  4   -.134                    +   XXXI      +
  5    .055                    +      IX     +
  6   -.021                    +     XI      +
  7   -.081                    +    XXI      +
  8    .024                    +      IX     +
  9   -.074                    +    XXI      +
 10    .178                    +      IXXXX  +
 11   -.076                    +    XXI      +
 12   -.024                   +      XI       +
 13    .136                   +       IXXX    +
 14   -.005                   +       I       +
 15    .013                   +       I       +
 16   -.005                   +       I       +
 17   -.204                   +  XXXXXI       +
 18    .075                   +       IXX     +
 19   -.042                   +      XI       +
 20    .132                   +       IXXX    +
 21    .060                   +       IXX     +
 22   -.195                   +  XXXXXI       +
 23   -.007                   +       I       +
 24    .193                   +       IXXXXX  +
 25   -.136                   +    XXXI       +
 26    .132                   +       IXXX    +
 27   -.184                  +   XXXXXI        +
 28    .038                  +        IX       +
 29    .117                  +        IXXX     +
 30   -.069                  +      XXI        +
 31   -.034                  +       XI        +
 32    .029                  +        IX       +
 33   -.044                  +       XI        +
 34    .030                  +        IX       +
 35    .014                  +        I        +
 36   -.020                  +       XI        +
```

std error

$= \frac{1}{\sqrt{59}}(1.96)$

$= .255$

Figure F-44. ACF - Lagged 1 Month

PARTIAL AUTOCORRELATIONS

1- 12	-.33	-.23	-.07	-.19	-.08	-.09	-.16	-.13	-.21	.03	-.09	-.08
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
13- 24	.05	.11	.12	.11	-.11	-.04	-.09	.11	.19	-.04	-.18	.07
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
25- 36	-.07	.08	-.15	-.08	.05	.01	-.08	.02	-.09	-.23	-.06	-.07
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13

PLOT OF PARTIAL AUTOCORRELATIONS

```
             -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG    CORR.  +----+----+----+----+----+----+----+----+----+----+
                                       I
  1    -.333                 XX+XXXXXI     +
  2    -.234                   XXXXXXI     +
  3    -.068                   +   XXI     +
  4    -.166                   +XXXXXI     +
  5    -.076                   +   XXI     +
  6    -.094                   +   XXI     +
  7    -.156                   + XXXXI     +
  8    -.135                   +  XXXI     +
  9    -.212                   +XXXXXI     +
 10     .029                   +     IX    +
 11    -.067                   +   XXI     +
 12    -.083                   +   XXI     +
 13     .052                   +     IX    +
 14     .109                   +     IXXX  +
 15     .117                   +     IXXX  +
 16     .108                   +     IXXX  +
 17    -.109                   +  XXXI     +
 18    -.038                   +    XI     +
 19    -.090                   +   XXI     +
 20     .108                   +     IXXX  +
 21     .166                   +     IXXXXX+
 22    -.039                   +    XI     +
 23    -.178                   + XXXXI     +
 24     .074                   +     IXX   +
 25    -.069                   +   XXI     +
 26     .077                   +     IXX   +
 27    -.152                   + XXXXI     +
 28    -.085                   +   XXI     +
 29     .052                   +     IX    +
 30     .008                   +     I     +
 31    -.060                   +   XXI     +
 32     .017                   +     I     +
 33    -.093                   +   XXI     +
 34    -.231                   XXXXXXI     +
 35    -.057                   +    XI     +
 36    -.075                   +   XXI     +
```

Figure F-45. PACF - Lagged 1 Month

```
ESTIMATION BY BACKCASTING METHOD
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN  .1000-004

SUMMARY OF THE MODEL

OUTPUT VARIABLE -- TRANS
INPUT VARIABLES -- NOISE

VARIABLE   VAR. TYPE  MEAN       TIME      DIFFERENCES
                                                1
TRANS       RANDOM             1-  60  (1-B   )

PARAMETER VARIABLE    TYPE  FACTOR  ORDER ESTIMATE        ST. ERR.  T-RATIC
      1   TRANS        MA      1       1      .8590          .0908      9.46
      2   TRANS        AR      1       1      .3461          .1677      2.06

RESIDUAL SUM OF SQUARES  =      13820.113403 (BACKCASTS EXCLUDED)
DEGREES OF FREEDOM       =                56
RESIDUAL MEAN SQUARE     =        246.787739
```

Figure F-46. Model Parameters - Coal

AUTOCORRELATIONS

1- 12	-.03	0.0	.07	-.11	-.01	-.07	-.11	0.0	-.04	.17	0.0	.05
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.14	.14
13- 24	.16	.05	0.0	-.05	-.21	0.0	-.04	.10	.03	-.18	-.02	.14
ST.E.	.14	.14	.14	.14	.14	.15	.15	.15	.15	.15	.15	.15
25- 36	-.12	.04	-.18	-.01	.06	-.10	-.07	-.01	-.06	.01	0.0	-.02
ST.E.	.15	.16	.16	.16	.16	.16	.16	.16	.16	.16	.16	.16

PLOT OF AUTOCORRELATIONS

```
           -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG    CORR.  +----+----+----+----+----+----+----+----+----+----+
                                       I
  1    -.029                   +    XI     +
  2    -.000                   +     I     +
  3     .065                   +     IXX   +
  4    -.113                   +  XXXI     +
  5    -.008                   +     I     +
  6    -.069                   +   XXI     +
  7    -.105                  +   XXXI      +
  8    -.002                  +      I      +
  9    -.038                  +     XI      +
 10     .172                  +      IXXXX  +
 11     .004                  +      I      +
 12     .046                  +      IX     +
 13     .163                  +      IXXXX  +
 14     .046                  +      IX     +
 15     .004                  +      I      +
 16    -.053                  +     XI      +
 17    -.205                  + XXXXXI      +
 18    -.005                  +      I      +
 19    -.043                  +     XI      +
 20     .098                  +      IXX    +
 21     .028                  +      IX     +
 22    -.178                  +  XXXXI      +    .181(59)=10.87
 23    -.020                  +     XI      +
 24     .136                  +      IXXX   +
 25    -.122                 +    XXXI       +
 26     .044                 +       IX      +
 27    -.184                 +  XXXXXI       +
 28    -.015                 +       I       +
 29     .055                 +       IX      +
 30    -.102                 +    XXXI       +
 31    -.072                 +     XXI       +
 32    -.011                 +       I       +
 33    -.056                 +      XI       +
 34     .005                 +       I       +
 35     .004                 +       I       +
 36    -.017                 +       I       +
```

Figure F-47. Estimated Residuals - Coal

FORECAST ON VARIABLE TRANS FROM TIME PERIOD 61

PERIOD	FORECASTS	ST. ERR.	ACTUAL	ERROR
61	27.37654	15.67752	19.888	-7.489
62	30.18750	17.43874	64.116	33.928
63	31.16040	18.10173	41.776	10.616
64	31.49713	18.51520	19.028	-12.469
65	31.61368	18.85389	40.916	9.302
66	31.65401	19.16555	34.147	2.493
67	31.66798	19.46520	19.197	-12.471
68	31.67281	19.75793	33.085	1.412
69	31.67448	20.04558	41.567	9.893
70	31.67506	20.32888	19.103	-12.572
71	31.67526	20.60620	19.405	-12.27
72	31.67533	20.88374	19.712	-11.963

STANDARD ERROR = 15.6775 (BY CONDITIONAL METHOD)

373.53 375.94 MSE = 192.60

Figure F-48. Forecast FY 82 - Coal

AUTOCORRELATIONS

1- 12	.41	.23	.10	.01	-.05	-.19	-.21	-.01	-.06	.12	.01	.04
ST.E.	.13	.15	.16	.16	.16	.16	.16	.16	.16	.16	.17	.17
13- 24	.05	-.01	-.09	-.21	-.34	-.19	-.16	-.05	-.17	-.17	-.08	.05
ST.E.	.17	.17	.17	.17	.17	.18	.19	.19	.19	.19	.19	.19
25- 36	-.12	-.07	-.12	.02	.08	.02	-.01	.12	.08	.09	.02	.03
ST.E.	.19	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20

PLOT OF AUTOCORRELATIONS

LAG	CORR.
1	.410
2	.230
3	.099
4	.006
5	-.050
6	-.189
7	-.209
8	-.009
9	-.055
10	.123
11	.007
12	.040
13	.046
14	-.007
15	-.092
16	-.206
17	-.335
18	-.190
19	-.155
20	-.046
21	-.172
22	-.172
23	-.080
24	.047
25	-.116
26	-.069
27	-.119
28	.016
29	.082
30	.019
31	-.014
32	.121
33	.085
34	.090
35	.019
36	.034

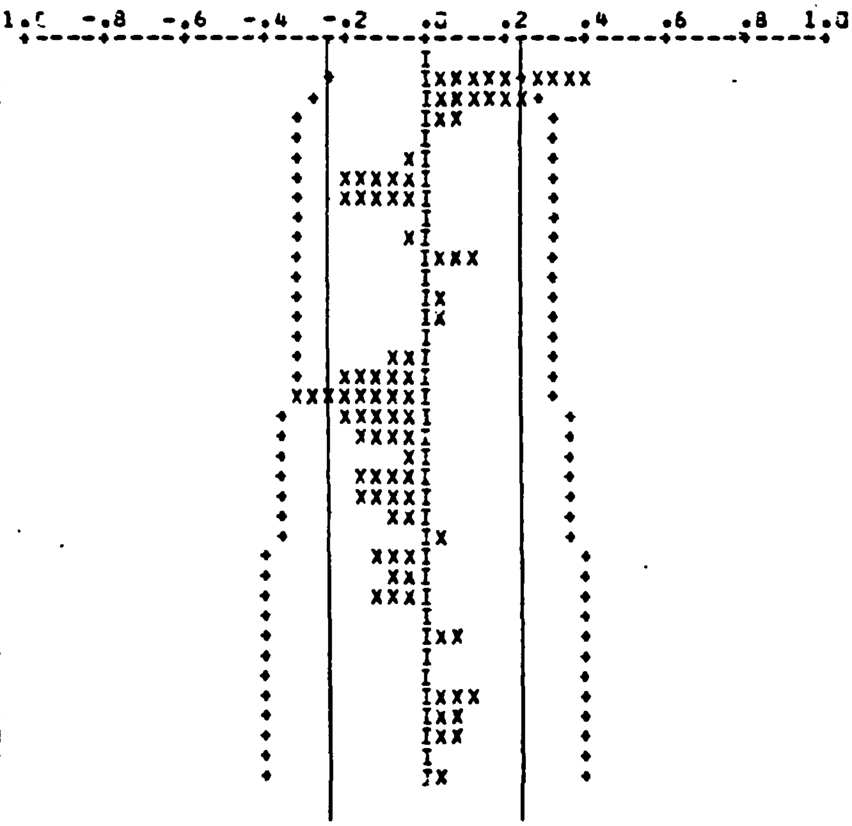


Figure F-49. ACF - Raw Data - Coal Adjusted

PARTIAL AUTOCORRELATIONS

1- 12	.41	.07	-.02	-.05	-.05	-.17	-.08	.18	-.07	.18	-.13	.01
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
13- 24	-.03	-.01	-.09	-.16	-.19	-.01	.04	.02	-.22	-.19	-.08	.12
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
25- 36	-.19	0.0	-.16	-.02	.12	-.06	-.08	.01	-.08	-.12	.10	-.05
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13

PLOT OF PARTIAL AUTOCORRELATIONS

```
            -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG    CORR.   +----+----+----+----+----+----+----+----+----+----+
                                        I
  1     .410                       +     IXXXXX+XXXX
  2     .075                       +     IXX   +
  3    -.023                       +    XI     +
  4    -.050                       +    XI     +
  5    -.048                       +    XI     +
  6    -.174                       +  XXXXI     +
  7    -.083                       +   XXI     +
  8     .184                       +     IXXXXX+
  9    -.074                       +   XXI     +
 10     .180                       +     IXXXX +
 11    -.133                       +  XXXI     +
 12     .014                       +     I     +
 13    -.026                       +    XI     +
 14    -.015                       +     I     +
 15    -.092                       +   XXI     +
 16    -.159                       + XXXXI     +
 17    -.187                       +XXXXXI     +
 18    -.007                       +     I     +
 19     .042                       +     IX    +
 20     .017                       +     I     +
 21    -.223                       XXXXXXI     +
 22    -.188                       +XXXXXI     +
 23    -.082                       +   XXI     +
 24     .115                       +     IXXX  +
 25    -.186                       +XXXXXI     +
 26     .001                       +     I     +
 27    -.158                       + XXXXI     +
 28    -.019                       +     I     +
 29     .118                       +     IXXX  +
 30    -.064                       +   XXI     +
 31    -.080                       +   XXI     +
 32     .008                       +     I     +
 33    -.077                       +   XXI     +
 34    -.118                       +  XXXI     +
 35     .101                       +     IXXX  +
 36    -.051                       +    XI     +
```

Figure F-50. PACF - Raw Data - Coal Adjusted

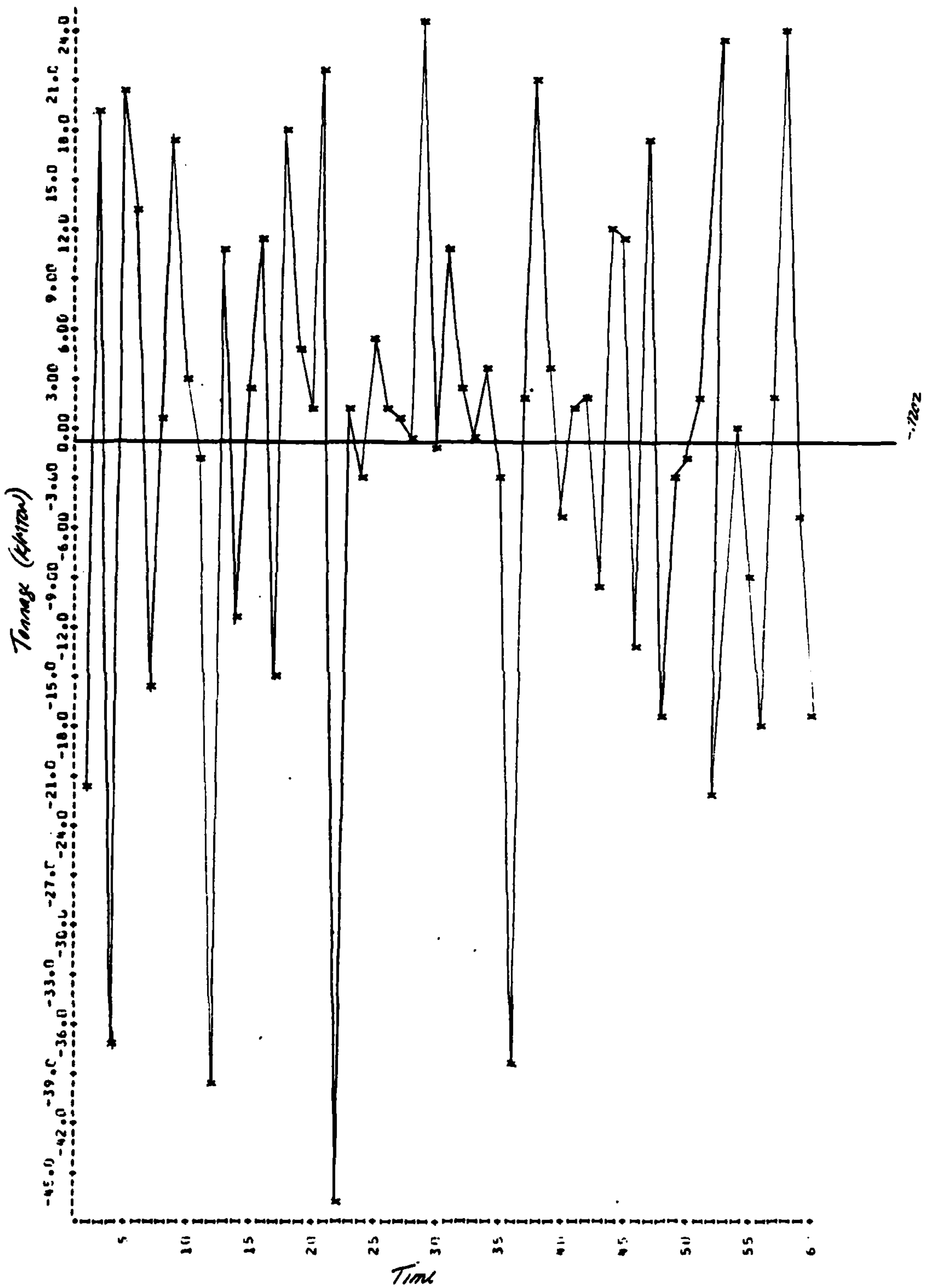


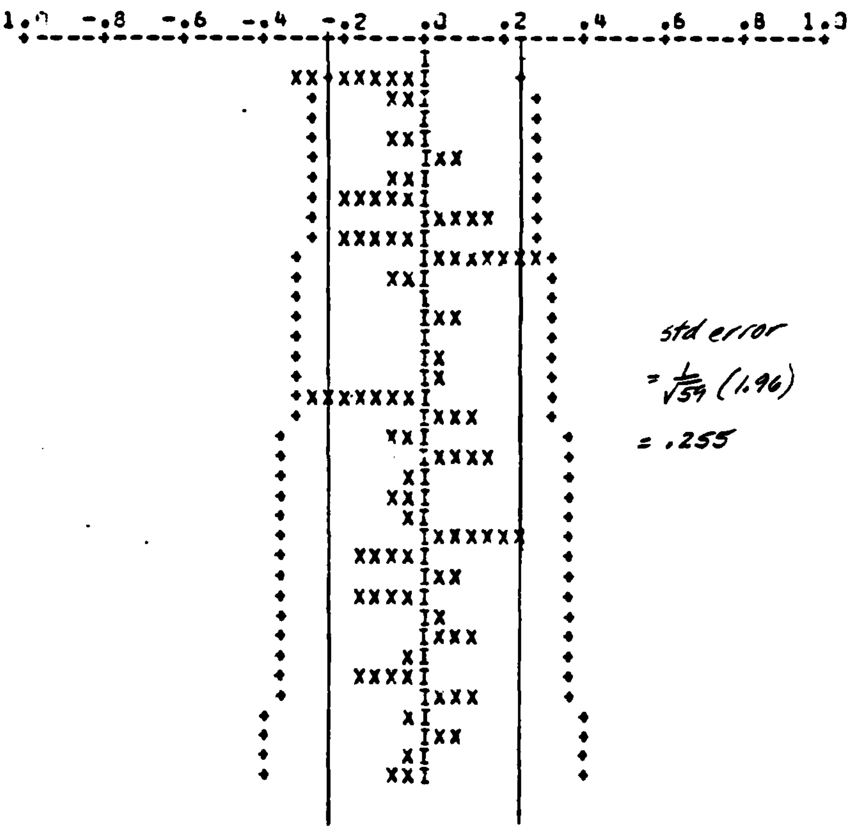
Figure F-51. Differenced Series (1-month lag) Coal Adjusted

AUTOCORRELATIONS

1- 12	-.31	-.07	-.01	-.07	.08	-.07	-.20	.16	-.18	.26	-.07	.01
ST.E.	.13	.14	.14	.14	.14	.14	.14	.15	.15	.16	.16	.15
13- 24	.10	0.0	.03	.02	-.29	.10	-.07	.17	-.03	-.09	-.06	.25
ST.E.	.16	.16	.16	.16	.16	.17	.17	.18	.18	.18	.18	.18
25- 36	-.14	.09	-.17	.03	.11	-.06	-.16	.12	-.04	.07	-.02	-.06
ST.E.	.18	.19	.19	.19	.19	.19	.19	.19	.19	.20	.20	.20

PLOT OF AUTOCORRELATIONS

LAG	CORR.
1	-.313
2	-.067
3	-.009
4	-.068
5	.076
6	-.071
7	-.200
8	.163
9	-.180
10	.265
11	-.068
12	.010
13	.096
14	.002
15	.027
16	.023
17	-.292
18	.105
19	-.072
20	.174
21	-.032
22	-.089
23	-.055
24	.250
25	-.140
26	.091
27	-.170
28	.026
29	.114
30	-.060
31	-.156
32	.121
33	-.045
34	.070
35	-.020
36	-.061



std error $= \frac{1}{\sqrt{59}}(1.96)$

$= .255$

Figure F-52. ACF - Lagged 1 Month

PARTIAL AUTOCORRELATIONS

1- 12	-.31	-.18	-.10	-.14	-.01	-.08	-.30	-.07	-.29	.08	-.05	.03
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
13- 24	.07	.09	.14	.14	-.11	-.07	-.07	.14	.10	.01	-.22	.07
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
25- 36	-.13	0.0	-.09	-.13	.08	-.02	-.15	-.05	-.02	-.20	0.0	-.15
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13

PLOT OF PARTIAL AUTOCORRELATIONS

```
                -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG    CORR.    +----+----+----+----+----+----+----+----+----+----+
                                         I
  1    -.313                     XX+XXXXXI     +
  2    -.183                       +XXXXXI     +
  3    -.105                       +  XXXI     +
  4    -.138                       +  XXXI     +
  5    -.009                       +     I     +
  6    -.084                       +   XXI     +
  7    -.300                      X+XXXXXI     +
  8    -.065                       +   XXI     +
  9    -.286                      X+XXXXXI     +
 10     .077                       +     IXX   +
 11    -.052                       +    XI     +
 12     .028                       +     IX    +
 13     .069                       +     IXX   +
 14     .095                       +     IXX   +
 15     .138                       +     IXXX  +
 16     .139                       +     IXXX  +
 17    -.107                       +  XXXI     +
 18    -.074                       +   XXI     +
 19    -.069                       +   XXI     +
 20     .142                       +     IXXXX +
 21     .097                       +     IXX   +
 22     .012                       +     I     +
 23    -.221                       XXXXXXI     +
 24     .065                       +     IXX   +
 25    -.134                       +  XXXI     +
 26    -.001                       +     I     +
 27    -.092                       +   XXI     +
 28    -.125                       +  XXXI     +
 29     .077                       +     IXX   +
 30    -.020                       +     I     +
 31    -.147                       + XXXXI     +
 32    -.046                       +    XI     +
 33    -.019                       +     I     +
 34    -.198                       +XXXXXI     +
 35    -.003                       +     I     +
 36    -.153                       + XXXXI     +
```

Figure F-53. PACF - Lagged 1 Month

```
ESTIMATION BY BACKCASTING METHOD
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN  .1000-004

SUMMARY OF THE MODEL

OUTPUT VARIABLE -- TRANS
INPUT VARIABLES -- NOISE

VARIABLE  VAR. TYPE  MEAN      TIME     DIFFERENCES
                                           1
TRANS      RANDOM              1-  60  (1-B  )

PARAMETER VARIABLE   TYPE  FACTOR  ORDER ESTIMATE        ST. ERR.  T-RATIO
      1   TRANS       MA      1       1     .7693          .0794      9.69
      2   TRANS       MA      1      10   -.2705          .0711     -3.80
      3   TRANS       AR      1       1     .2168          .1484      1.46

RESIDUAL SUM OF SQUARES  =      9903.394165 (BACKCASTS EXCLUDED)
DEGREES OF FREEDOM       =               55
RESIDUAL MEAN SQUARE     =       180.061710
```

Figure F-54. Model Parameters - Coal Adjusted

AUTOCORRELATIONS

1- 12	.02	-.04	-.01	-.06	.03	-.06	-.14	.10	-.07	.06	-.05	.04
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.14	.14
13- 24	.08	.03	.03	-.05	-.26	-.02	-.05	.15	-.01	-.12	-.05	.17
ST.E.	.14	.14	.14	.14	.14	.15	.15	.15	.15	.15	.15	.15
25- 36	-.13	.01	-.15	-.02	.09	-.07	-.14	.09	.01	.03	.01	-.04
ST.E.	.15	.16	.16	.16	.16	.16	.16	.16	.16	.16	.16	.16

PLOT OF AUTOCORRELATIONS

```
            -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR.   +----+----+----+----+----+----+----+----+----+----+
                                       I
  1     .020                      +    I    +
  2    -.043                      +   XI    +
  3    -.014                      +    I    +
  4    -.056                      +   XI    +
  5     .027                      +    IX   +
  6    -.065                      +  XXI    +
  7    -.143                      +XXXXI    +
  8     .100                     +     IXX   +
  9    -.072                     +   XXI     +
 10     .062                     +     IXX   +
 11    -.049                     +    XI     +
 12     .035                     +     IX    +
 13     .085                     +     IXX   +
 14     .030                     +     IX    +
 15     .033                     +     IX    +
 16    -.050                     +    XI     +
 17    -.260                    XXXXXXXI     +
 18    -.023                     +    XI     +
 19    -.047                     +    XI     +
 20     .148                     +     IXXXX +
 21    -.009                     +     I     +
 22    -.124                     +   XXXI     +
 23    -.054 .175(60)=10.51      +    XI     +
 24     .175                     +     IXXXX +
 25    -.134                    +   XXXI      +
 26     .005                    +      I      +
 27    -.151                    +  XXXXI      +
 28    -.018                    +      I      +
 29     .093                    +      IXX    +
 30    -.074                    +    XXI      +
 31    -.136                    +   XXXI      +
 32     .094                    +      IXX    +
 33     .008                    +      I      +
 34     .030                    +      IX     +
 35     .013                    +      I      +
 36    -.036                    +     XI      +
```

Figure F-55. Estimated Residuals - Coal Adjusted

FORECAST ON VARIABLE TRANS FROM TIME PERIOD 61

PERIOD	FORECASTS	ST. ERR.	ACTUAL	ERROR
61	25.70256	15.46104	19.888	-5.814
62	23.11375	16.93817	64.116	41.003
63	28.94411	17.67957	41.776	12.832
64	34.56539	18.28460	19.028	-15.537
65	36.85821	18.84892	40.916	4.058
66	34.34627	19.39238	38.247	3.901
67	31.67653	19.92009	19.197	-12.479
68	36.47410	20.43398	33.085	-3.389
69	39.01207	20.93522	41.567	2.555
70	36.44484	21.42472	19.103	-17.342
71	35.88835	23.13714	19.405	-16.483
72	35.76772	25.06581	19.712	-16.055

STANDARD ERROR = 15.4610 (BY CONDITIONAL METHOD)

398.80

376.67

MSE = 262.99

Figure F-56. Forecast FY 82 - Coal Adjusted

F-6. AMMUNITION

a. The raw series for ammunition is depicted in Figure F-57. The raw series depicts a recurring pattern with the troughs occurring in the first two quarters of each fiscal year and the peaks in the latter two quarters. This pattern is more identifiable in the 3-month and 6-month moving average diagrams (Figures F-58 and F-59). However, a visual examination of the 12-month moving average (Figure F-60) indicates that the amount of ammunition shipped from year to year has remained relatively constant with a slight trend downwards.

b. Autocorrelation function analysis of the model data confirms the evidence of a trend in the data and suggests the possibility of seasonal data (Figure F-61). The seasonality in the data was eliminated by differencing the series at a lag of 12 months. The autocorrelation function of the resulting series is depicted in Figure F-62. Stationarity in the data has not been achieved as evidenced by an increasing trend in the autocorrelation function for lags 1-4. Attempts to achieve stationarity through differencing or other transformations of the seasonally adjusted series were futile. Therefore, the original series was differenced at a lag of one month and the plot is depicted in Figure F-63.

c. The autocorrelation and partial autocorrelation of the differenced series are illustrated in Figures F-64 and F-65. Analysis of the autocorrelation function indicates that an ARIMA (2,1,0) model is appropriate to model the data. This model was tested and the resulting fit of the model was not good due to significant autocorrelation coefficients at lags 4 through 7. To improve the fit of the model, MA parameters were added. The resulting model was an ARIMA (2,1,4) model of the form:

$$(1-\phi_1 B - \phi_2 B^2)(1-B)X_t = (1-\theta_4 B^4 - \theta_5 B^5 - \theta_6 B^6 - \theta_7 B^7)\epsilon_t$$

d. The results of the model (Figure F-66) are as follows:

$$\underset{(-7.33)}{(1+.8418B} + \underset{(-4.59)}{.5399 B^2)}(1-B)X_t = (1\underset{(-3.11)}{+.3454B^4}\underset{(3.86)}{-.3689B^5}\underset{(4.57)}{-.3875B^6}\underset{(2.43)}{-.2561^7})\epsilon_t$$

$$x^2\ (6,20) = 17.61$$

All of the estimated parameters are significant at the 5 percent significance level. The Q statistic for the model (Figure F-67) indicates that the null hypothesis, estimated residuals are uncorrelated, should not be rejected at the 40 percent significance level.

e. The model forecasted that ammunition shipments during FY 82 would be 189.62 K/MTON (Figure F-68). The actual lift of ammunition during FY 82 was 179.31. The MSE of the ammunition forecast was 119.91 and the annual forecast error was 5.7 percent. It should be noted that this model, used in conjunction with a slightly modified model, resulted in an annual forecast error of .3 percent.

f. Problems with attaining stationarity in the data are in part attributed to outliers in the data series. The amounts of tonnage shipped during February 1980, November 1980, and January 1981 are far below the average amount of ammunition shipped during a given month. Like coal, the ammunition data series should be monitered and adjusted with extreme care. An attempt was made to modify the data series, however, additional work in this area is required before adequate modeling can proceed.

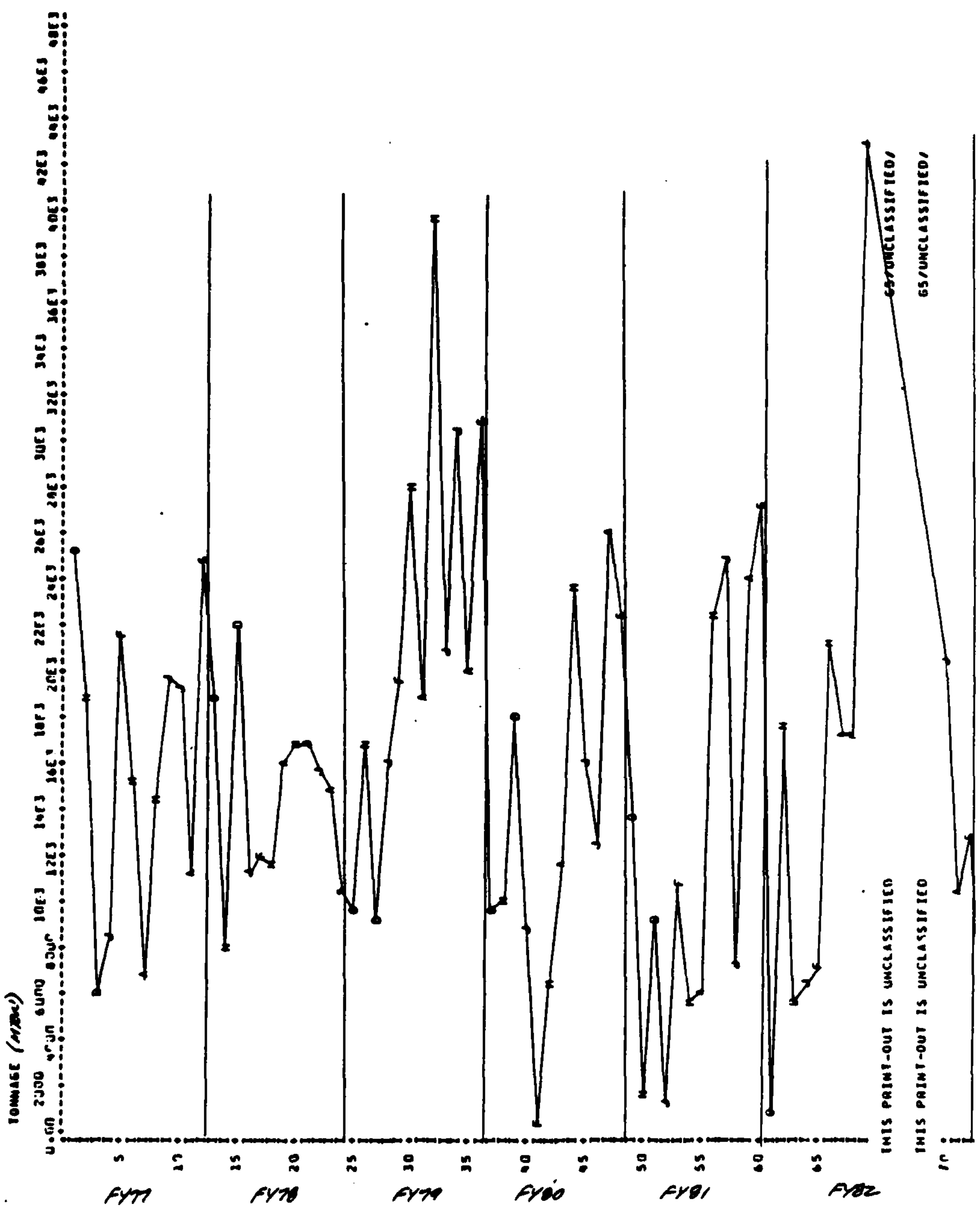
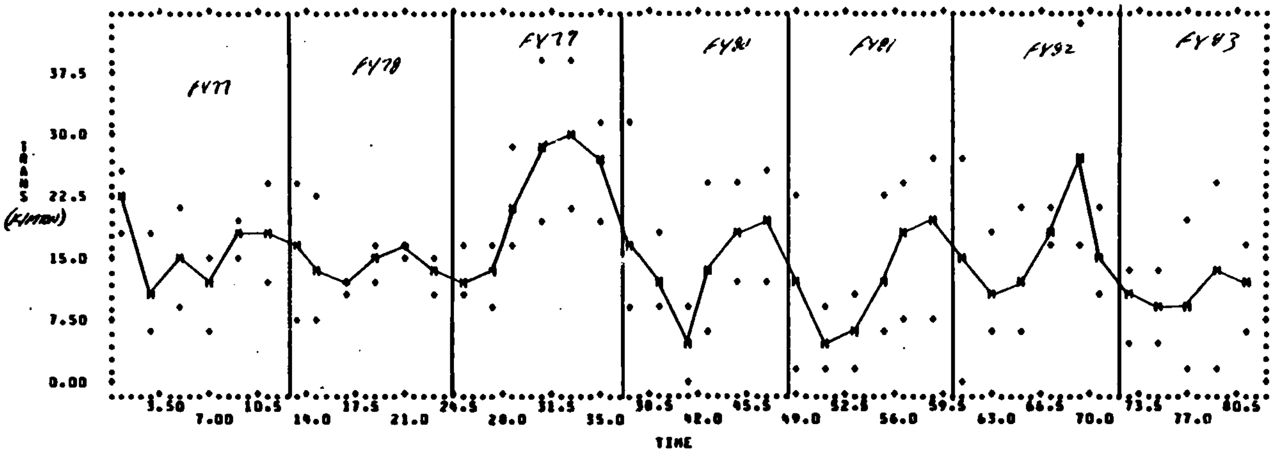
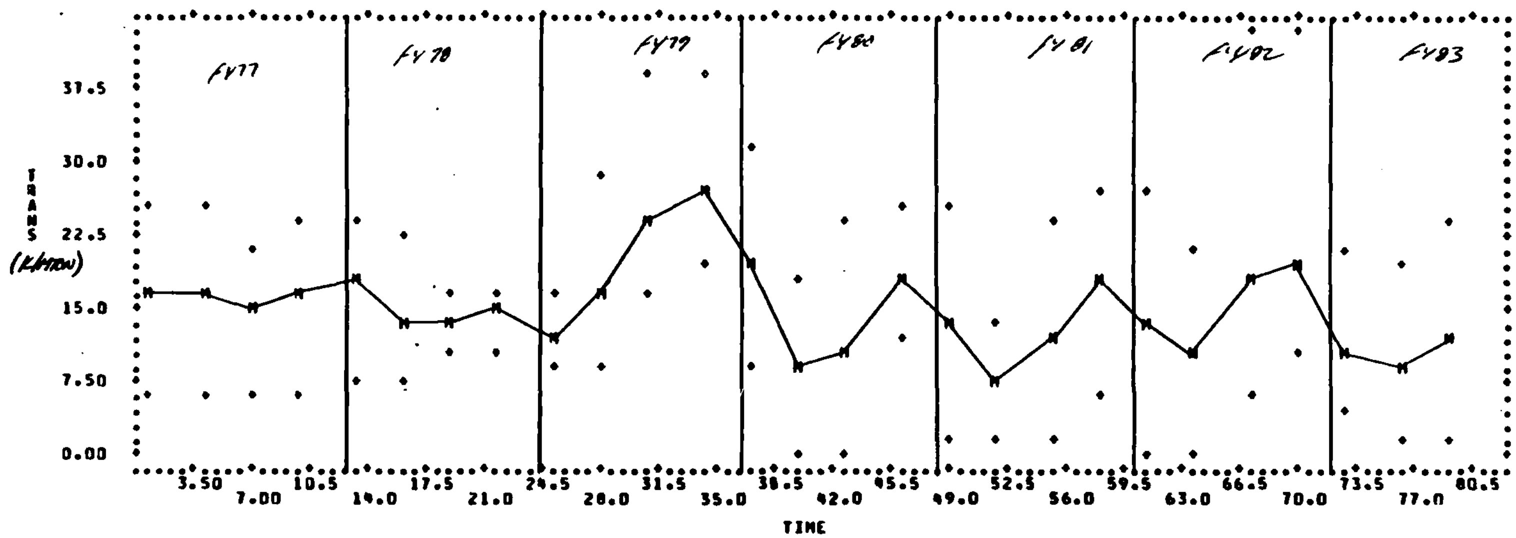


Figure F-57. Ammunition Cargo FY 77 - FY 82



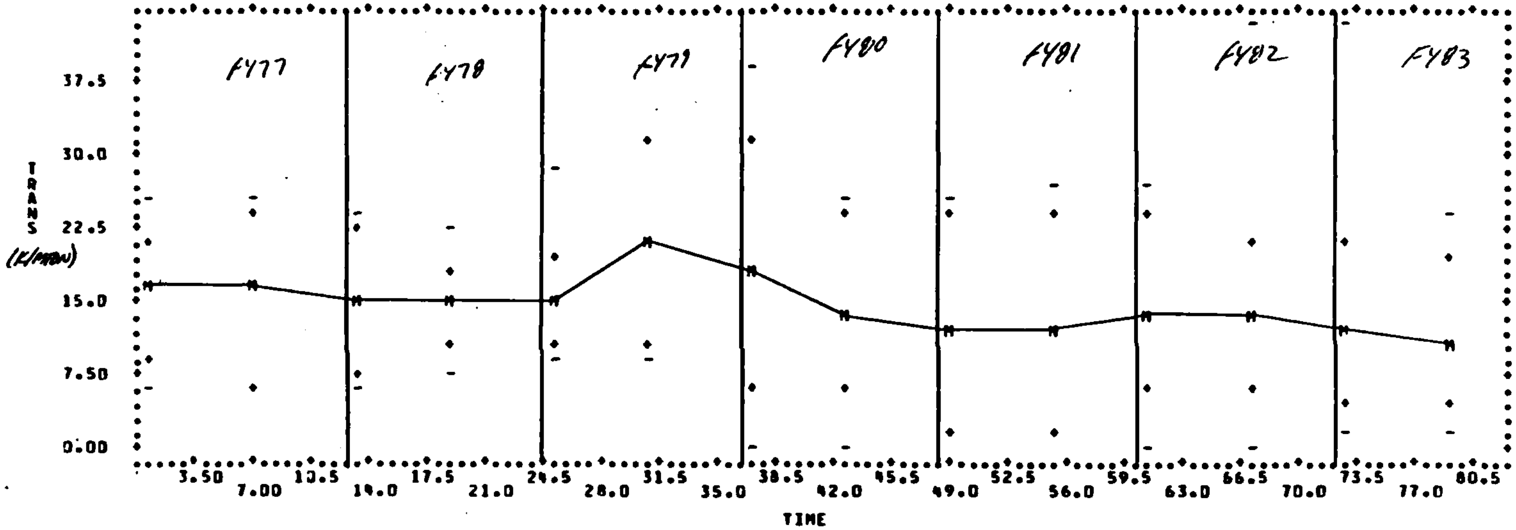
TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	2	18.6054	21.9412	25.2773
3.000	3	5.8570	10.9691	18.6054
5.000	3	8.4300	15.1283	21.6070
7.000	3	6.6960	12.1830	15.3480
9.000	3	14.5050	17.7237	19.5950
11.000	3	11.3190	18.3663	24.7093
13.000	3	7.9900	17.1107	24.7093
15.000	3	7.9900	13.6729	21.9550
17.000	3	11.0738	11.5955	12.1969
19.000	3	11.5163	14.7511	16.7197
21.000	3	15.4436	16.3716	16.9514
23.000	3	10.4451	13.5629	15.4436
25.000	3	9.7973	12.3711	16.8709
27.000	3	9.0937	13.9552	16.8709
29.000	3	15.9010	21.1055	27.9130
31.000	3	18.9489	28.7573	39.4099
33.000	3	20.6076	30.1368	39.4099
35.000	3	19.8860	27.0322	30.8177
37.000	3	9.6241	16.7715	30.8177
39.000	3	8.6192	12.1439	17.9396
41.000	3	.5154	5.2056	8.6192
43.000	3	6.4821	13.8747	23.4551
45.000	3	12.3595	17.2782	23.4551
47.000	3	12.3595	20.2429	25.8786
49.000	3	1.6279	12.5351	22.4935
51.000	3	1.2351	3.9907	9.1090
53.000	3	1.2351	5.8947	10.9083
55.000	3	5.5409	11.3291	22.2604
57.000	3	7.0733	17.9823	24.6131
59.000	3	7.0733	19.4165	27.3331
61.000	3	.6620	15.1090	27.3331
63.000	3	5.4822	9.8318	17.5570
65.000	3	6.4562	11.6254	21.0274
67.000	3	17.2187	18.4919	21.0274
69.000	3	17.2187	26.8211	42.9027
71.000	3	10.3941	14.4617	20.3419
73.000	3	4.8552	10.3689	13.6024
75.000	3	5.0458	8.2854	13.6024
77.000	3	1.5781	9.2399	19.9335
79.000	3	1.5781	10.0386	23.4994
81.000	2	5.8467	11.4425	17.0384

Figure F-58. Three-month Moving Average - Ammunition



TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	3	5.8570	16.5798	25.2770
4.000	6	5.8570	15.8541	25.2770
7.000	6	6.6960	14.3635	21.6070
10.000	6	6.6960	15.9825	24.7090
13.000	6	7.9900	17.2795	24.7090
16.000	6	7.9900	13.8941	21.9550
19.000	6	11.0738	14.0792	16.9514
22.000	6	10.4451	15.0629	16.9514
25.000	6	9.0937	12.7418	16.8709
28.000	6	9.0937	16.5131	27.9130
31.000	6	15.9010	23.7139	39.4099
34.000	6	18.9489	26.6772	39.4099
37.000	6	9.6241	19.7555	30.8177
40.000	6	.5154	8.8422	17.9396
43.000	6	.5154	11.1298	23.4551
46.000	6	11.6867	18.6484	25.8786
49.000	6	1.6279	14.1587	25.8785
52.000	6	1.2351	6.9846	13.4869
55.000	6	1.2351	11.7906	24.6131
58.000	6	6.1860	18.5515	27.3331
61.000	6	.6620	13.6585	27.3331
64.000	6	.6620	9.7629	21.0274
67.000	6	6.4562	19.7043	42.9027
70.000	6	10.3941	20.1224	42.9027
73.000	6	4.8552	11.1481	20.3419
76.000	6	1.5781	8.5372	19.9335
79.000	6	1.5781	12.3507	23.4994

Figure F-59. Six-month Moving Average - Ammunition



TIME VALUE	NO. OF CASES	MINIMUM VALUE	TRIMMED MINIMUM	TRIMMED MEAN	TRIMMED MAXIMUM	MAXIMUM VALUE
1.000	6	5.8570	8.4300	15.9976	21.6073	25.2773
7.000	12	5.8570	6.6960	15.9885	24.7090	25.2770
13.000	12	6.6960	7.9900	14.7855	21.9550	24.7090
19.000	12	7.9900	10.4451	14.3797	18.6330	21.9550
25.000	12	9.0937	9.7973	15.2449	19.5024	27.9130
31.000	12	9.0937	9.7973	21.0638	33.8177	39.4099
37.000	12	.5154	6.4821	17.3191	33.8177	39.4099
43.000	12	.5154	6.4821	13.8553	23.4551	25.8786
49.000	12	1.2351	1.6279	12.6685	23.4551	25.8786
55.000	12	1.2351	1.6279	12.4649	24.6131	27.3331
61.000	12	.6620	5.4822	14.1891	24.6131	27.3331
67.000	12	.6620	5.4822	13.5747	21.3274	42.9027
73.000	12	1.5781	4.8552	12.7477	23.3419	42.9027
79.000	9	1.5781	4.8557	10.3614	19.9335	23.4994

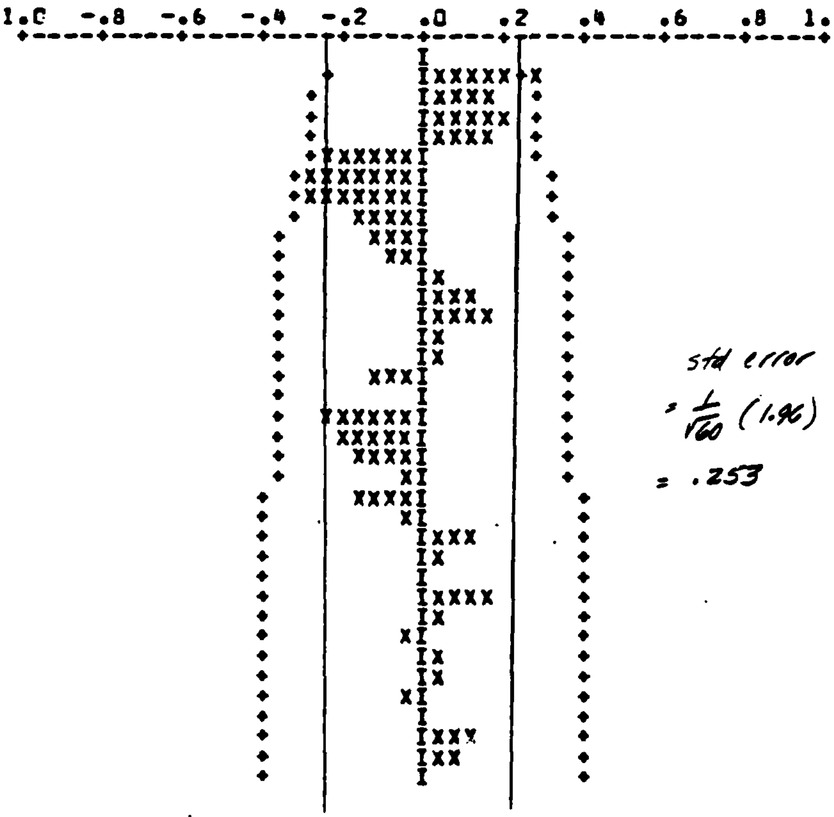
Figure F-60. Twelve-month Moving Average - Ammunition

AUTOCORRELATIONS

1- 12	.27	.16	.18	.17	-.26	-.29	-.29	-.16	-.12	-.07	.03	.13
ST.E.	.13	.14	.14	.15	.15	.16	.16	.17	.18	.18	.18	.18
13- 24	.17	.04	.03	-.11	0.0	-.23	-.22	-.17	-.03	-.16	-.03	.12
ST.E.	.18	.18	.18	.18	.18	.18	.19	.19	.19	.19	.20	.20
25- 36	.05	0.0	.15	.03	-.04	.02	.05	-.04	-.01	.11	.08	.01
ST.E.	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20

PLOT OF AUTOCORRELATIONS

LAG	CORR.
1	.272
2	.165
3	.185
4	.167
5	-.255
6	-.290
7	-.289
8	-.157
9	-.124
10	-.066
11	.029
12	.125
13	.159
14	.038
15	.030
16	-.109
17	.004
18	-.229
19	-.218
20	-.155
21	-.028
22	-.165
23	-.033
24	.116
25	.048
26	.002
27	.147
28	.027
29	-.041
30	.024
31	.047
32	-.039
33	-.009
34	.112
35	.079
36	.010



std error

$= \frac{1}{\sqrt{60}} (1.96)$

$= .253$

Figure F-61. ACF - Raw Data - Ammunition

AUTOCORRELATIONS

1- 12	.19	.28	.22	.39	-.12	-.01	-.08	-.15	-.26	-.15	-.13	-.45
ST.E.	.14	.15	.16	.17	.18	.19	.19	.19	.19	.20	.20	.20
13- 24	.01	-.13	-.09	-.18	.19	-.10	-.01	-.04	.14	-.15	-.03	.12
ST.E.	.22	.22	.22	.22	.23	.23	.23	.23	.23	.23	.23	.23
25- 36	-.01	-.08	.04	.09	-.04	.02	.01	.01	-.04	.09	-.04	-.07
ST.E.	.24	.24	.24	.24	.24	.24	.24	.24	.24	.24	.24	.24

PLOT OF AUTOCORRELATIONS

```
            -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR.   +----+----+----+----+----+----+----+----+----+----+
                                       I
  1    .190                     +      IXXXXX +
  2    .275                     +      IXXXXXXX
  3    .224                    +       IXXXXXXX +
  4    .394                    +       IXXXXXXX+XX
  5   -.121                   +     XXXI        +
  6   -.010                   +        I        +
  7   -.084                   +      XXI        +
  8   -.154                   +    XXXXI        +
  9   -.263                   + XXXXXXXI        +
 10   -.149                  +     XXXXI         +
 11   -.129                  +      XXXI         +
 12   -.451                 X+XXXXXXXXXI         +
 13    .035                 +          I          +
 14   -.125                 +       XXXI          +
 15   -.097                 +        XXI          +
 16   -.183                 +     XXXXXI          +
 17    .189                 +          IXXXXX     +
 18   -.097                 +        XXI          +
 19   -.014                 +          I          +
 20   -.038                 +         XI          +
 21    .141                 +          IXXXX      +
 22   -.154                 +      XXXXI          +
 23   -.034                 +         XI          +
 24    .119                +           IXXX        +
 25   -.005                +           I           +
 26   -.081                +         XXI           +
 27    .038                +           IX          +
 28    .088                +           IXX         +
 29   -.037                +          XI           +
 30    .024                +           IX          +
 31    .008                +           I           +
 32    .011                +           I           +
 33   -.036                +          XI           +
 34    .094                +           IXX         +
 35   -.045                +          XI           +
 36   -.069                +         XXI           +
```

std error

$= \frac{1}{\sqrt{48}} (1.96)$

$= .283$

Figure F-62. ACF - Lagged 12 Months

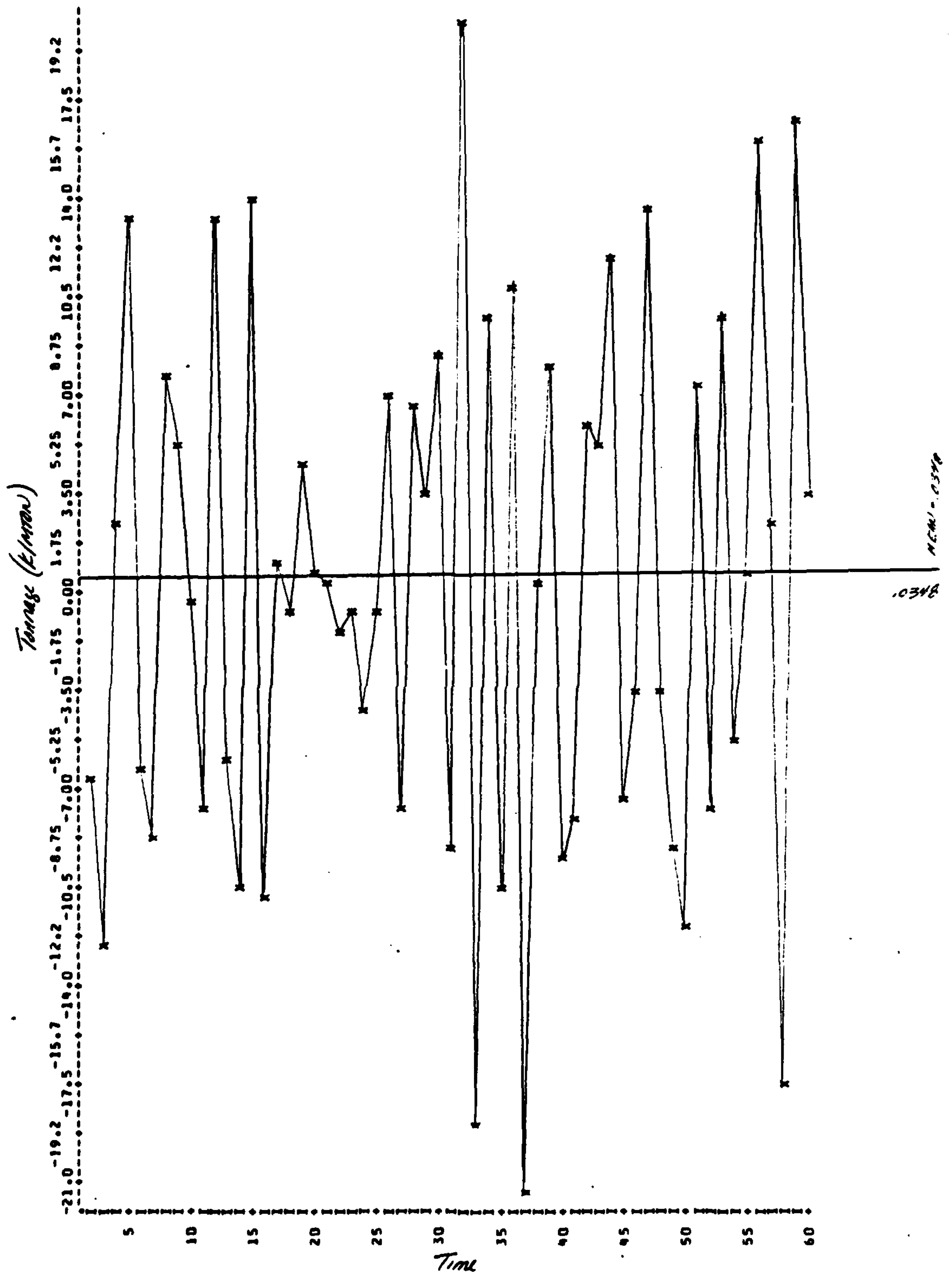


Figure F-63. Differenced Series (1-month lag) - Ammunition

AUTOCORRELATIONS

```
 1- 12    -.43 -.03 -.02  .27 -.23 -.01 -.12  .08 -.03  0.0 -.05  .03
 ST.E.     .13  .15  .15  .15  .16  .17  .17  .17  .17  .17  .17  .17

13- 24     .14 -.08  .11 -.20  .28 -.17 -.02 -.08  .18 -.17  0.0  .11
 ST.E.     .17  .17  .17  .17  .18  .18  .19  .19  .19  .19  .19  .19

25- 36     0.0 -.15  .20 -.09 -.07  .03  .06 -.04 -.07  .11  .02  0.0
 ST.E.     .19  .19  .19  .20  .20  .20  .20  .20  .20  .20  .20  .20
```

PLOT OF AUTOCORRELATIONS

```
            -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR. +----+----+----+----+----+----+----+----+----+----+
                                     I
  1   -.425               XXXXX+XXXXXI     +
  2   -.030                   +     XI      +
  3   -.017                   +      I      +
  4    .271                   +      IXXXXXXX
  5   -.230                  + XXXXXXI       +
  6   -.008                  +       I       +
  7   -.121                  +    XXXI       +
  8    .084                  +       IXX     +
  9   -.035                  +      XI       +
 10    .005                  +       I       +
 11   -.052                  +      XI       +
 12    .029                  +       IX      +
 13    .137                  +       IXXX    +
 14   -.083                  +     XXI       +
 15    .105                  +       IXXX    +
 16   -.199                  +  XXXXXI       +
 17    .275                 +        IXXXXXXX +
 18   -.171                 +    XXXXI        +
 19   -.018                 +        I        +
 20   -.079                 +      XXI        +
 21    .179                 +        IXXXX    +
 22   -.173                 +    XXXXI        +
 23   -.003                 +        I        +
 24    .108                 +        IXXX     +
 25   -.004                 +        I        +
 26   -.147                 +    XXXXI        +
 27    .199                +         IXXXXX    +
 28   -.086                +       XXI         +
 29   -.065                +       XXI         +
 30    .027                +         IX        +
 31    .059                +         IX        +
 32   -.040                +        XI         +
 33   -.069                +       XXI         +
 34    .112                +         IXXX      +
 35    .022                +         IX        +
 36   -.002                +         I         +
```

std error

$= \frac{1}{\sqrt{59}}(1.96)$

$= .255$

Figure F-64. ACF - Lagged 1 Month

```
PARTIAL  AUTOCORRELATIONS

  1- 12    -.43  -.26  -.19   .23   .01  -.07  -.28  -.26  -.11   .02   .05  -.07
  ST.E.     .13   .13   .13   .13   .13   .13   .13   .13   .13   .13   .13   .13

 13- 24     .05  -.04   .15  -.17   .10  -.02  -.08  -.04   .01   0.0  -.12   .13
  ST.E.     .13   .13   .13   .13   .13   .13   .13   .13   .13   .13   .13   .13

 25- 36    -.01  -.16   .04  -.11  -.10  -.14   .03  -.01  -.01   .03   .07   .10
  ST.E.     .13   .13   .13   .13   .13   .13   .13   .13   .13   .13   .13   .13
```

```
PLOT OF PARTIAL AUTOCORRELATIONS

             -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG     CORR.  +----+----+----+----+----+----+----+----+----+----+
                                        I
  1    -.425                 XXXXX+XXXXXI     +
  2    -.258                      XXXXXXI     +
  3    -.186                      +XXXXXI     +
  4     .232                      +     IXXXXXX
  5     .012                      +     I     +
  6    -.068                      +   XXI     +
  7    -.283                     X+XXXXXI     +
  8    -.262                     X+XXXXXI     +
  9    -.108                      +  XXXI     +
 10     .016                      +     I     +
 11     .047                      +     IX    +
 12    -.065                      +   XXI     +
 13     .052                      +     IXX   +
 14    -.044                      +    XI     +
 15     .154                      +     IXXXX +
 16    -.167                      + XXXXI     +
 17     .098                      +     IXX   +
 18    -.021                      +    XI     +
 19    -.082                      +   XXI     +
 20    -.044                      +    XI     +
 21     .012                      +     I     +
 22    -.000                      +     I     +
 23    -.122                      +  XXXI     +
 24     .134                      +     IXXX  +
 25    -.013                      +     I     +
 26    -.163                      + XXXXI     +
 27     .039                      +     IX    +
 28    -.109                      +  XXXI     +
 29    -.095                      +   XXI     +
 30    -.141                      + XXXXI     +
 31     .034                      +     IX    +
 32    -.007                      +     I     +
 33    -.007                      +     I     +
 34     .034                      +     IX    +
 35     .074                      +     IXX   +
 36     .101                      +     IXXX  +
```

Figure F-65. PACF - Lagged 1 Month

```
ESTIMATION BY BACKCASTING METHOD
* * * WARNING.  MAXIMUM NO. OF ITERATIONS ( 10) USED.

SUMMARY OF THE MODEL

OUTPUT VARIABLE -- TRANS
INPUT VARIABLES -- NOISE

VARIABLE   VAR. TYPE  MEAN       TIME      DIFFERENCES
                                                 1
TRANS       RANDOM              1-  60  (1-B  )

PARAMETER VARIABLE    TYPE   FACTOR   ORDER ESTIMATE         ST. ERR.   T-RATIO
    1    TRANS         MA       1       4     -.3454           .1111      -3.11
    2    TRANS         MA       1       5      .3689           .0955       3.86
    3    TRANS         MA       1       6      .3875           .0848       4.57
    4    TRANS         MA       1       7      .2561           .1053       2.43
    5    TRANS         AR       1       1     -.8418           .1148      -7.33
    6    TRANS         AR       1       2     -.5399           .1176      -4.59

RESIDUAL SUM OF SQUARES  =      2111.992340 (BACKCASTS EXCLUDED)
DEGREES OF FREEDOM       =               51
RESIDUAL MEAN SQUARE     =        41.411614
```

Figure F-66. Model Parameters - Ammunition

AUTOCORRELATIONS

1- 12	-.06	.05	.01	.04	-.14	-.21	-.19	-.06	-.05	.04	0.0	.15
ST.E.	.13	.13	.13	.13	.13	.13	.14	.14	.14	.14	.14	.14
13- 24	.11	-.09	.07	-.09	.17	-.19	-.10	-.14	.02	-.09	-.05	.14
ST.E.	.15	.15	.15	.15	.15	.15	.16	.16	.16	.16	.16	.16
25- 36	0.0	-.02	.19	-.01	0.0	-.03	-.01	-.03	-.02	.14	.02	.01
ST.E.	.16	.16	.16	.17	.17	.17	.17	.17	.17	.17	.17	.17

PLOT OF AUTOCORRELATIONS

```
               -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR.    +----+----+----+----+----+----+----+----+----+----+
                                          I
  1   -.059                              XI
  2    .051                               IX
  3    .014                               I
  4    .043                               IX
  5   -.138                            XXXI
  6   -.209                          XXXXXI
  7   -.193                          XXXXXI
  8   -.057                              XI
  9   -.048                              XI
 10    .040                               IX
 11    .001                               I
 12    .147                               IXXXX
 13    .106                               IXXX
 14   -.086                             XXI
 15    .068                               IXX
 16   -.092                             XXI
 17    .170                               IXXXX
 18   -.187                          XXXXXI
 19   -.102                            XXXI
 20   -.138                            XXXI
 21    .018                               I
 22   -.093                             XXI
 23   -.046                              XI
 24    .142                               IXXXX
 25   -.002                               I
 26   -.020  .293(60) = 17.61            XI
 27    .186                               IXXXXX
 28   -.005                               I
 29    .005                               I
 30   -.027                              XI
 31   -.005                               I
 32   -.032                              XI
 33   -.015                               I
 34    .143                               IXXXX
 35    .017                               I
 36    .009                               I
```

Figure F-67. Estimated Residuals - Ammunition

FORECAST ON VARIABLE TRANS FROM TIME PERIOD 61

PERIOD	FORECASTS	ST. ERR.	ACTUAL	ERROR
61	14.82388	6.88577	.662	-14.162
62	13.27270	6.97144	17.557	4.284
63	19.90887	7.32575	5.482	-14.426
64	17.02037	8.54706	6.456	-10.564
65	15.51233	9.58698	7.393	-8.119
66	15.87883	9.61184	21.027	5.148
67	15.31700	9.67796	17.228	1.911
68	15.59204	9.72631	17.219	1.627
69	15.66387	9.76489	42.903	27.239
70	15.45490	9.82005	20.342	4.877
71	15.59202	9.86582	10.394	-5.198
72	15.58943	9.90975	12.649	-2.94

STANDARD ERROR = 6.68577 (BY CONDITIONAL METHOD)

189.62 179.31 MSE = 119.91

Figure F-68. Forecast FY 82 - Ammunition

F-7. SPECIAL

a. The raw series for the special cargo commodity is illustrated in Figure F-69. The raw series does not depict a discernible pattern or trend in the data. Also, examination of the 3-month and 6-month moving averages does not identify a visible pattern (Figures F-70 and F-71). The 12-month moving average (Figure F-72) suggests that a general trend may exist in the data which could be interpreted as the program funding of the defense budget. In fact, the trend shows a gradual decline during the period under study.

b. Autocorrelation function analysis of the data (Figures F-73 and F-74) suggests the possibility of seasonal data. Therefore, the series was differenced at a lag of 12 months in an effort to achieve stationarity. The variance of the seasonally differenced series exhibited heteroscedasticity (change in variance over time). Thus, the original series was transformed using natural logarithms and then differenced at a lag of 12 months. The differenced logarithmetic series is found in Figure F-75. The autocorrelation and partial autocorrelation functions of the data (Figures F-76 and F-77) indicates that a random stationary series has been generated.

c. Analysis of the autocorrelation and partial autocorrelation functions indicates that the data could be modeled as a possible ARIMA (2,0,0) nonseasonal process and an ARIMA (0,1,1) seasonal model. Thus, the appropriate model is:

$$(1 - \phi_1 B - \phi_2 B^2)(1 - B^{12}) \ln x_t = (1 - \theta_{12} B^{12}) \epsilon_t$$

d. The results of this model (Figure F-78) are as follows:

$$\underset{(1.21)}{(1 - .1496B} - \underset{(3.16)}{.3875B^2)} (1 - B^{12}) \ln X_t = (1 - \underset{(10.61)}{.801B^{12}} - \underset{(1.65)}{.1503B^{14}})\epsilon_t$$

$$\chi^2\ (4,20) = 13.15$$

All of the estimated parameters except ϕ_1 and θ_{14} are significant at the 5 percent significance level. The additional MA parameter (θ_{14}) was added to the model since the autocorrelation coefficient at lag 14 of the original hypothesized seasonal model was highly significant. The model was verified using the Box-Pierce test and a visual check of the estimated residuals. The Q statistic for this model with 20 degrees of freedom is 13.15 (Figure F-79). This diagnostic indicates that the residuals are not significant and that the null hypothesis should not be rejected at the 15 percent significance level. All of the residuals are within the 95 percent confidence interval.

e. This model forecasted that 559.42 K/MTON of special cargo would be shipped during FY 82 (Figure F-80) versus an actual amount of 489.83 K/MTON The annual forecast error was 12.4 percent and the forecast MSE was 159.23. Although this discrepancy would cause one to doubt the usefulness of this model, it should be noted that the amount of special cargo tonnage shipped during FY 82 is much lower than any of the preceding years. In fact, the average tonnage of special cargo shipped over the past 5 years was 669.17 K/MTON. In all cases, forecasting methodologies are employed based upon the assumption that the behavior of future observations will not differ greatly from the behavior of past observations. When the future is radically different than the past, as in the case of special cargo tonnage for FY 82, forecasts cannot predict the future with any degree of accuracy.

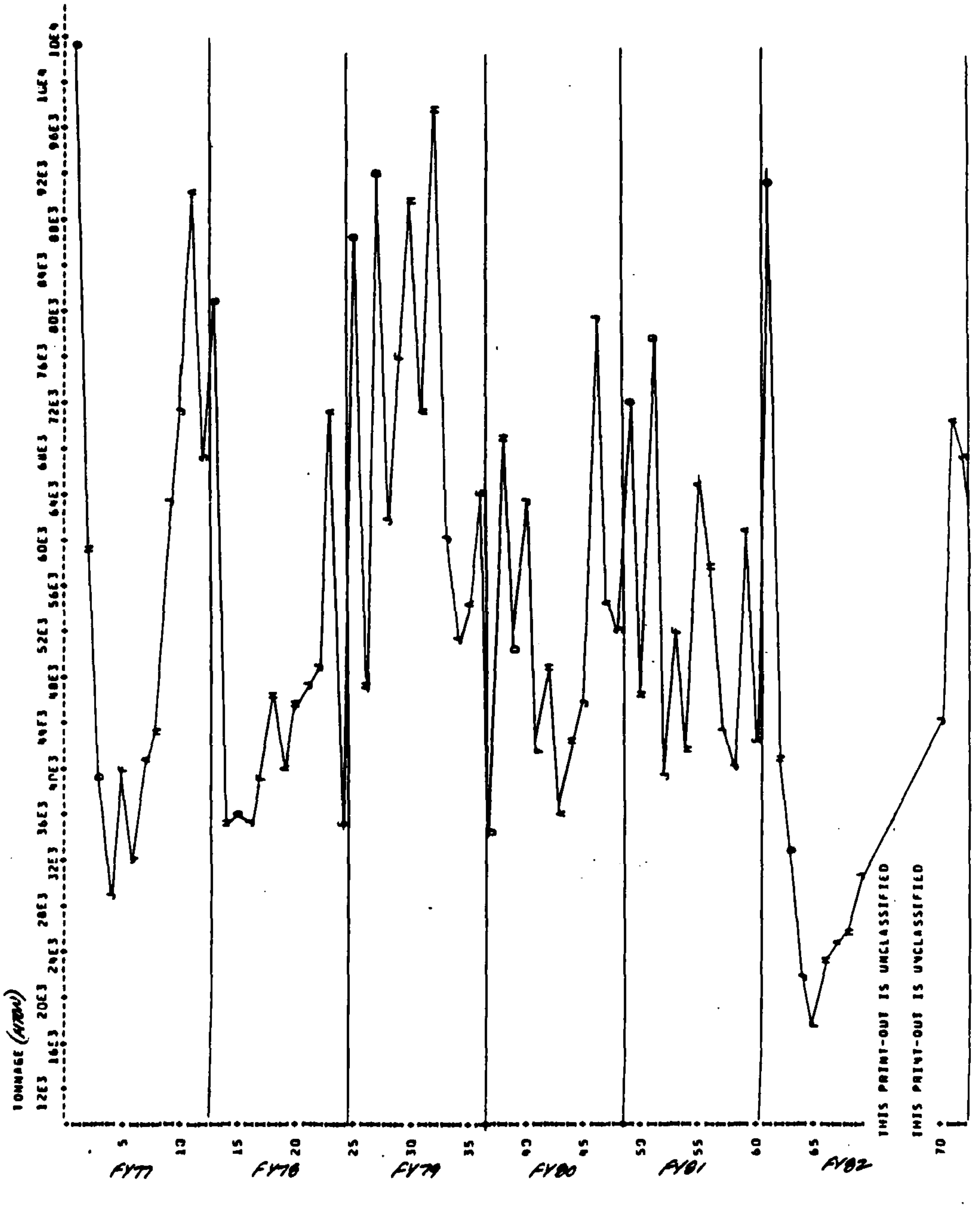
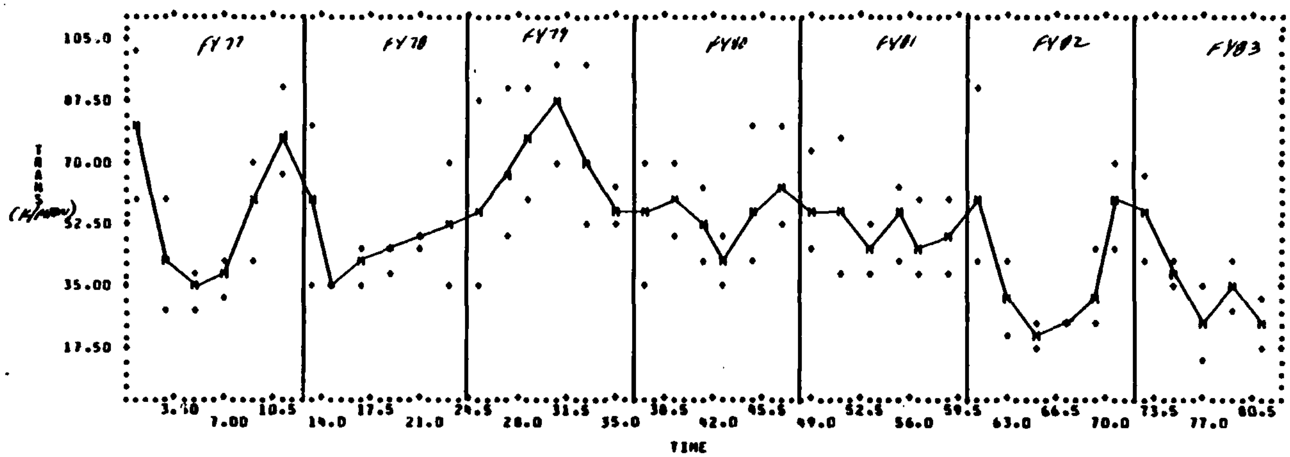
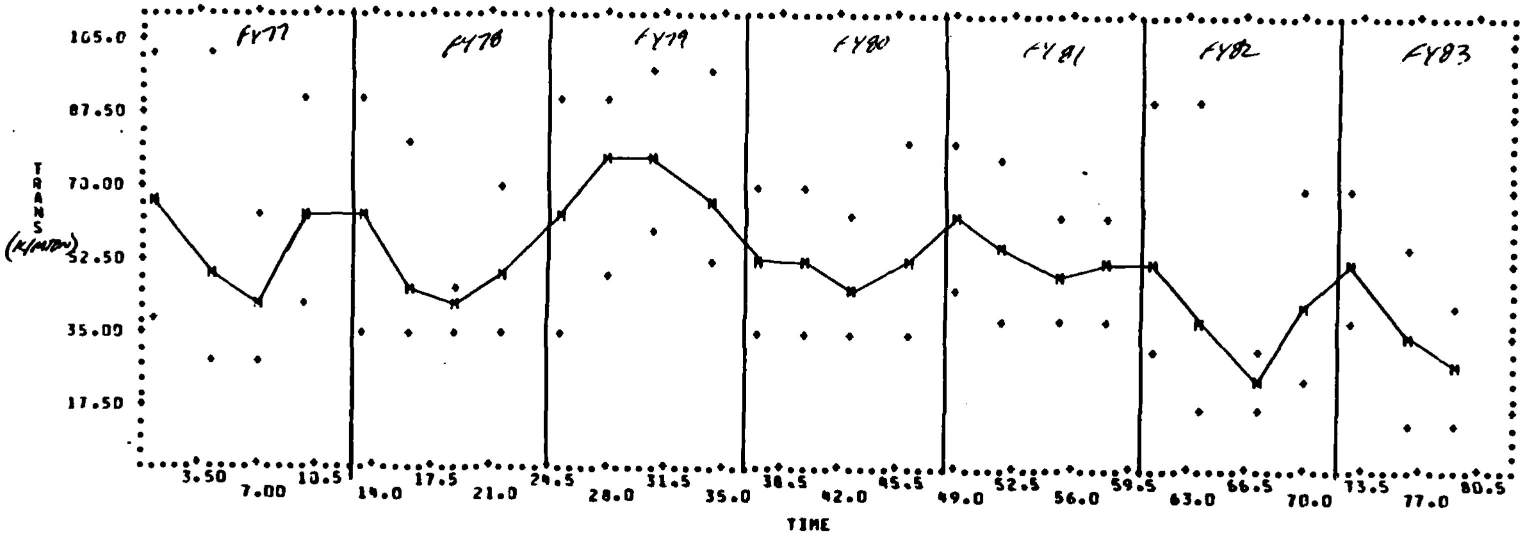


Figure F-69. Special Cargo FY 77 - FY 82



TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	2	58.8710	81.0140	103.1570
3.000	3	24.4770	42.2693	58.8710
5.000	3	28.4770	33.3747	39.8540
7.000	3	31.7930	38.7012	43.1397
9.000	3	43.1397	59.3142	71.2807
11.000	3	67.3351	76.2557	90.1931
13.000	3	35.1168	61.2073	81.1703
15.000	3	35.1168	35.4409	35.6830
17.000	3	35.5454	40.2537	46.1395
19.000	3	39.6838	43.8654	46.1395
21.000	3	45.7729	47.2721	48.9943
23.000	3	34.8689	51.7748	71.4612
25.000	3	34.8689	56.1375	86.1509
27.000	3	47.3928	66.9249	92.1618
29.000	3	61.2186	75.5618	89.7008
31.000	3	77.4103	86.3621	97.9752
33.000	3	51.0957	69.7997	97.9752
35.000	3	51.0957	56.6973	64.1873
37.000	3	34.1999	55.7720	68.9292
39.000	3	50.7155	60.8269	68.9292
41.000	3	41.7536	51.1527	62.8359
43.000	3	35.9816	42.5301	48.8685
45.000	3	42.7402	55.7154	79.0213
47.000	3	51.7484	61.6455	79.0213
49.000	3	46.7733	56.9497	72.3276
51.000	3	39.0462	54.3733	77.3005
53.000	3	39.0462	44.3007	52.0462
55.000	3	41.8096	54.7250	64.5550
57.000	3	40.2291	47.1263	57.8104
59.000	3	40.2291	47.6559	63.6740
61.000	3	41.0209	58.1562	91.3879
63.000	3	21.8588	31.8693	41.0209
65.000	3	17.8238	21.0695	23.5263
67.000	3	23.5260	24.6399	25.3995
69.000	3	25.3995	33.2373	44.2224
71.000	3	44.2224	60.3509	70.0033
73.000	3	41.9286	55.2381	66.8269
75.000	3	33.9871	37.8759	41.9286
77.000	3	13.1577	25.1859	33.9871
79.000	3	28.4127	33.6022	40.2973
81.000	2	17.6220	24.6594	32.0967

Figure F-70. Three-month Moving Average - Special

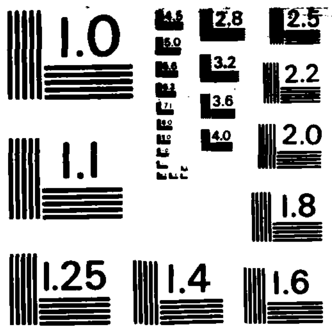


TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	3	39.4600	67.1627	103.1570
4.000	6	28.4770	50.2687	103.1570
7.000	6	28.4770	41.3248	63.5142
10.000	6	41.1710	62.7653	90.1431
13.000	6	35.1168	63.4561	90.1431
16.000	6	35.1168	45.4551	81.1790
19.000	6	35.5454	42.2112	47.0492
22.000	6	34.8689	47.9717	71.4612
25.000	6	34.8689	63.5050	92.1618
28.000	6	47.3928	75.3985	92.1619
31.000	6	60.3283	76.0665	97.9752
34.000	6	51.0957	66.6093	97.9752
37.000	6	34.1999	53.9644	68.9292
40.000	6	34.1999	51.2171	68.9292
43.000	6	35.9816	46.2610	62.8359
46.000	6	35.9816	51.5074	79.0213
49.000	6	46.7733	63.5563	79.0213
52.000	6	39.0462	54.8839	77.3005
55.000	6	39.0462	49.7678	64.5550
58.000	6	40.2291	51.4454	64.5550
61.000	6	32.7281	51.3499	91.3829
64.000	6	17.8238	39.0568	91.3829
67.000	6	17.8238	23.9487	30.0899
70.000	6	24.9941	43.5894	70.0033
73.000	6	37.7103	52.9417	70.0033
76.000	6	13.1577	35.3592	56.9587
79.000	6	13.1577	27.5956	40.2970

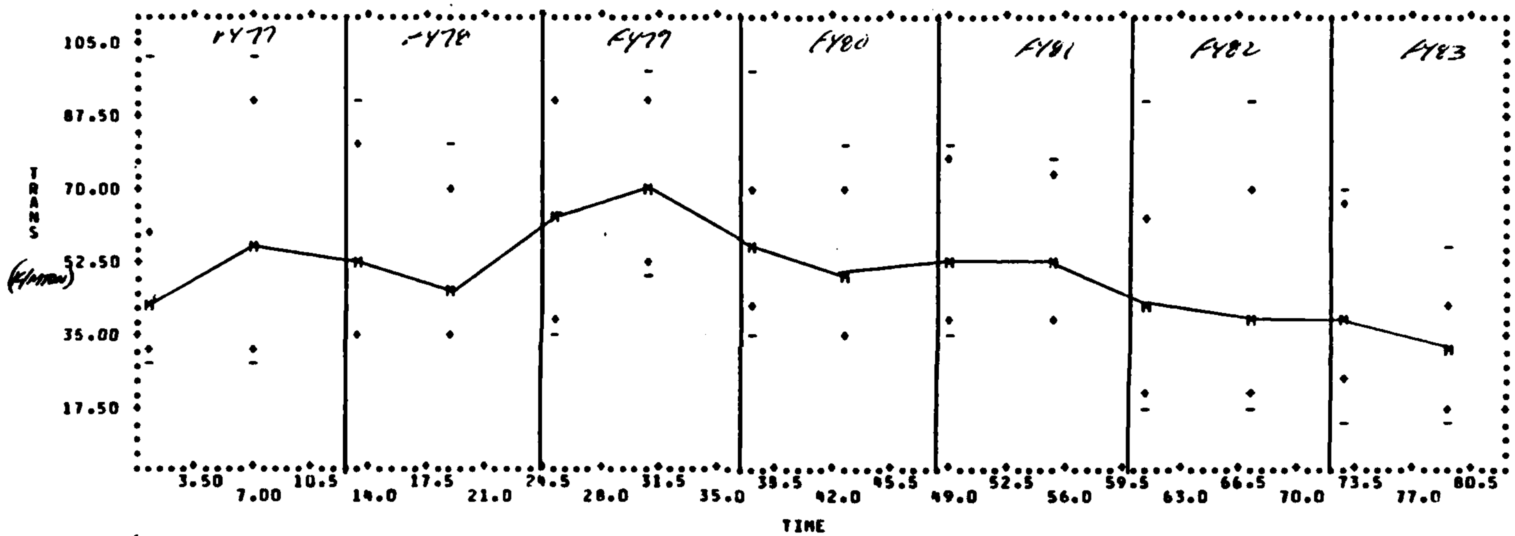
Figure F-71. Six-month Moving Average - Special

AD-A139 872 TRANSPORTATION WORKLOAD FORECASTING (TWF) STUDY(U) ARMY CONCEPTS ANALYSIS AGENCY BETHESDA MD J N KEENAN ET AL. JAN 84 CAA-SR-84-2 3/4

UNCLASSIFIED F/G 15/5 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



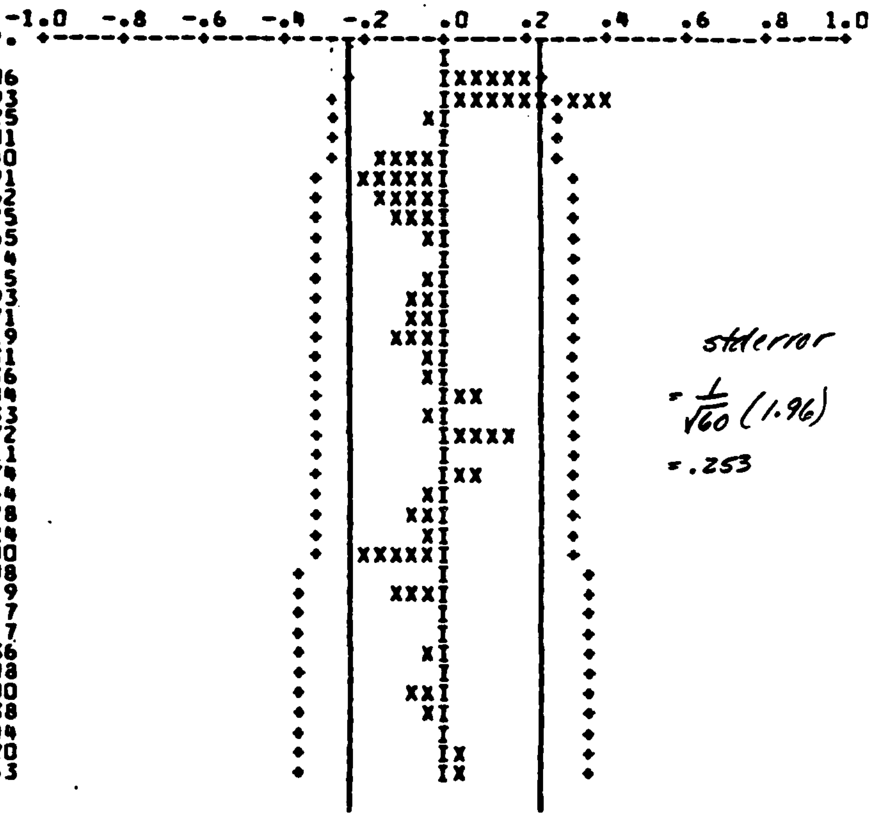
TIME VALUE	NO. OF CASES	MINIMUM VALUE	TRIMMED MINIMUM	TRIMMED MEAN	TRIMMED MAXIMUM	MAXIMUM VALUE
1.000	6	28.4770	31.7930	42.4945	58.8710	103.1570
7.000	12	28.4770	31.7930	54.6570	93.1431	103.1570
13.000	12	35.1168	35.5454	52.4063	81.1700	90.1431
19.000	12	34.8689	35.1169	44.4522	71.4612	81.1700
25.000	12	34.8689	39.6839	61.3191	89.7008	92.1618
31.000	12	47.3928	51.0957	70.6679	92.1618	97.9752
37.000	12	34.1999	41.7536	57.4783	71.4103	97.9752
43.000	12	34.1999	35.9816	50.3126	68.9292	79.0213
49.000	12	35.9816	39.0462	52.3345	77.3005	79.0213
55.000	12	39.0462	40.2291	52.1629	72.3276	77.3005
61.000	12	17.8238	21.8589	42.7807	64.5550	91.3829
67.000	12	17.8238	21.8589	38.0670	73.0033	91.3829
73.000	12	13.1577	24.9941	39.0530	66.8269	70.0033
79.000	9	13.1577	17.6220	33.1507	41.9286	56.9587

Figure F-72. Twelve-month Moving Average - Special

AUTOCORRELATIONS

1- 12	.21	.39	-.03	0.0	-.14	-.19	-.16	-.12	-.06	.01	-.05	-.09
ST.E.	.13	.13	.15	.15	.15	.15	.16	.16	.16	.16	.16	.16
13- 24	-.07	-.12	-.03	-.04	.08	-.03	.17	.01	.07	-.04	-.09	-.02
ST.E.	.16	.16	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17
25- 36	-.18	-.01	-.12	-.02	.02	-.04	.01	-.10	-.04	0.0	.02	.05
ST.E.	.17	.17	.17	.18	.18	.18	.18	.18	.18	.18	.18	.18

PLOT OF AUTOCORRELATIONS



LAG	CORR.
1	.206
2	.393
3	-.025
4	.001
5	-.140
6	-.191
7	-.162
8	-.125
9	-.055
10	.014
11	-.045
12	-.093
13	-.071
14	-.119
15	-.031
16	-.036
17	.084
18	-.033
19	.172
20	.011
21	.074
22	-.044
23	-.088
24	-.024
25	-.180
26	-.008
27	-.119
28	-.017
29	.017
30	-.036
31	.008
32	-.100
33	-.038
34	-.004
35	.020
36	.053

stderror

$= \frac{1}{\sqrt{60}}(1.96)$

$= .253$

Figure F-73. ACF - Raw Data - Special

PARTIAL AUTOCORRELATIONS

1- 12	.21	.37	-.18	-.14	-.05	-.14	-.05	.03	0.0	.03	-.11	-.19
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
13- 24	-.02	-.05	.01	.04	.06	-.15	.10	-.02	-.08	0.0	-.11	.04
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
25- 36	-.14	-.01	-.03	-.05	.03	-.11	-.04	-.13	-.05	.06	.02	-.07
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13

PLOT OF PARTIAL AUTOCORRELATIONS

```
            -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8   1.0
LAG     CORR. +----+----+----+----+----+----+----+----+----+----+
                                       I
  1      .206                    +     IXXXXX+
  2      .366                    +     IXXXXXX+XXX
  3     -.183                    +XXXXXI     +
  4     -.137                    +  XXXI     +
  5     -.051                    +    XI     +
  6     -.142                    + XXXXI     +
  7     -.045                    +    XI     +
  8      .026                    +     IX    +
  9      .003                    +     I     +
 10      .031                    +     IX    +
 11     -.105                    +  XXXI     +
 12     -.189                    +XXXXXI     +
 13     -.019                    +     I     +
 14     -.046                    +    XI     +
 15      .009                    +     I     +
 16      .038                    +     IX    +
 17      .061                    +     IXX   +
 18     -.152                    + XXXXI     +
 19      .097                    +     IXX   +
 20     -.024                    +    XI     +
 21     -.079                    +   XXI     +
 22     -.001                    +     I     +
 23     -.105                    +  XXXI     +
 24      .038                    +     IX    +
 25     -.137                    +  XXXI     +
 26     -.014                    +     I     +
 27     -.028                    +    XI     +
 28     -.055                    +    XI     +
 29      .034                    +     IX    +
 30     -.107                    +  XXXI     +
 31     -.045                    +    XI     +
 32     -.131                    +  XXXI     +
 33     -.047                    +    XI     +
 34      .057                    +     IX    +
 35      .016                    +     I     +
 36     -.067                    +   XXI     +
```

Figure F-74. PACF - Raw Data - Special

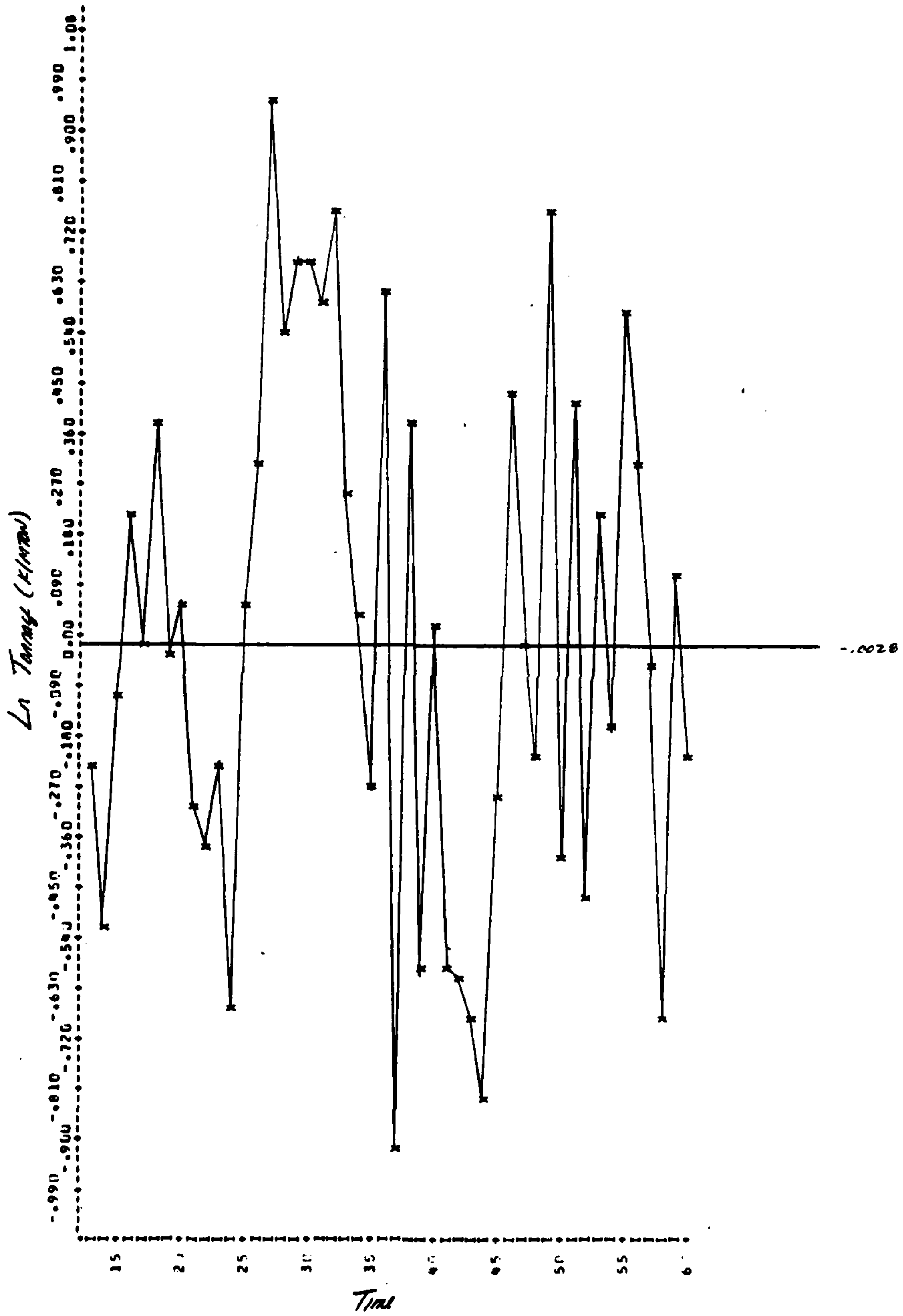


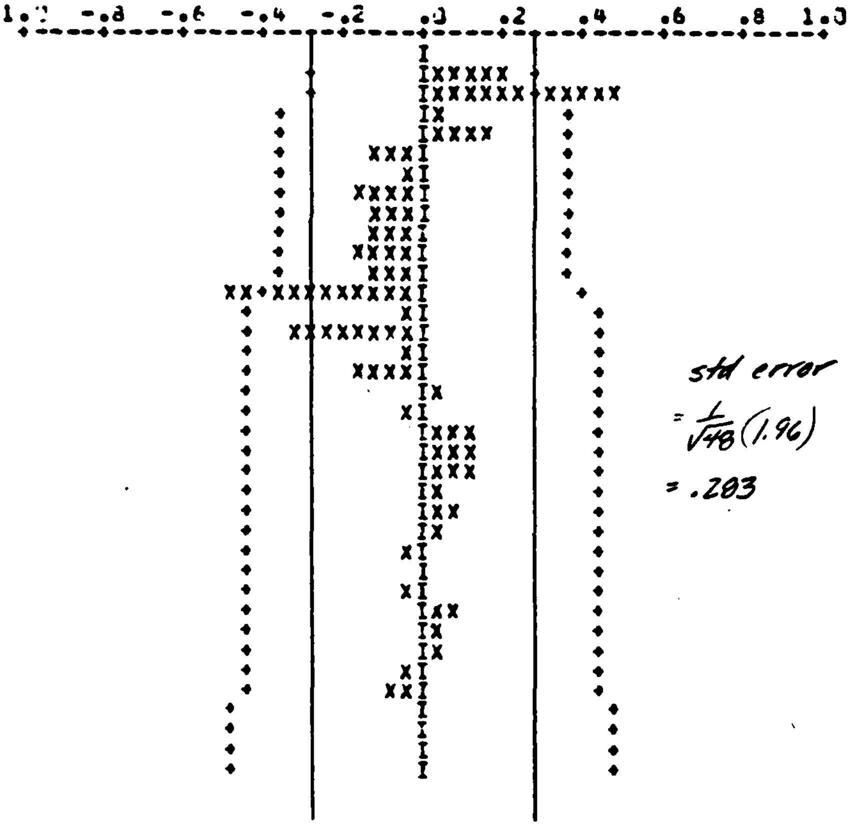
Figure F-75. Log Differenced Series (12-month lag) - Special

AUTOCORRELATIONS

1- 12	.21	.49	.03	.15	-.10	-.04	-.14	-.14	-.12	-.16	-.11	-.46
ST.E.	.14	.15	.18	.18	.18	.18	.18	.19	.19	.19	.19	.19
13- 24	-.05	-.32	-.02	-.17	.02	-.03	.12	.12	.12	.02	.09	.04
ST.E.	.22	.22	.23	.23	.23	.23	.23	.23	.23	.23	.23	.23
25- 36	-.06	0.0	-.03	.07	.04	.03	-.04	-.09	-.01	-.01	-.01	.02
ST.E.	.23	.23	.23	.23	.23	.23	.23	.23	.24	.24	.24	.24

PLOT OF AUTOCORRELATIONS

LAG	CORR.
1	.213
2	.486
3	.030
4	.150
5	-.103
6	-.039
7	-.142
8	-.135
9	-.123
10	-.160
11	-.113
12	-.460
13	-.047
14	-.315
15	-.024
16	-.168
17	.021
18	-.029
19	.121
20	.121
21	.116
22	.020
23	.090
24	.039
25	-.059
26	.003
27	-.027
28	.071
29	.040
30	.033
31	-.036
32	-.091
33	-.012
34	-.014
35	-.007
36	.017



std error

$= \frac{1}{\sqrt{48}}(1.96)$

$= .283$

Figure F-76. ACF - Lagged 12 Months

```
PARTIAL AUTOCORRELATIONS

  1- 12      .21  .46 -.17 -.07 -.08 -.07 -.03 -.09 -.01 -.07 -.05 -.49
 ST.E.       .14  .14  .14  .14  .14  .14  .14  .14  .14  .14  .14  .14

 13- 24      .20  .07 -.18 -.02 -.06  .03  .05  .03 -.09 -.13  .05 -.24
 ST.E.       .14  .14  .14  .14  .14  .14  .14  .14  .14  .14  .14  .14

 25- 36     -.03 -.01  .04  .08 -.09 -.13 -.04  .01  .02  0.0  .08 -.14
 ST.E.       .14  .14  .14  .14  .14  .14  .14  .14  .14  .14  .14  .14

PLOT OF PARTIAL AUTOCORRELATIONS

            -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR. +----+----+----+----+----+----+----+----+----+----+
                                     I
  1    .213                   +      IXXXXX +
  2    .461                   +      IXXXXXX+XXXXX
  3   -.165                   +  XXXXI      +
  4   -.074                   +    XXI      +
  5   -.078                   +    XXI      +
  6   -.066                   +    XXI      +
  7   -.026                   +     XI      +
  8   -.068                   +    XXI      +
  9   -.006                   +      I      +
 10   -.073                   +    XXI      +
 11   -.052                   +     XI      +
 12   -.491              XXXXX+XXXXXXI      +
 13    .197                   +      IXXXXX +
 14    .071                   +      IXX    +
 15   -.177                   +  XXXXI      +
 16   -.019                   +      I      +
 17   -.065                   +    XXI      +
 18    .028                   +      IX     +
 19    .054                   +      IX     +
 20    .029                   +      IX     +
 21   -.097                   +    XXI      +
 22   -.135                   +   XXXI      +
 23    .054                   +      IX     +
 24   -.242                   +XXXXXXI      +
 25   -.025                   +     XI      +
 26   -.011                   +      I      +
 27    .037                   +      IX     +
 28    .082                   +      IXX    +
 29   -.091                   +    XXI      +
 30   -.123                   +   XXXI      +
 31   -.039                   +     XI      +
 32    .008                   +      I      +
 33    .020                   +      IX     +
 34    .002                   +      I      +
 35    .078                   +      IXX    +
 36   -.141                   +  XXXXI      +
```

Figure F-77. PACF - Lagged 12 Months

```
ESTIMATION BY BACKCASTING METHOD
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN  .1000-004

SUMMARY OF THE MODEL

OUTPUT VARIABLE -- TRANS
INPUT VARIABLES -- NOISE

VARIABLE  VAR. TYPE  MEAN      TIME     DIFFERENCES
                                              12
TRANS       RANDOM             1-  60  (1-B   )

PARAMETER VARIABLE    TYPE  FACTOR  ORDER ESTIMATE        ST. ERR.  T-RATIO
       1   TRANS       MA      1      12     .8014         .0756     10.61
       2   TRANS       MA      1      14     .1503         .0912      1.65
       3   TRANS       AR      1       1     .1496         .1232      1.21
       4   TRANS       AR      1       2     .3875         .1224      3.16

RESIDUAL SUM OF SQUARES  =        3.427251 (BACKCASTS EXCLUDED)
DEGREES OF FREEDOM       =              42
RESIDUAL MEAN SQUARE     =         .081601
```

Figure F-78. Model Parameters - Special

AUTOCORRELATIONS

1- 12	.10	.07	-.13	-.04	-.16	-.09	-.11	-.03	-.0	.16	.05	-.19
ST.E.	.13	.13	.13	.13	.13	.14	.14	.14	.14	.14	.14	.14
13- 24	-.01	-.13	-.03	0.0	.04	.01	.10	.17	.07	-.05	.07	-.06
ST.E.	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15
25- 36	-.17	-.12	-.11	.02	.07	.05	-.01	-.12	0.0	.08	-.06	-.02
ST.E.	.15	.16	.16	.16	.16	.16	.16	.16	.16	.16	.16	.16

PLOT OF AUTOCORRELATIONS

```
           -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG  CORR.  +----+----+----+----+----+----+----+----+----+----+
                                     I
  1   .096                     +     IXX   +
  2   .067                     +     IXX   +
  3  -.134                     +  XXXI     +
  4  -.035                    +     XI      +
  5  -.161                    +  XXXXI      +
  6  -.091                    +    XXI      +
  7  -.112                    +   XXXI      +
  8  -.033                    +     XI      +
  9  -.005                    +      I      +
 10   .159                    +      IXXXX  +
 11   .045                    +      IX     +
 12  -.188                    + XXXXXI      +
 13  -.010                    +      I      +
 14  -.131                    +   XXXI      +
 15  -.034                    +     XI      +
 16  -.003                    +      I      +
 17   .041                    +      IX     +
 18   .011                    +      I      +
 19   .103                    +      IXXX   +
 20   .169                    +      IXXXX  +
 21   .071                   +       IXX     +
 22  -.050                   +      XI       +
 23   .070                   +       IXX     +
 24  -.062                   +     XXI       +    (.219)60 = 13.15
 25  -.168                   +   XXXXI       +
 26  -.123                   +    XXXI       +
 27  -.114                   +    XXXI       +
 28   .018                   +       I       +
 29   .072                   +       IXX     +
 30   .053                   +       IX      +
 31  -.015                   +       I       +
 32  -.116                   +    XXXI       +
 33  -.001                   +       I       +
 34   .076                   +       IXX     +
 35  -.060                   +     XXI       +
 36  -.016                   +       I       +
```

Figure F-79. Estimated Residuals - Special

FORECAST ON VARIABLE TRANS FROM TIME PERIOD 61

PERIOD	FORECASTS		ST. ERR.	ACTUAL	
61	11.15629	69.503	.39957	91.303	21.8
62	10.61142	40.588	[illegible]	41.021	.433
63	10.81754	49.808	.43595	32.728	-17.08
64	10.30615	29.916	.43855	21.859	-8.057
65	10.43561	34.050	.44419	17.824	-16.226
66	10.33114	30.673	.44514	23.526	-7.147
67	10.56622	38.801	.44627	24.994	-13.807
68	10.56392	38.712	.44655	25.4	-13.312
69	10.73868	46.165	.44690	30.09	-16.015
70	10.80981	49.564	.44697	44.282	-5.282
71	11.21739	74.413	.44693	70.03	-4.383
72	10.95415	57.190	.44695	66.827	9.637

STANDARD ERROR = .399574 (BY CONDITIONAL METHOD)

559.42 489.83 MSE = 159.23

Figure F-80. Forecast FY 82 - Special

F-8. CARGO TRAILER/CONEX

a. The raw series for cargo trailer shipments is depicted in Figure F-81. The raw data do exhibit a seasonal pattern that trends upwards over time. The increasing trend over time is more clearly evident after reviewing the 3-month and 6-month moving average diagrams (Figures F-82 and F-83). According to the 12-month moving average diagram (Figure F-84), the increasing trend appears to be an increasing linear function over time. However, it should be noted that over the past 2 years (FY 81-FY 83), the trend has remained flat.

b. Autocorrelation function analysis (Figures F-85 and F-86) of the data confirms the existence of the seasonality in the data as indicated by the damping peaks at 12, 24, and 36 lags. To eliminate the seasonality, the series was differenced at a lag of 12 months. Figure F-87 depicts the seasonally adjusted series. The autocorrelation and partial autocorrelation functions of the seasonally adjusted series are illustrated in Figures F-88 and F-89. The autocorrelation function indicates that the series is stationary and that a mean exists in the series (t-value of mean is significant at the 5 percent significance level).

c. Analysis of the autocorrelation and partial autocorrelation functions suggests that the data could be modeled with an ARIMA (0,0,1) nonseasonal model and an ARIMA (0,1,1) seasonal model. Thus, the suggested model takes the form:

$$(1 - B^{12})\, X_t = \mu + (1 - \theta_1 B)\,(1 - \theta_{12} B^{12})\epsilon_t$$

d. The results of the model (Figure F-90) are as follows:

$$(1 - B^{12})\, X_t = \underset{(4.09)}{.4057} + (1 + \underset{(-2.32)}{.2912}B)\,(1 - \underset{(14.97)}{.8264}B^{12})\epsilon_t$$

$$\chi^2\,(2,20) = 12.74$$

The results indicate that all of the estimated parameters are significant at the 5 percent significance level. The Q statistic for the estimated model residuals at 20 degrees of freedom is 12.74 which is significant at the 13 percent significance level (Figure F-91). Therefore, the null hypothesis, uncorrelated residuals, should not be rejected at the 13 percent significance level.

e. The model forecasted CONEX/cargo trailer shipments for FY 82 to be 76.43 K/MTON (Figure F-92) versus an actual lift for FY 82 of 74.47 K/MTON. The MSE of the forecast was .81 and the annual forecast error was 2.6 percent.

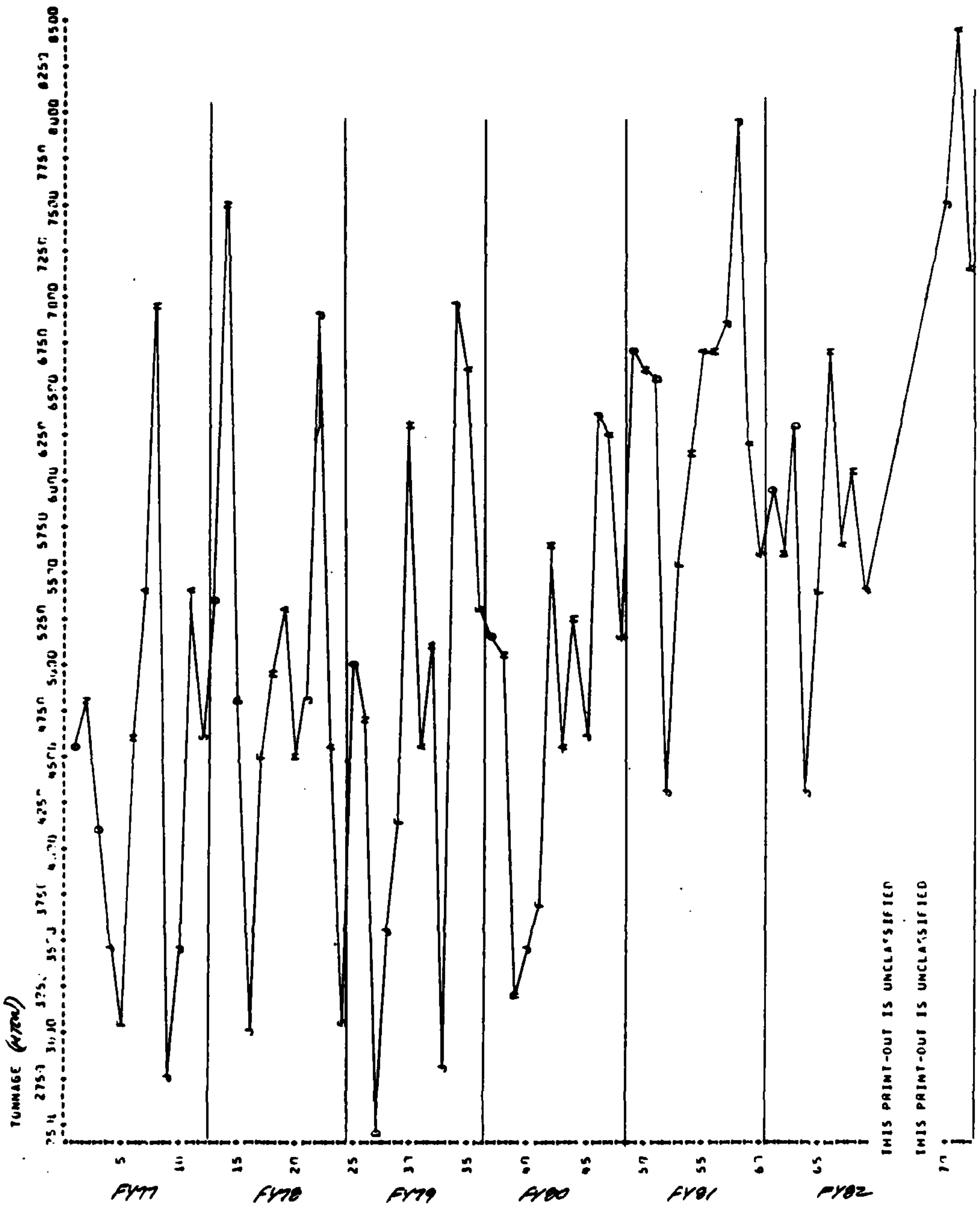
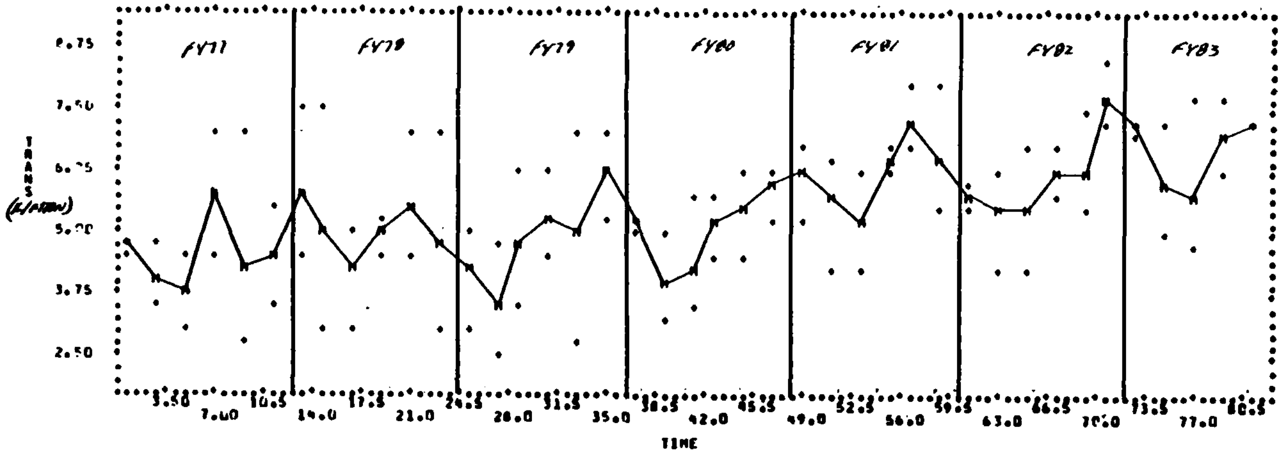
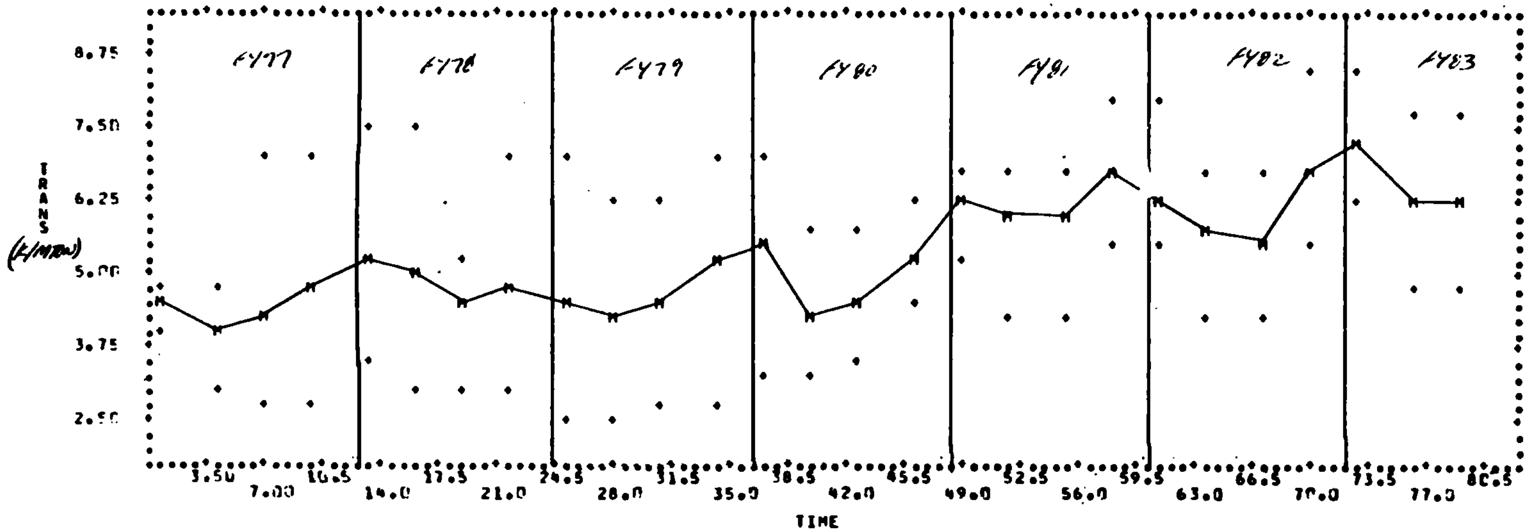


Figure F-81. CONEX Cargo FY 77 - FY 82



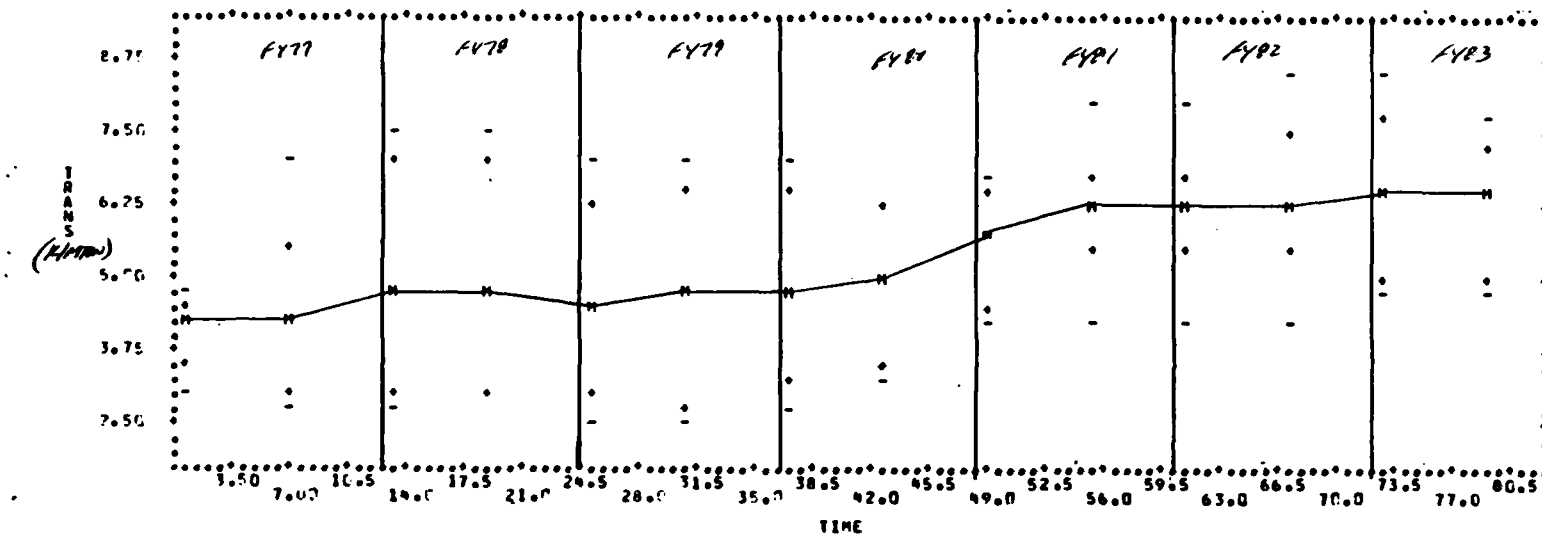
TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	2	4.5660	4.6815	4.7970
3.000	3	3.4350	4.1057	4.7970
5.000	3	3.0350	3.6963	4.6190
7.000	3	4.6190	5.6490	6.9250
9.000	3	2.7400	4.3670	6.9250
11.000	3	3.4360	4.4813	5.4230
13.000	3	4.5850	5.8357	7.5030
15.000	3	3.0784	5.1058	7.5000
17.000	3	3.0084	4.1492	4.9552
19.000	3	4.5176	4.9284	5.3122
21.000	3	4.5178	5.3948	6.8901
23.000	3	3.0430	4.8203	6.8901
25.000	3	3.0470	4.2472	4.9971
27.000	3	2.4597	3.5679	4.7088
29.000	3	3.5361	4.6595	6.3034
31.000	3	4.5670	5.3157	6.3034
33.000	3	2.8797	4.9493	6.9616
35.000	3	5.3198	6.2965	6.9616
37.000	3	5.0691	5.1822	5.3198
39.000	3	3.1546	3.9096	5.7691
41.000	3	3.4648	4.2686	5.6343
43.000	3	4.5471	5.1497	5.6343
45.000	3	4.6012	5.4091	6.3585
47.000	3	5.1696	5.9232	6.3585
49.000	3	5.1696	6.1646	6.6991
51.000	3	4.3275	5.4327	6.6250
53.000	3	4.3275	5.3502	6.1658
55.000	3	6.1658	6.5266	6.7184
57.000	4	6.7184	7.1730	7.9621
59.000	3	5.5836	6.5787	7.9671
61.000	3	5.5836	5.7238	5.9678
63.000	3	4.2890	5.4148	6.3056
65.000	3	4.2890	5.4738	6.7176
67.000	3	5.6284	6.1295	6.7176
69.000	4	5.3789	6.5071	7.4995
71.000	3	7.1727	7.7119	8.4327
73.000	3	7.0979	7.1755	7.2497
75.000	3	4.9122	6.1072	7.2497
77.000	3	4.7567	5.7764	7.6672
79.000	3	6.1662	6.9922	7.6672
81.000	2	7.1513	7.2449	7.3395

Figure F-82. Three-month Moving Average - CONEX



TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	3	4.0850	4.4827	4.7970
4.000	6	3.0350	4.0895	4.7970
7.000	6	2.7410	4.3595	6.9250
10.000	6	2.7400	4.7523	6.9250
13.000	6	3.4360	5.1808	7.5000
16.000	6	3.[illegible]094	5.0348	7.5000
19.000	6	3.0084	4.5789	5.3122
22.000	6	3.0438	4.8445	6.8973
25.000	6	2.4587	4.4368	6.8973
28.000	6	2.4587	4.3564	6.[illegible]34
31.000	6	2.8097	4.4753	6.[illegible]34
34.000	6	2.6097	5.2238	6.9616
37.000	6	3.1948	5.3842	6.9616
40.000	6	3.1948	4.37[illegible]3	5.6343
43.000	6	3.4646	4.537[illegible]	5.6343
46.000	6	4.5471	5.3643	6.3585
49.000	6	5.[illegible]696	6.2774	6.6991
52.000	6	4.3205	5.99[illegible]9	6.6991
55.000	6	4.3205	6.[illegible]5[illegible]9	6.94[illegible]7
58.000	6	5.5836	6.6648	7.9621
61.000	6	5.5636	6.2712	7.9621
64.000	6	4.2890	5.7191	6.7176
67.000	6	4.2890	5.[illegible]765	6.7176
70.000	6	5.3789	6.6924	8.4320
73.000	6	6.1747	7.2696	8.4320
76.000	6	4.7567	6.3[illegible]71	7.66[illegible]2
79.000	6	4.7567	6.33[illegible]9	7.66[illegible]2

Figure F-83. Six-month Moving Average - CONEX



TIME VALUE	NO. OF CASES	MINIMUM VALUE	TRIMMED MINIMUM	TRIMMED MEAN	TRIMMED MAXIMUM	MAXIMUM VALUE
1.000	6	3.0350	3.4350	4.1762	4.6190	4.7970
7.000	12	2.7400	3.0350	4.3384	5.4230	6.9250
13.000	12	2.7400	3.0084	4.0361	6.9750	7.5000
19.000	12	3.0084	3.2008	4.8647	6.8903	7.5000
25.000	12	2.4587	3.0408	4.5856	6.3734	6.8903
31.000	12	2.4587	2.8397	4.8061	6.6282	6.9616
37.000	12	2.9397	3.1948	4.7793	6.6282	6.9616
43.000	12	3.1946	3.4648	4.8854	6.2414	6.3585
49.000	12	4.3205	4.5471	5.7111	6.6250	6.6991
55.000	12	4.3205	5.5643	6.3651	6.8407	7.9621
61.000	12	4.2890	5.4147	6.2052	6.8407	7.9621
67.000	12	4.2890	5.3789	6.1746	7.4995	8.4320
73.000	12	4.7567	4.9122	6.4808	7.6602	8.4320
79.000	9	4.7567	4.9122	6.5631	7.3395	7.6672

Figure F-84. Twelve-month Moving Average - CONEX

AUTOCORRELATIONS

1- 12	.35	.08	.11	.20	.04	.07	.12	.16	0.0	-.10	.09	.24
ST.E.	.13	.14	.14	.15	.15	.15	.15	.15	.16	.16	.16	.16
13- 24	.01	.02	.06	.03	-.06	-.16	-.12	.02	.05	.02	.12	.15
ST.E.	.16	.16	.16	.16	.16	.16	.17	.17	.17	.17	.17	.17
25- 36	-.15	-.14	-.06	.04	-.07	-.15	-.19	-.08	-.10	-.05	.05	.14
ST.E.	.17	.17	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18

PLOT OF AUTOCORRELATIONS

-1.0 -.8 -.6 -.4 -.2 .0 .2 .4 .6 .8 1.0

LAG	CORR.
1	.353
2	.079
3	.110
4	.197
5	.039
6	.075
7	.115
8	.165
9	.001
10	-.101
11	.085
12	.243
13	.014
14	.019
15	.061
16	.027
17	-.060
18	-.159
19	-.119
20	.019
21	.046
22	.023
23	.119
24	.146
25	-.150
26	-.140
27	-.062
28	.035
29	-.074
30	-.152
31	-.189
32	-.081
33	-.095
34	-.045
35	.052
36	.138

std error

$= \frac{1}{\sqrt{60}}(1.96)$

$= .253$

Figure F-85. ACF - Raw Data - CONEX

PARTIAL AUTOCORRELATIONS

1- 12	.35	-.05	.11	.14	-.09	.10	.04	.10	-.10	-.12	.16	.16
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
13- 24	-.13	.08	-.05	-.03	0.0	-.22	-.05	.06	.11	.09	.05	.08
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
25- 36	-.26	-.04	-.07	0.0	-.04	-.06	-.08	.04	.04	.04	-.03	.09
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13

PLOT OF PARTIAL AUTOCORRELATIONS

```
           -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG  CORR.  +----+----+----+----+----+----+----+----+----+----+
                                     I
  1   .353                     +     IXXXXX+XXX
  2  -.052                     +    XI     +
  3   .113                     +     IXXX  +
  4   .143                     +     IXXXX +
  5  -.093                     +   XXI     +
  6   .105                     +     IXXX  +
  7   .041                     +     IX    +
  8   .100                     +     IXX   +
  9  -.097                     +   XXI     +
 10  -.118                     +  XXXI     +
 11   .164                     +     IXXXX +
 12   .155                     +     IXXXX +
 13  -.126                     +  XXXI     +
 14   .076                     +     IXX   +
 15  -.045                     +    XI     +
 16  -.035                     +    XI     +
 17  -.005                     +     I     +
 18  -.216                     +XXXXXI     +
 19  -.051                     +    XI     +
 20   .061                     +     IXX   +
 21   .115                     +     IXXX  +
 22   .094                     +     IXX   +
 23   .055                     +     IX    +
 24   .082                     +     IXX   +
 25  -.258                     XXXXXXI     +
 26  -.043                     +    XI     +
 27  -.068                     +   XXI     +
 28   .001                     +     I     +
 29  -.039                     +    XI     +
 30  -.058                     +    XI     +
 31  -.083                     +   XXI     +
 32   .040                     +     IX    +
 33   .036                     +     IX    +
 34   .037                     +     IX    +
 35  -.033                     +    XI     +
 36   .090                     +     IXX   +
```

Figure F-86. PACF - Raw Data - CONEX

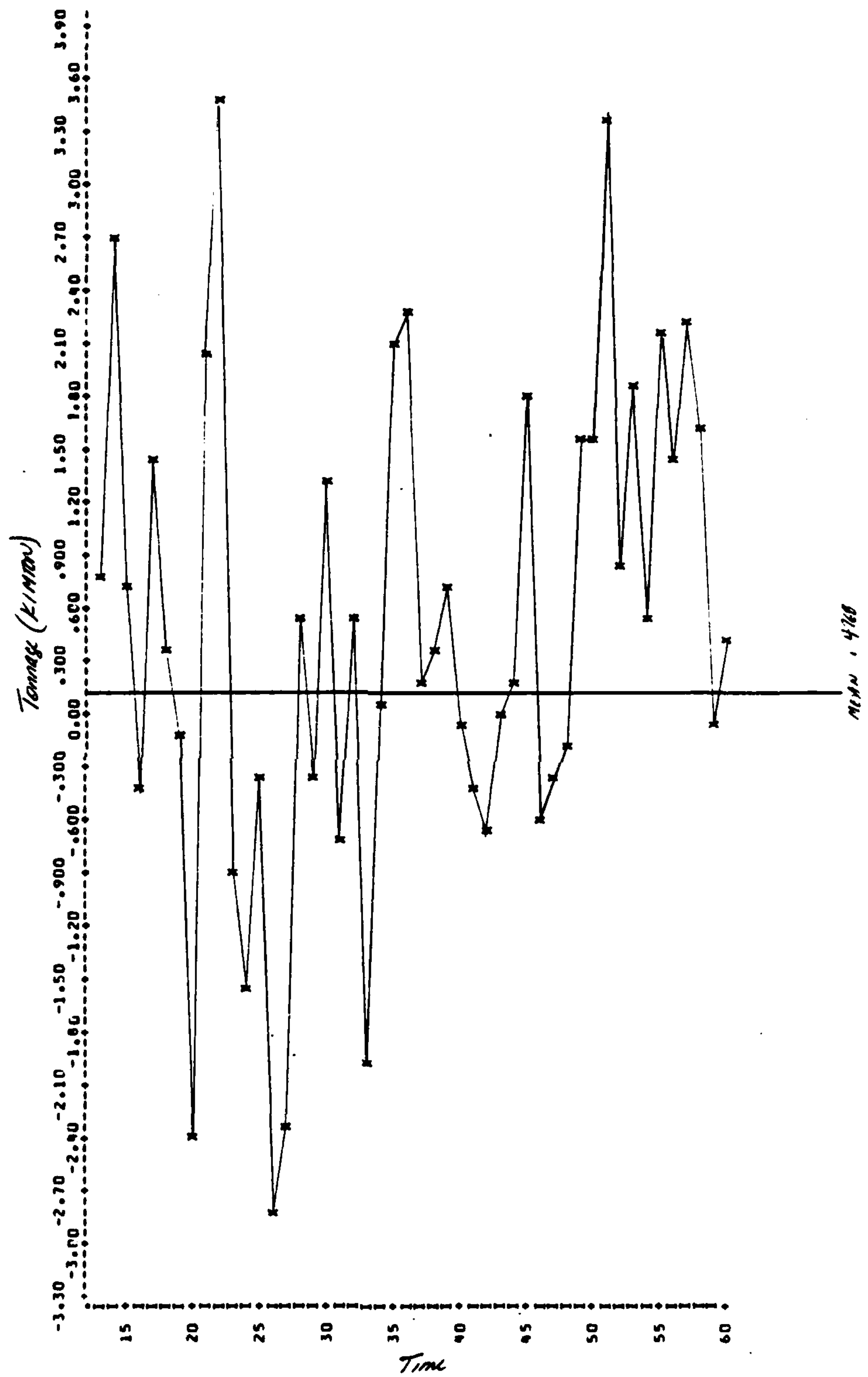


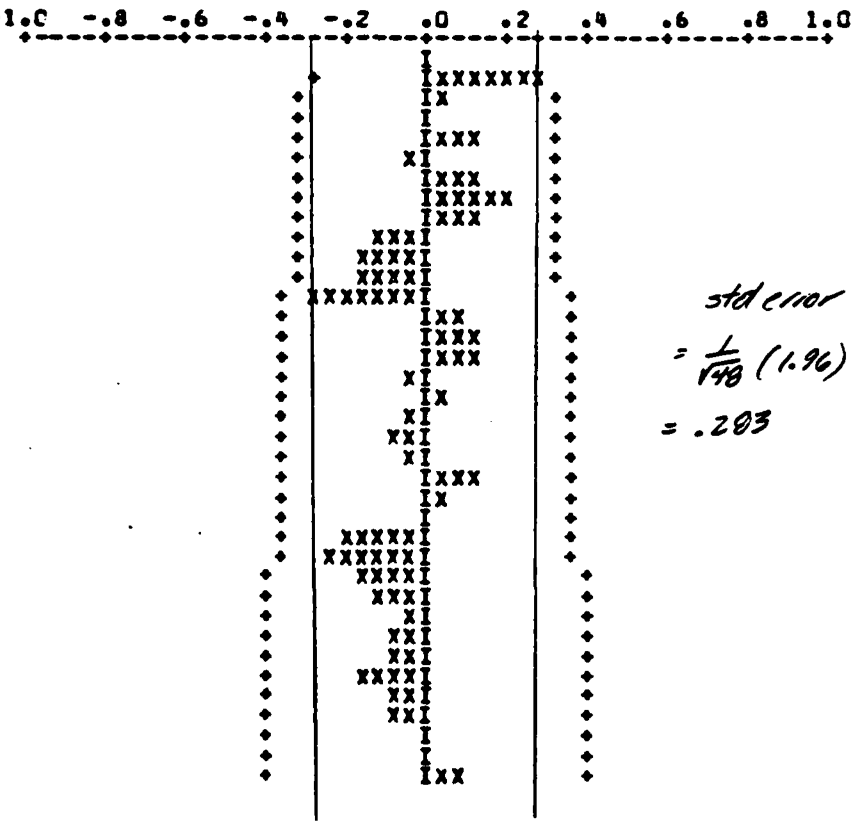
Figure F-87. Differenced Series (12-month lag) - CONEX

AUTOCORRELATIONS

1- 12	.28	.03	.01	.12	-.03	.12	.21	.10	-.13	-.15	-.15	-.27
ST.E.	.14	.16	.16	.16	.16	.16	.16	.16	.17	.17	.17	.17
13- 24	.08	.12	.10	-.03	.05	-.05	-.06	-.04	.12	.04	.01	-.21
ST.E.	.18	.18	.18	.19	.19	.19	.19	.19	.19	.19	.19	.19
25- 36	-.24	-.15	-.10	-.05	-.09	-.10	-.16	-.10	-.06	.01	.02	.08
ST.E.	.19	.20	.20	.20	.20	.20	.20	.21	.21	.21	.21	.21

PLOT OF AUTOCORRELATIONS

LAG	CORR.
1	.277
2	.035
3	.013
4	.118
5	-.034
6	.116
7	.212
8	.104
9	-.131
10	-.151
11	-.152
12	-.267
13	.077
14	.122
15	.103
16	-.034
17	.049
18	-.052
19	-.061
20	-.039
21	.124
22	.042
23	.008
24	-.205
25	-.237
26	-.147
27	-.105
28	-.049
29	-.093
30	-.099
31	-.156
32	-.096
33	-.060
34	.010
35	.016
36	.080



std error

$= \frac{1}{\sqrt{48}}(1.96)$

$= .283$

Figure F-88. ACF - Lagged 12 Months

PARTIAL AUTOCORRELATIONS

1- 12	.28	-.05	.02	.12	-.11	.18	.15	-.02	-.15	-.12	-.13	-.24
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14
13- 24	.26	.01	.12	.08	.07	0.0	-.06	-.11	-.07	-.07	-.01	-.28
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14
25- 36	-.03	.02	-.02	.08	-.07	-.06	-.06	.03	.01	-.08	.03	-.12
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14

PLOT OF PARTIAL AUTOCORRELATIONS

```
             -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG     CORR. +----+----+----+----+----+----+----+----+----+----+
                                        I
  1     .277                  +      IXXXXXXX
  2    -.046                  +     XI      +
  3     .017                  +      I      +
  4     .121                  +      IXXX   +
  5    -.110                  +   XXXI      +
  6     .175                  +      IXXXX  +
  7     .149                  +      IXXXX  +
  8    -.020                  +     XI      +
  9    -.146                  +  XXXXI      +
 10    -.122                  +   XXXI      +
 11    -.127                  +   XXXI      +
 12    -.243                  +XXXXXXI      +
 13     .260                  +      IXXXXXXX
 14     .011                  +      I      +
 15     .120                  +      IXXX   +
 16     .076                  +      IXX    +
 17     .067                  +      IXX    +
 18     .001                  +      I      +
 19    -.057                  +     XI      +
 20    -.113                  +   XXXI      +
 21    -.072                  +    XXI      +
 22    -.065                  +    XXI      +
 23    -.014                  +      I      +
 24    -.284                  XXXXXXXI      +
 25    -.028                  +     XI      +
 26     .016                  +      I      +
 27    -.025                  +     XI      +
 28     .080                  +      IXX    +
 29    -.065                  +    XXI      +
 30    -.061                  +    XXI      +
 31    -.059                  +     XI      +
 32     .025                  +      IX     +
 33     .008                  +      I      +
 34    -.077                  +    XXI      +
 35     .031                  +      IX     +
 36    -.120                  +   XXXI      +
```

Figure F-89. PACF - Lagged 12 Months

```
ESTIMATION BY BACKCASTING METHOD
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN  .1000-004

SUMMARY OF THE MODEL

OUTPUT VARIABLE -- TRANS
INPUT VARIABLES -- NOISE

VARIABLE  VAR. TYPE  MEAN       TIME      DIFFERENCES
                                                  12
TRANS       RANDOM              1-  60  (1-B   )

PARAMETER VARIABLE    TYPE  FACTOR  ORDER ESTIMATE         ST. ERR.  T-RATIO
     1    TRANS        MA      1      1     -.2912          .1254     -2.32
     2    TRANS        MA      2     12      .8264          .0552     14.97
     3    TRANS       TRND     1      0      .4057          .0992      4.09

RESIDUAL SUM OF SQUARES  =          40.249663 (BACKCASTS EXCLUDED)
DEGREES OF FREEDOM       =                 45
RESIDUAL MEAN SQUARE     =            .894437
```

Figure F-90. Model Parameters - CONEX

AUTOCORRELATIONS

1- 12	.01	.03	-.07	.13	-.06	.20	.08	.02	-.11	-.03	.03	-.22
ST.E.	.13	.13	.13	.13	.13	.13	.14	.14	.14	.14	.14	.14
13- 24	.02	.05	.05	-.09	.12	-.09	-.11	-.13	.10	0.0	.09	-.19
ST.E.	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15
25- 36	-.25	-.10	-.06	.05	-.06	-.07	-.14	0.0	-.06	.05	-.03	.05
ST.E.	.16	.16	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17

PLOT OF AUTOCORRELATIONS

```
            -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR.   +----+----+----+----+----+----+----+----+----+----+
                                       I
  1   .008                       +     I     +
  2   .028                       +     IX    +
  3  -.068                       +   XXI     +
  4   .133                       +     IXXX  +
  5  -.056                       +    XI     +
  6   .205                       +     IXXXXX+
  7   .079                      +      IXX    +
  8   .018                      +      I      +
  9  -.114                      +   XXXI      +
 10  -.035                      +     XI      +
 11   .027                      +      IX     +
 12  -.224                      +XXXXXXI      +
 13   .025                      +      IX     +
 14   .050                      +      IX     +
 15   .052                      +      IX     +
 16  -.087                      +    XXI      +
 17   .118                      +      IXXX   +
 18  -.088                      +    XXI      +
 19  -.108                      +   XXXI      +
 20  -.129                      +   XXXI      +
 21   .095                     +       IXX     +
 22   .001                     +       I       +
 23   .087                     +       IXX     +
 24  -.189                     +  XXXXXI       +
 25  -.247                     + XXXXXXI       +
 26  -.098                     +     XXI       +
 27  -.056                     +      XI       +
 28   .045                     +       IX      +
 29  -.063                     +     XXI       +
 30  -.071                     +     XXI       +
 31  -.137                     +    XXXI       +
 32  -.002                     +       I       +
 33  -.056                     +      XI       +
 34   .052                     +       IX      +
 35  -.029                     +      XI       +
 36   .051                     +       IX      +
```

.212(60) = 12.74

Figure F-91. Estimated Residuals - CONEX

FORECAST ON VARIABLE TRANS FROM TIME PERIOD 61

PERIOD	FORECASTS	ST. ERR.	ACTUAL	ERROR
61	6.58911	1.29529	5.968	-.621
62	6.84431	1.34909	5.62	-1.224
63	5.70318	1.34909	6.306	.603
64	4.99943	1.34909	4.289	-.710
65	5.27962	1.34909	5.415	.136
66	6.70210	1.34909	6.718	.016
67	6.83282	1.34909	5.628	-1.205
68	7.63256	1.34909	6.623	-1.59
69	5.36297	1.34909	5.379	.016
70	6.83380	1.34909	7.499	.665
71	7.16252	1.34909	8.432	1.269
72	6.21428	1.34909	7.173	.959

STANDARD ERROR = 1.29529 (BY CONDITIONAL METHOD)

76.43 74.47 MSE = .81

Figure F-92. Forecast FY 82 - CONEX

F-9. FREEZE

a. The raw series for commodity freeze is depicted in Figure F-93. The raw series does not depict any visible pattern; however, the data exhibit an upward trend over time. The 3-month moving average (Figure F-94) indicates that the data may be seasonal with peaks and troughs occurring at the end and beginning of the fiscal year, respectively. The 6-month moving average (Figure F-95) clearly identifies an upward trend in the data, but the seasonal trend is muted. Finally, the 12-month moving average (Figure F-96) indicates a steady increase of tonnage shipped throughout the data period. In fact, the 12-month moving average suggests that the annual data follow a linear trend upwards.

b. Autocorrelation function analysis (Figure F-97) of the data affirms the trend and seasonality of the freeze data. The trend is verified by the high number of positive coefficients during the first 12 lags. The seasonality of the data is suggested by the significant coefficients at lags 11, 23, and 35. Seasonality in the data was eliminated by differencing the series at a lag of 12 months. The plot of the seasonally adjusted series is shown in Figure F-98. The autocorrelation and partial autocorrelation function of the seasonally adjusted series (Figures F-99 and F-100) indicate that stationarity in the data has not been achieved. To achieve stationarity the seasonally adjusted data was differenced at a lag of one month. The resulting autocorrelation and partial autocorrelation functions are depicted in Figures F-101 and F-102.

c. The autocorrelation function of the differenced series suggests the possibility of a mixed nonseasonal model and a MA seasonal model. The initial model hypothesized was an ARIMA (1,1,1) nonseasonal model and an ARIMA (0,1,1) seasonal model. The autocorrelation function of the estimated residuals for the model depicted significant coefficients at lags 2,3,5, and 11. Next a ARIMA (2,1,2) nonseasonal model was tried. The coefficient for lag 2 was statistically insignificant and the autocorrelation coefficient at lag 11 of the estimated residual was still significant. Finally, an ARIMA (2,1,2) model incorporating the parameter 11 as the second MA parameter was attempted. The form of this model was:

$$(1-\phi_1 B - \phi_2 B^2)(1-B^{12})(1-B)X_t = (1-\theta_1 B - \theta_{11} B^{11})(1-\theta_{12}B^{12})\epsilon_t$$

d. The results of the model (Figure F-103) are as follows:

$$
\underset{(-6.76)}{(1+.7740B}\underset{(-5.96)}{+.6789B^2)}\,(1-B^{12})\,(1-B)\,X_t = \underset{(4.32)}{(1-.4729B}\underset{(-5.76)}{+.5038B^{11})}\,\underset{(12.04)}{(1-.7753B^{12})}\epsilon_t
$$

$$
\chi^2\,(5,20) = 14.66
$$

The results indicate that all of the estimated parameters of the model are significant at the 5 percent significance level (Figure F-104). The Q statistic for 20 degrees of freedom is 14.66. Therefore, the null hypothesis, residuals are uncorrelated, should not be rejected at the 22 percent significance level.

e. The freeze seasonal model forecasted that 31.9 K/MTON would be transported during FY 82 versus an actual shipment of 36.4 K/MTON (Figure F-105). The MSE of the forecast was .49, and the annual forecast error was -12.5 percent.

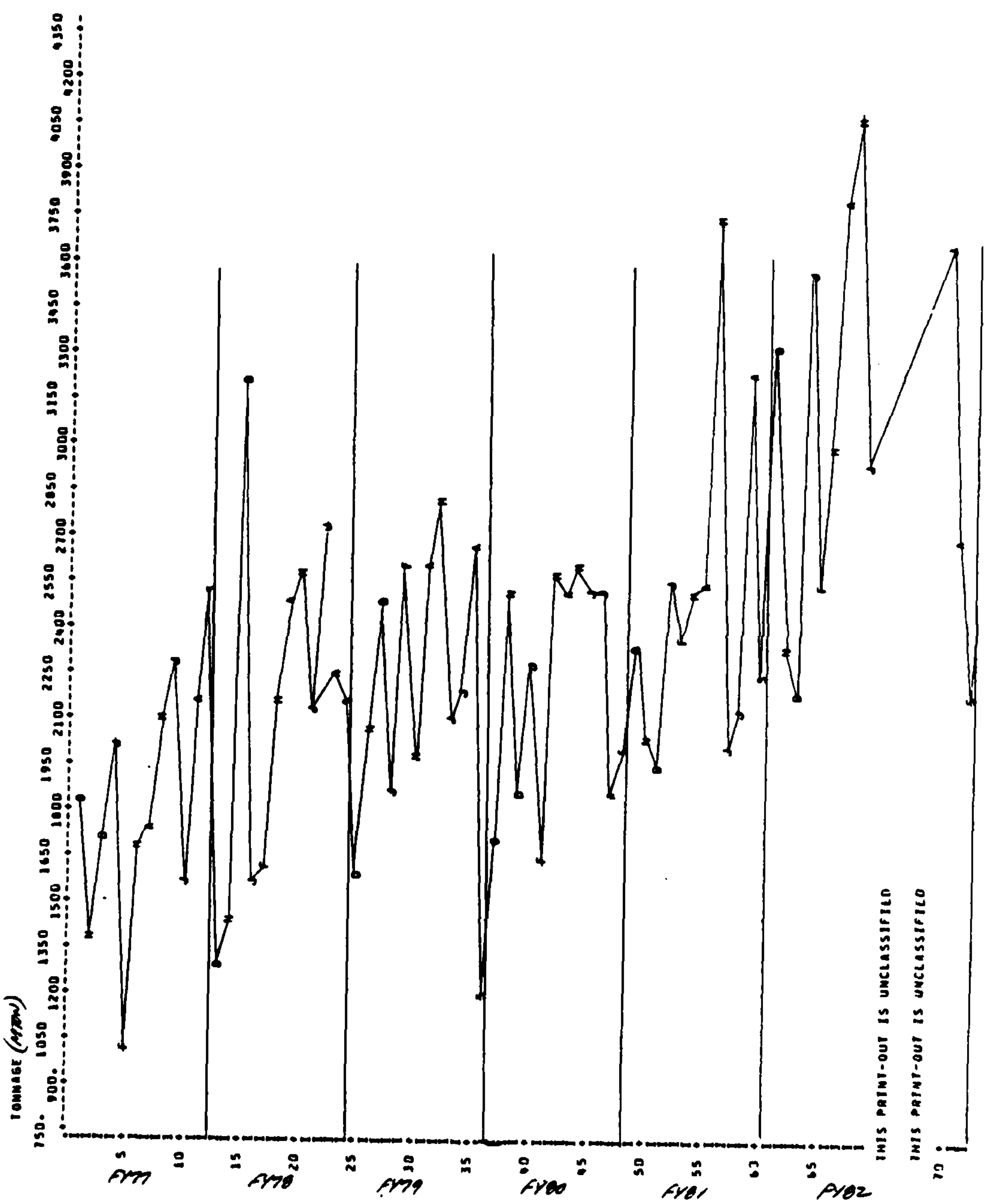
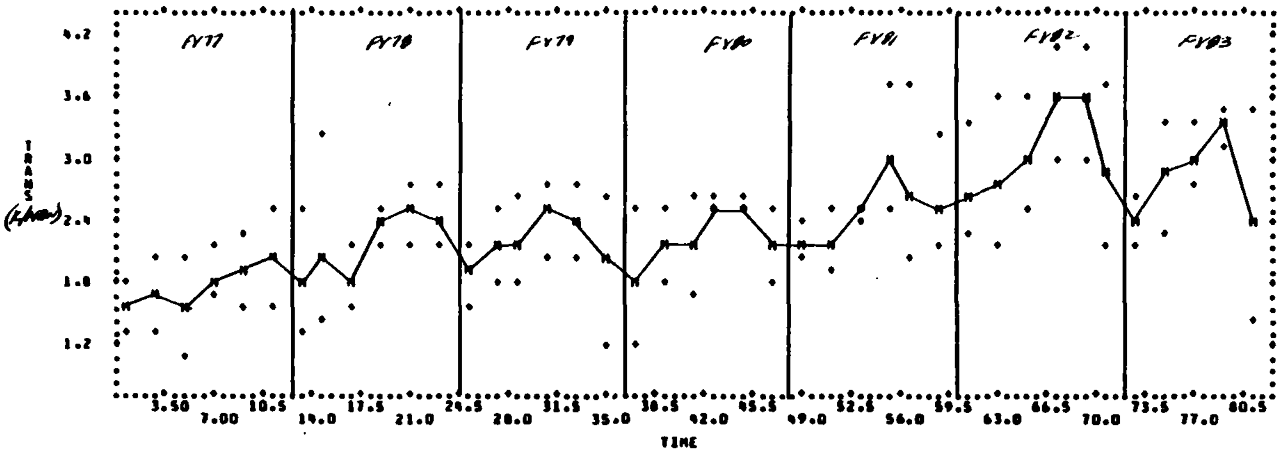
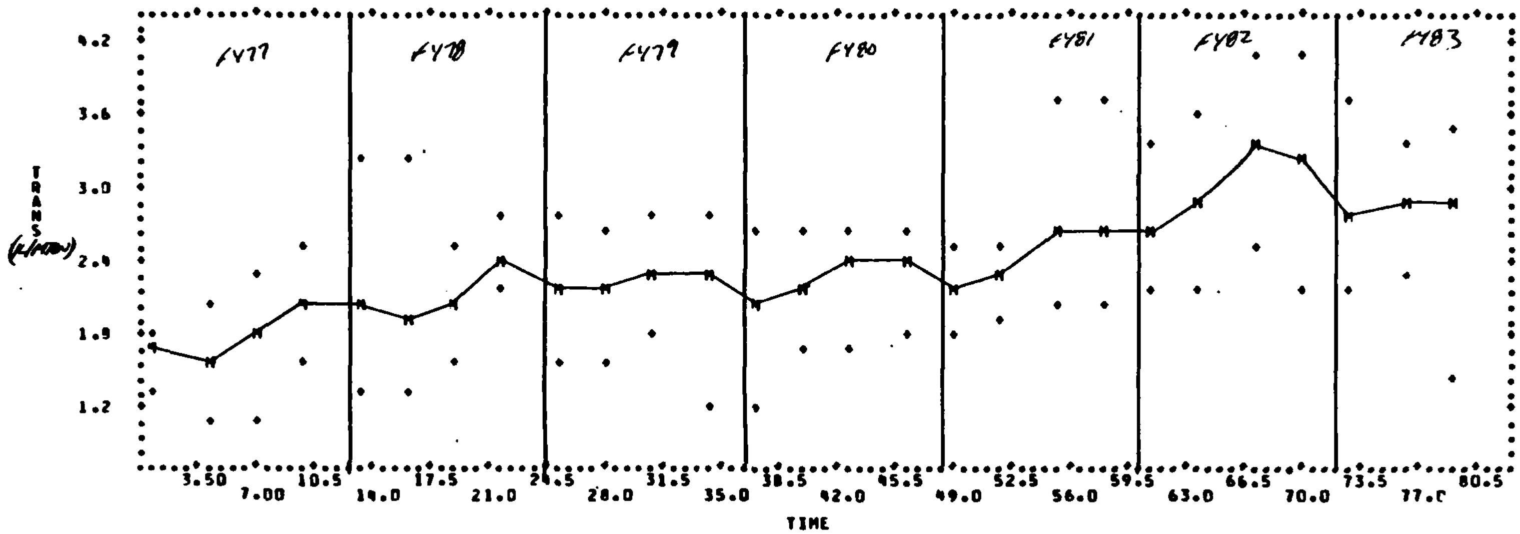


Figure F-93. Freeze Cargo FY 77 - FY 82



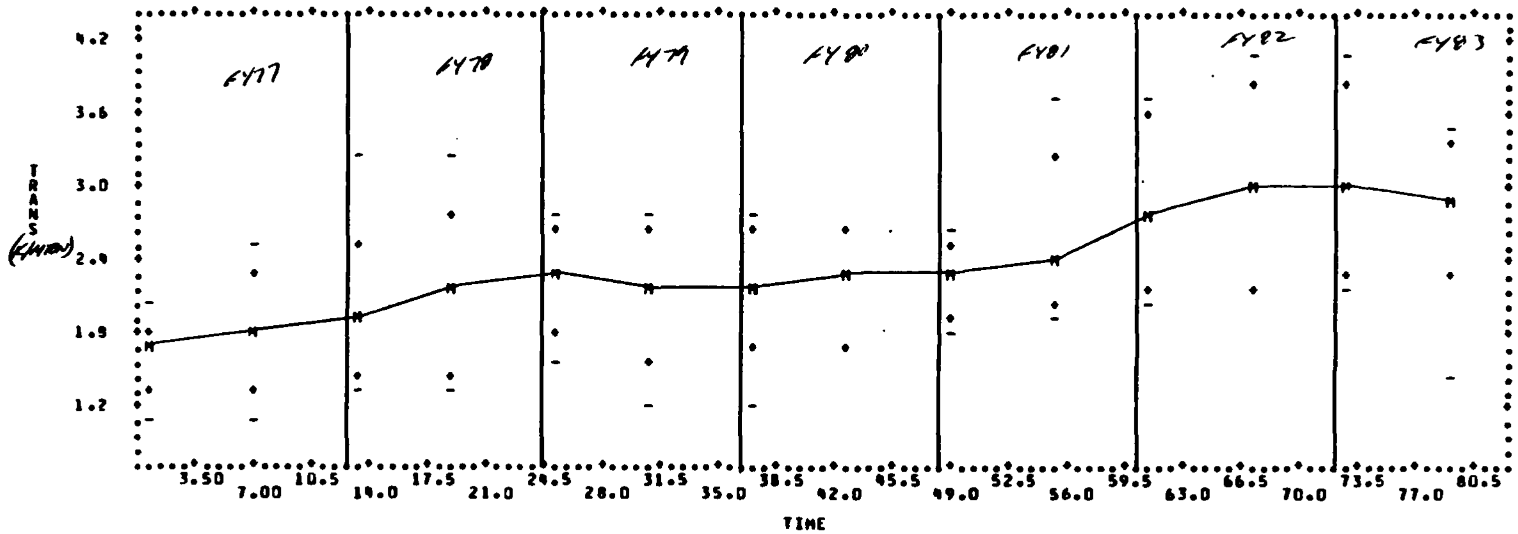
TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	2	1.3770	1.6010	1.8250
3.000	3	1.3770	1.6961	1.9970
5.000	3	1.0200	1.5697	1.9970
7.000	3	1.6920	1.8980	2.1050
9.000	3	1.5515	1.9788	2.2800
11.000	3	1.5515	2.0800	2.5206
13.000	3	1.2975	1.7502	2.5206
15.000	3	1.6326	2.0724	3.2220
17.000	3	1.5627	1.7852	2.1730
19.000	3	2.1730	2.4103	2.5750
21.000	3	2.1262	2.4790	2.7356
23.000	3	2.1556	2.3799	2.7356
25.000	3	1.6032	1.9913	2.1556
27.000	3	1.8542	2.1318	2.4759
29.000	3	1.8542	2.1565	2.6209
31.000	3	1.9942	2.4676	2.8079
33.000	3	2.0960	2.3667	2.8079
35.000	3	1.2047	2.0263	2.6781
37.000	3	1.2047	1.8065	2.5097
39.000	3	1.8493	2.2175	2.5097
41.000	3	1.6581	2.1808	2.5910
43.300	3	2.5100	2.5745	2.6224
45.000	3	2.5102	2.5580	2.6224
47.000	3	1.8560	2.1283	2.5182
49.000	3	2.0108	2.1354	2.3420
51.000	3	1.9486	2.1818	2.5435
53.000	3	2.3660	2.4782	2.5435
55.000	3	2.5252	2.9439	3.7428
57.000	3	2.0029	2.6299	3.7428
59.000	3	2.1439	2.5443	3.2403
61.000	3	2.2490	2.6393	3.3203
63.000	3	2.2046	2.7080	3.5709
65.000	3	2.5641	3.0490	3.5709
67.000	3	3.0119	3.6317	4.0762
69.000	3	2.9528	3.5640	4.0762
71.000	3	2.1891	2.8536	3.6629
73.000	3	2.1891	2.3988	2.6793
75.000	3	2.3331	2.8464	3.3674
77.003	3	2.7393	3.0538	3.3674
79.000	3	3.0846	3.3077	3.4893
81.003	2	1.4088	2.4490	3.4893

Figure F-94. Three-month Moving Average - Freeze



TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	3	1.3770	1.6388	1.8250
4.000	6	1.0200	1.6042	1.9970
7.000	6	1.0200	1.8068	2.2800
10.000	6	1.5515	2.0620	2.5206
13.000	6	1.2975	2.0327	3.2270
16.000	6	1.2975	1.8846	3.2220
19.000	6	1.5627	2.0930	2.5750
22.000	6	2.1262	2.3873	2.7356
25.000	6	1.6032	2.2140	2.7356
28.000	6	1.6032	2.1023	2.6209
31.000	6	1.8542	2.3290	2.8079
34.000	6	1.2047	2.2639	2.8079
37.000	6	1.2047	2.0239	2.6781
40.000	6	1.6581	2.1011	2.5910
43.000	6	1.6581	2.3680	2.6224
45.000	6	1.8560	2.3418	2.6224
49.000	6	1.8560	2.1215	2.5182
52.000	6	1.9486	2.2964	2.5435
55.000	6	2.0029	2.6240	3.7428
58.000	6	2.0029	2.6571	3.7428
61.000	6	2.1439	2.5944	3.3203
54.000	6	2.2046	2.9357	3.5709
67.000	6	2.5641	3.3335	4.0762
70.000	6	2.1841	3.2328	4.0762
73.000	6	2.1841	2.7353	3.6629
76.000	6	2.3331	2.8354	3.3674
79.000	6	1.4090	2.9714	3.4893

Figure F-95. Six-month Moving Average - Freeze



TIME VALUE	NO. OF CASES	MINIMUM VALUE	TRIMMED MINIMUM	TRIMMED MEAN	TRIMMED MAXIMUM	MAXIMUM VALUE
1.000	6	1.0200	1.3770	1.6521	1.8253	1.9970
7.000	12	1.0200	1.3770	1.8457	2.2803	2.5206
13.000	12	1.2975	1.4326	1.9160	2.5206	3.2220
19.000	12	1.2975	1.4325	2.1112	2.7356	3.2220
25.000	12	1.6032	1.6542	2.2599	2.6209	2.7356
31.000	12	1.2047	1.6032	2.2184	2.6781	2.8079
37.000	12	1.2047	1.6581	2.2178	2.6781	2.8079
43.000	12	1.6581	1.7052	2.2377	2.5910	2.6224
49.000	12	1.8560	1.9486	2.3351	2.5435	2.6224
55.003	12	1.9486	2.0029	2.4030	3.2403	3.7429
61.003	12	2.0029	2.1439	2.7217	3.5739	3.7429
67.000	12	2.1841	2.2046	3.0157	3.8071	4.0762
73.000	12	2.1841	2.3331	3.0149	3.8071	4.0762
79.000	9	1.4088	2.3331	2.9088	3.3674	3.4893

Figure F-96. Twelve-month Moving Average - Freeze

AUTOCORRELATIONS

1- 12	.09	.01	.37	.13	-.05	-.06	.06	.06	0.0	-.01	.30	.17
ST.E.	.13	.13	.13	.15	.15	.15	.15	.15	.15	.15	.15	.16
13- 24	0.0	.07	-.05	-.03	-.09	-.13	-.14	.03	-.02	-.03	.17	.07
ST.E.	.16	.16	.16	.16	.16	.16	.17	.17	.17	.17	.17	.17
25- 36	.01	-.06	.04	-.06	-.06	-.04	.01	0.0	0.0	.15	.01	.01
ST.E.	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.18	.18

PLOT OF AUTOCORRELATIONS

```
              -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG     CORR.  +----+----+----+----+----+----+----+----+----+----+
  1      .090                     +     IXX   +
  2      .015                     +     I     +
  3      .373                     +     IXXXXX+XXX
  4      .133                    +      IXXX   +
  5     -.045                    +     XI      +
  6     -.055                    +     XI      +
  7      .059                    +      IX     +
  8      .056                    +      IX     +
  9      .005                    +      I      +
 10     -.006                    +      I      +
 11      .303                    +      IXXXXXX+X
 12      .170                   +       IXXXX   +
 13      .001                   +       I       +
 14      .068                   +       IXX     +
 15     -.049                   +      XI       +
 16     -.029                   +      XI       +
 17     -.085                   +     XXI       +
 18     -.135                   +    XXXI       +
 19     -.135                   +    XXXI       +
 20      .034                   +       IX      +
 21     -.024                   +      XI       +
 22     -.034                   +      XI       +
 23      .166                   +       IXXXX   +
 24      .069                   +       IXX     +
 25      .015                   +       I       +
 26     -.056                   +      XI       +
 27      .038                   +       IX      +
 28     -.062                   +     XXI       +
 29     -.055                   +      XI       +
 30     -.036                   +      XI       +
 31      .012                   +       I       +
 32      .004                   +       I       +
 33     -.001                   +       I       +
 34      .153                   +       IXXXX   +
 35      .005                  +        I        +
 36      .013                  +        I        +
```

std error

$= \frac{1}{\sqrt{60}}(1.96)$

$= .253$

Figure F-97. ACF - Raw Data - Freeze

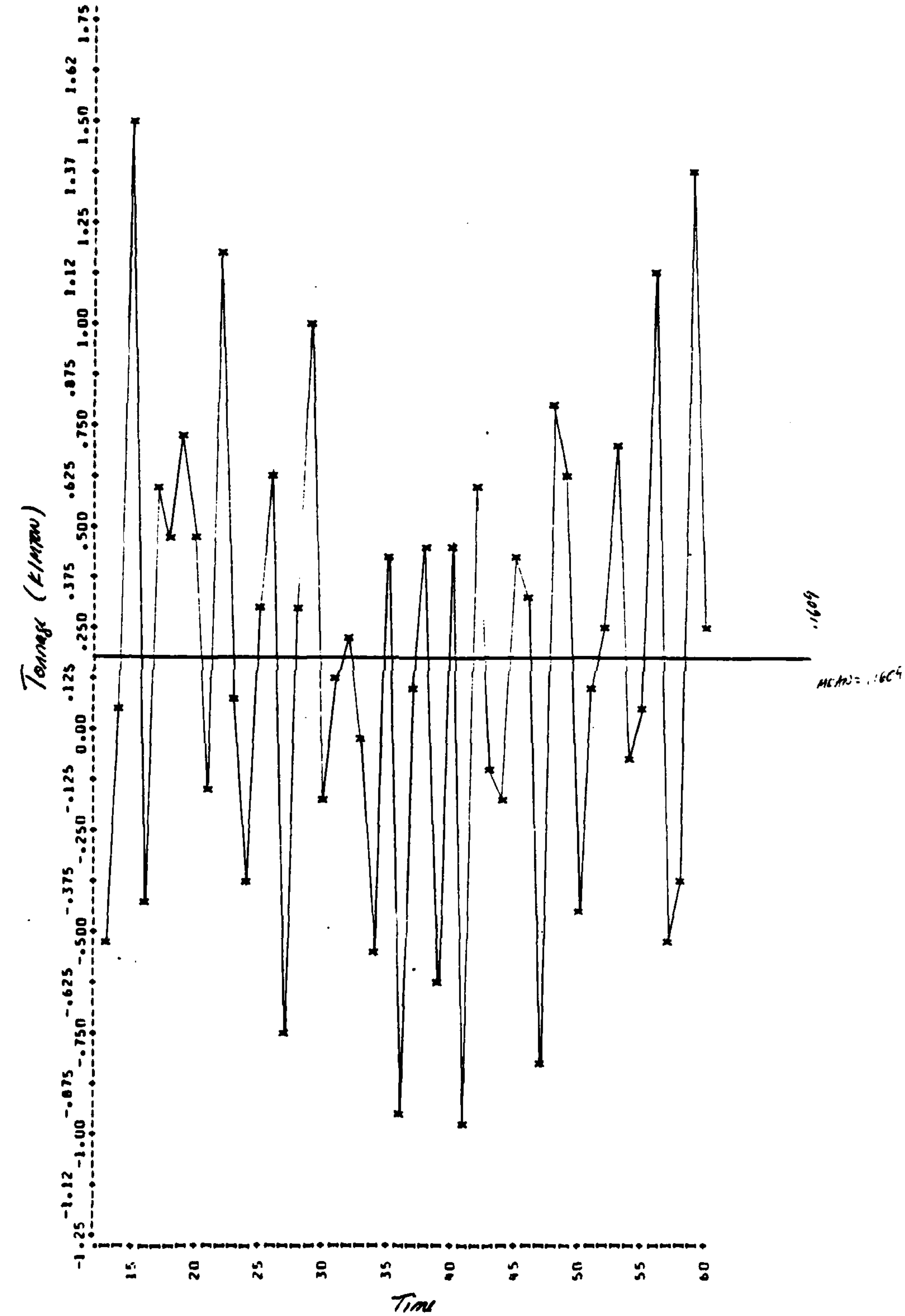


Figure F-98. Differenced Series (12-month lag) - Freeze

AUTOCORRELATIONS

1- 12	-.31	-.18	.38	.02	-.08	-.03	.20	-.02	-.16	.02	.28	-.32
ST.E.	.14	.16	.16	.18	.18	.18	.18	.19	.19	.19	.19	.20
13- 24	.01	.16	-.21	.02	-.02	-.09	-.15	.09	-.11	-.13	.12	-.05
ST.E.	.21	.21	.21	.21	.21	.21	.21	.22	.22	.22	.22	.22
25- 36	-.09	-.07	.14	-.04	-.16	.15	.13	-.26	.07	.21	-.17	-.03
ST.E.	.22	.22	.22	.23	.23	.23	.23	.23	.24	.24	.24	.24

PLOT OF AUTOCORRELATIONS

```
            -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG     CORR. +----+----+----+----+----+----+----+----+----+----+
                                       I
  1    -.313                   X+XXXXXXI      +
  2    -.179                   +   XXXXI       +
  3     .382                   +       IXXXXXXX+XX
  4     .022                  +        IX       +
  5    -.081                  +      XXI        +
  6    -.028                  +       XI        +
  7     .202                  +        IXXXXX   +
  8    -.017                  +        I        +
  9    -.159                  +    XXXXI        +
 10     .022                  +        IX       +
 11     .281                  +        IXXXXXXX +
 12    -.315                 + XXXXXXXXI         +
 13     .013                 +         I         +
 14     .156                 +         IXXXX     +
 15    -.214                 +    XXXXXI         +
 16     .016                 +         I         +
 17    -.016                 +         I         +
 18    -.088                 +       XXI         +
 19    -.155                +      XXXXI          +
 20     .093                +          IXX        +
 21    -.108                +       XXXI          +
 22    -.134                +       XXXI          +
 23     .121                +          IXXX       +
 24    -.046                +         XI          +
 25    -.092                +        XXI          +
 26    -.073                +        XXI          +
 27     .142                +          IXXXX      +
 28    -.040                +         XI          +
 29    -.163                +      XXXXI          +
 30     .152                +          IXXXX      +
 31     .133                +          IXXX       +
 32    -.257                +    XXXXXXI          +
 33     .071               +           IXX         +
 34     .206               +           IXXXXX      +
 35    -.171               +       XXXXI           +
 36    -.028               +          XI           +
```

std error

$= \frac{1}{\sqrt{48}}(1.96)$

$= .283$

Figure F-99. ACF - Lagged 12 Months

PARTIAL AUTOCORRELATIONS

1- 12	-.31	-.31	.26	.25	.18	-.13	.05	.05	-.05	-.21	.20	-.13
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14
13- 24	.04	-.13	-.14	-.04	-.01	-.18	-.27	.04	-.04	-.14	.13	.05
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14
25- 36	.03	-.12	-.05	.05	.01	.06	.08	-.07	-.02	-.13	-.07	-.13
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14

PLOT OF PARTIAL AUTOCORRELATIONS

```
          -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG   CORR. +----+----+----+----+----+----+----+----+----+----+
                                     I
 1    -.313                  X+XXXXXXI      +
 2    -.306                  X+XXXXXXI      +
 3     .261                   +      IXXXXXXX
 4     .254                   +      IXXXXXX+
 5     .176                   +      IXXXX  +
 6    -.127                   +   XXXI      +
 7     .052                   +      IX     +
 8     .054                   +      IX     +
 9    -.052                   +     XI      +
10    -.209                   + XXXXXI      +
11     .205                   +      IXXXXX +
12    -.125                   +   XXXI      +
13     .039                   +      IX     +
14    -.125                   +   XXXI      +
15    -.143                   +  XXXXI      +
16    -.044                   +     XI      +
17    -.006                   +      I      +
18    -.180                   + XXXXXI      +
19    -.269                   XXXXXXXI      +
20     .039                   +      IX     +
21    -.037                   +     XI      +
22    -.135                   +   XXXI      +
23     .125                   +      IXXX   +
24     .050                   +      IX     +
25     .027                   +      IX     +
26    -.121                   +   XXXI      +
27    -.053                   +     XI      +
28     .047                   +      IX     +
29     .010                   +      I      +
30     .056                   +      IX     +
31     .084                   +      IXX    +
32    -.074                   +    XXI      +
33    -.019                   +      I      +
34    -.125                   +   XXXI      +
35    -.069                   +    XXI      +
36    -.130                   +   XXXI      +
```

Figure F-100. PACF - Lagged 12 Months

AUTOCORRELATIONS

1- 12	-.56	-.09	.30	-.12	0.0	-.06	.10	.01	-.07	-.11	.35	-.31
ST.E.	.15	.19	.19	.20	.20	.20	.20	.20	.20	.20	.20	.21
13- 24	.05	.13	-.15	.39	-.03	.03	-.14	.20	-.10	-.08	.16	-.07
ST.E.	.22	.22	.23	.23	.23	.23	.23	.23	.23	.23	.24	.24
25- 36	0.0	-.06	.12	-.03	-.10	.06	.17	-.25	.06	.17	-.16	0.0
ST.E.	.24	.24	.24	.24	.24	.24	.24	.24	.25	.25	.25	.25

PLOT OF AUTOCORRELATIONS

```
             -1.0 -.8  -.6  -.4  -.2  .0   .2   .4   .6   .8   1.0
LAG   CORR.  +----+----+----+----+----+----+----+----+----+----+
                                      I
  1  -.560              XXXXXXX+XXXXXXI      +
  2  -.093                   +      XXI         +
  3   .297                   +        IXXXXXXX  +
  4  -.117                  +      XXXI          +
  5  -.002                  +         I          +
  6  -.061                  +       XXI          +
  7   .095                  +         IXX        +
  8   .006                  +         I          +
  9  -.073                  +       XXI          +
 10  -.115                  +      XXXI          +
 11   .353                  +         IXXXXXXXXX +
 12  -.312                 +  XXXXXXXXI           +
 13   .054                 +          IX          +
 14   .128                 +          IXXX        +
 15  -.147                 +      XXXXI           +
 16   .089                 +          IXX         +
 17  -.028                 +         XI           +
 18   .025                 +          IX          +
 19  -.137                 +       XXXI           +
 20   .196                 +          IXXXXX      +
 21  -.104                 +       XXXI           +
 22  -.081                +         XXI            +
 23   .159                +           IXXXX        +
 24  -.068                +         XXI            +
 25  -.004                +           I            +
 26  -.060                +          XI            +
 27   .119                +           IXXX         +
 28  -.031                +          XI            +
 29  -.105                +        XXXI            +
 30   .058                +           IX           +
 31   .167                +           IXXXX        +
 32  -.249                +     XXXXXXI            +
 33   .057                +           IX           +
 34   .171                +           IXXXX        +
 35  -.156                +       XXXXI            +
 36   .004                +           I            +
```

std error

$= \frac{1}{\sqrt{47}} (1.96)$

$= .286$

Figure F-101. ACF - Lagged 12 Months and 1 Month

```
PARTIAL AUTOCORRELATIONS

  1- 12     -.56 -.59 -.27 -.08  .15 -.02 -.03  .02  .08 -.32  .07 -.04
  ST.E.      .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15

 13- 24      .11  .01 -.06 -.07  .06  .08 -.28 -.10  .05 -.16 -.04  0.0
  ST.E.      .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15

 25- 36      .12 -.01 -.07 -.07 -.11 -.03  .13  0.0  .07  .01  .09 -.06
  ST.E.      .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15  .15

PLOT OF PARTIAL AUTOCORRELATIONS

            -1.0  -.8  -.6  -.4  -.2  .0   .2   .4   .6   .8   1.0
LAG    CORR.  +----+----+----+----+----+----+----+----+----+----+
                                       I
  1     -.560            XXXXXXX+XXXXXXI      +
  2     -.594           XXXXXXXX+XXXXXXI      +
  3     -.270                   XXXXXXXI      +
  4     -.083                   +    XXI      +
  5      .147                   +      IXXXX  +
  6     -.017                   +      I      +
  7     -.032                   +     XI      +
  8      .021                   +      IX     +
  9      .082                   +      IXX    +
 10     -.320                  X+XXXXXXI      +
 11      .066                   +      IXX    +
 12     -.044                   +     XI      +
 13      .107                   +      IXXX   +
 14      .013                   +      I      +
 15     -.062                   +    XXI      +
 16     -.072                   +    XXI      +
 17      .064                   +      IXX    +
 18      .079                   +      IXX    +
 19     -.277                   XXXXXXXI      +
 20     -.105                   +   XXXI      +
 21      .048                   +      IX     +
 22     -.162                   +  XXXXI      +
 23     -.037                   +     XI      +
 24     -.004                   +      I      +
 25      .117                   +      IXXX   +
 26     -.010                   +      I      +
 27     -.068                   +    XXI      +
 28     -.070                   +    XXI      +
 29     -.106                   +   XXXI      +
 30     -.033                   +     XI      +
 31      .126                   +      IXXX   +
 32     -.001                   +      I      +
 33      .068                   +      IXX    +
 34      .007                   +      I      +
 35      .086                   +      IXX    +
 36     -.063                   +    XXI      +
```

Figure F-102. PACF - Lagged 12 Months and 1 Month

ESTIMATION BY BACKCASTING METHOD

RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN .1000-004

SUMMARY OF THE MODEL

OUTPUT VARIABLE -- TRANS
INPUT VARIABLES -- NOISE

VARIABLE	VAR. TYPE	MEAN	TIME	DIFFERENCES
TRANS	RANDOM		1- 60	$(1-B^{12})(1-B^{1})$

PARAMETER	VARIABLE	TYPE	FACTOR	ORDER	ESTIMATE	ST. ERR.	T-RATIO
1	TRANS	MA	1	1	.4729	.1095	4.32
2	TRANS	MA	1	11	-.5038	.0875	-5.76
3	TRANS	MA	2	12	.7753	.0644	12.04
4	TRANS	AR	1	1	-.7740	.1145	-6.76
5	TRANS	AR	1	2	-.6789	.1139	-5.96

RESIDUAL SUM OF SQUARES = 4.795347 (BACKCASTS EXCLUDED)
DEGREES OF FREEDOM = 40
RESIDUAL MEAN SQUARE = .119884

Figure F-103. Model Parameters - Freeze

AUTOCORRELATIONS

1- 12	-.15	.01	-.09	.01	-.18	-.03	.14	0.0	-.03	.15	.10	-.11
ST.E.	.13	.13	.13	.13	.13	.14	.14	.14	.14	.14	.14	.14
13- 24	-.14	.09	-.10	.03	-.09	.08	-.12	.02	.02	-.12	.10	-.15
ST.E.	.14	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.16
25- 36	.03	-.05	.10	-.10	-.08	.04	.03	-.09	.10	.09	-.02	-.07
ST.E.	.15	.16	.16	.16	.16	.16	.16	.16	.16	.16	.16	.16

PLOT OF AUTOCORRELATIONS

```
               -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG    CORR.    +----+----+----+----+----+----+----+----+----+----+
  1    -.149                         + XXXX I    +
  2     .011                         +      I    +
  3    -.091                         +   XX I    +
  4     .007                        +       I     +
  5    -.183                        + XXXXX I     +
  6    -.026                        +      XI     +
  7     .140                        +       IXXX  +
  8     .001                        +       I     +
  9    -.027                        +      XI     +
 10     .146                        +       IXXXX +
 11     .096                        +       IXX   +
 12    -.113                        +    XXXI     +
 13    -.136                        +    XXXI     +
 14     .085                        +       IXX   +
 15    -.105                        +    XXXI     +
 16     .034                        +       IX    +
 17    -.089                        +     XXI     +
 18     .076                        +       IXX   +
 19    -.124                        +    XXXI     +
 20     .020                        +       I     +
 21     .023                        +       IX    +
 22    -.119                        +    XXXI     +
 23     .079                       +        IXX    +
 24    -.148                       +    XXXXI      +
 25     .032  .244(60) = 14.66     +        IX     +
 26    -.049                       +       XI      +
 27     .079                       +        IXX    +
 28    -.077                       +      XXI      +
 29    -.081                       +      XXI      +
 30     .045                       +        IX     +
 31     .022                       +        IX     +
 32    -.096                       +      XXI      +
 33     .101                       +        IXXX   +
 34     .091                       +        IXX    +
 35    -.016                       +        I      +
 36    -.070                       +      XXI      +
```

Figure F-104. Estimated Residuals - Freeze

FORECAST ON VARIABLE TRANS FROM TIME PERIOD 61

PERIOD	FORECASTS	ST. ERR.	ACTUAL	
61	2.00563	.47265	3.32	1.32
62	2.34216	.48683	2.348	.006
63	2.86668	.48719	2.205	-.662
64	2.62217	.57961	3.571	.949
65	2.44941	.57964	2.564	.115
66	2.77187	.58139	3.012	.24
67	3.05363	.62199	3.807	.754
68	3.02205	.62397	4.076	1.054
69	2.55615	.62686	2.953	.397
70	2.75182	.64922	3.663	.911
71	2.87791	.65384	2.714	-.164
72	2.54864	.72470	2.184	-.365

STANDARD ERROR = .472645 (BY CONDITIONAL METHOD)

31.86 36.42 MSE = .498

Figure F-105. Forecast FY 82 - Freeze

F-10. CHILL

a. The raw series for chill is shown in Figure F-106. The raw series indicates the evidence of a recurring pattern and the possibility of seasonality in the data. Visual examination of the plots of the 3-month and 6-month (Figures F-107 and F-108) moving averages indicates that the data do follow a seasonal trend. However, the 12-month moving average indicates that the overall mean of the series during the last 6 1/2 years has been constant (Figure F-109).

b. Autocorrelation function analysis of the modeled data confirms the fact that seasonality does exist in the data (Figures F-110 and F-111). Therefore, to eliminate seasonality, the series was differenced at a lag of 12 months. This process did not produce stationary data since the resulting data plot exhibited heteroscedasticity (change in variance over time). The original series was then transformed using natural logarithms and the logarithmic series was then differenced as a lag of 12 months. The plot of the logarithmic differenced series is depicted in Figure F-112. The autocorrelation and partial autocorrelation functions of the seasonally adjusted series are shown in Figures F-113 and F-114. The autocorrelation function suggests that the data is stationary.

c. Analysis of the autocorrelation and partial autocorrelation function suggests the possibility of an ARIMA (0,0,2) nonseasonal model and an ARIMA (1,1,0) seasonal model. An AR seasonal process was used since the results from the AR model were better than the MA seasonal model. The suggested model is of the form:

$$(1 - \phi_{12}B^{12})(1 - B^{12}) \ln X_t = (1 - \theta_1 B - \theta_2 B^2)\epsilon_t$$

d. The results of the model (Figure F-115) are as follows:

$$\underset{(-5.61)}{(1 + .6371B^{12})}(1 - B^{12}) \ln X_t = (1 - \underset{(2.0)}{.3012B} + \underset{(-1.83)}{.2716B^2})\epsilon_t$$

$$\chi^2\ (3.20) = 15.63$$

All of the estimated parameters except θ_2 are significant at the 5 percent significance level (Figure F-116). The Q statistic for 20 degrees of freedom is 15.63, which indicates that the residuals are not significant and that the null hypothesis should not be rejected at the 26 percent significance level. Also, all of the estimated residuals fall within the 95 percent confidence interval and apprear to be distributed randomly. The FY 82 forecast for chill using this model was 15.32 K/MTON of cargo shipped versus an actual lift of 14.13 K/MTON. The MSE of the chill forecast was .21, and the annual forecast error was 8.4 percent.

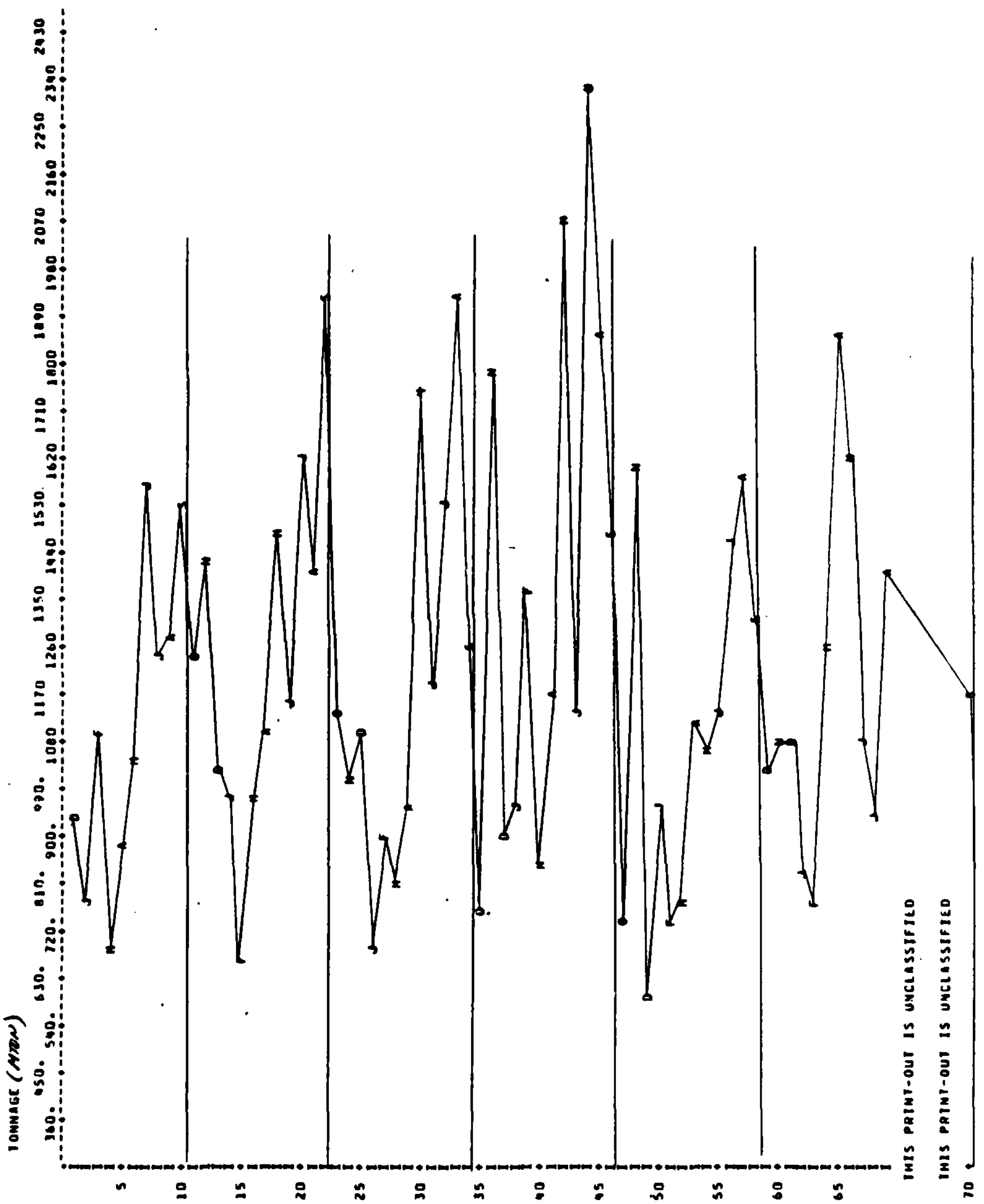
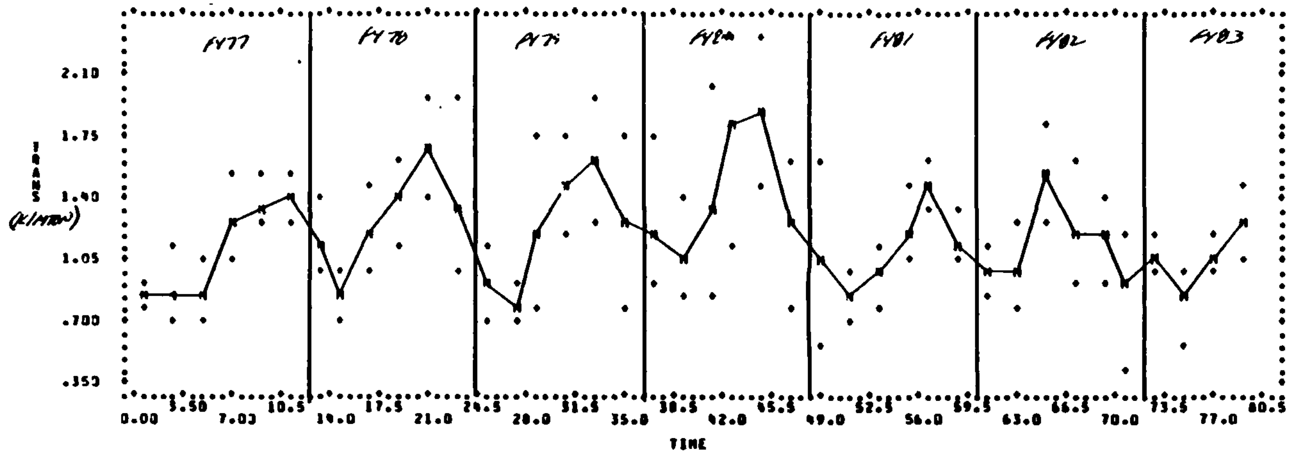
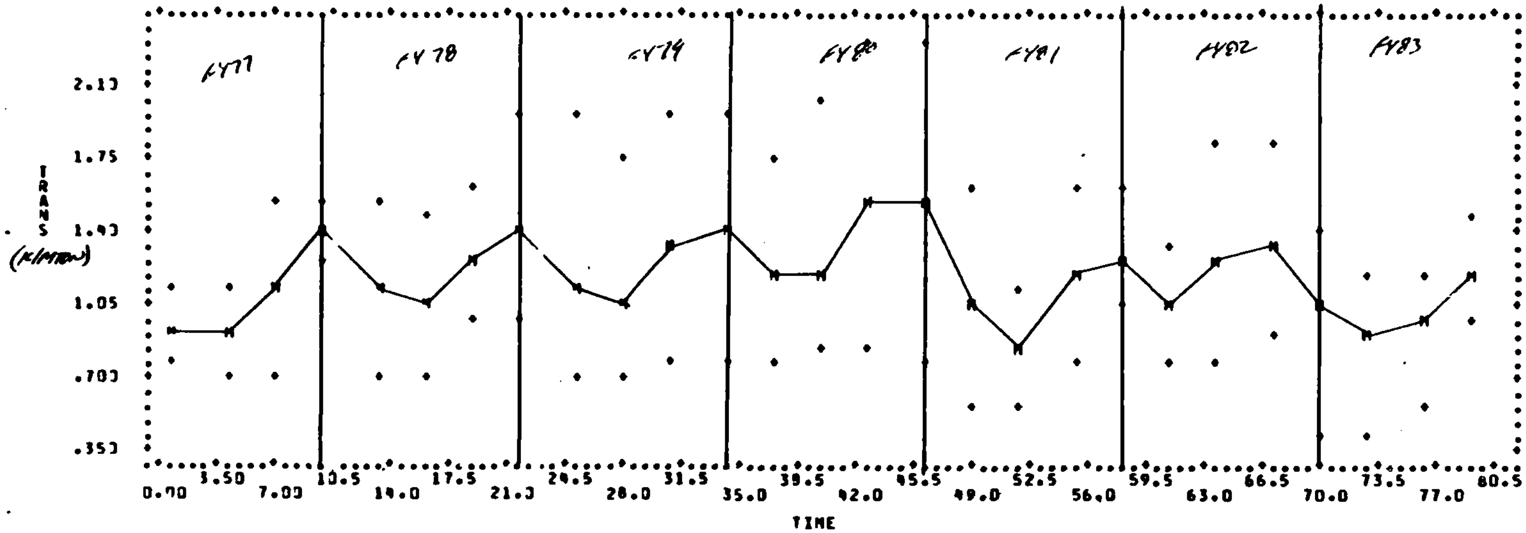


Figure F-106. Chill Cargo FY 77 - FY 82



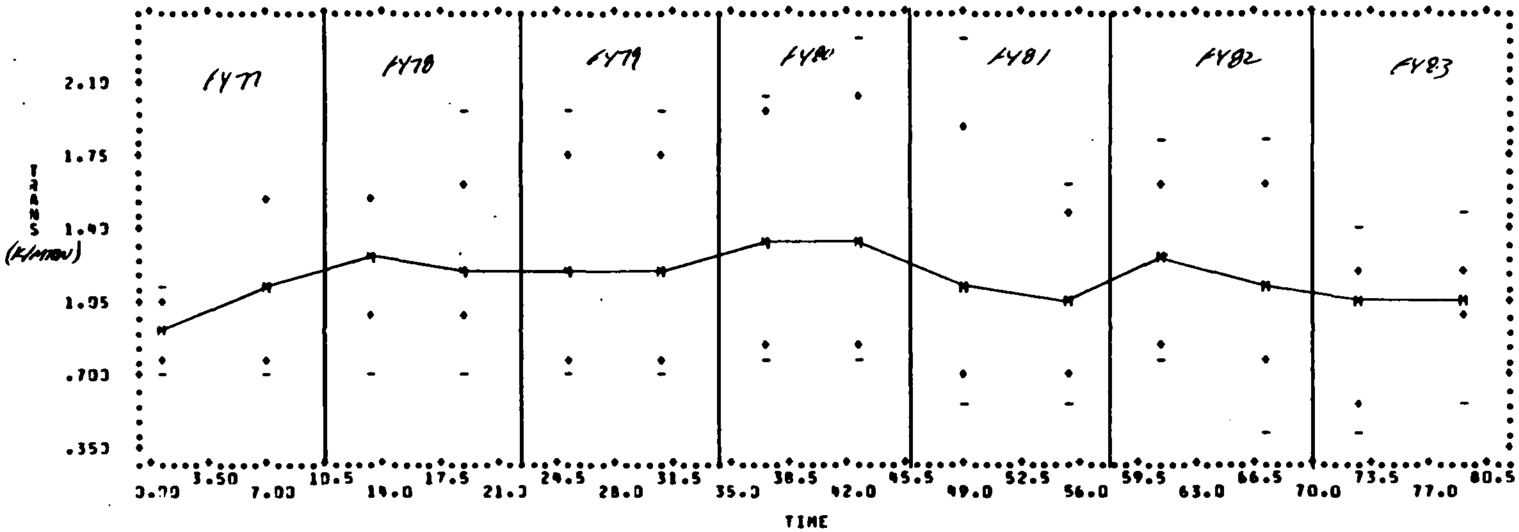
TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	2	.7730	.8510	.9293
3.000	3	.6860	.8503	1.0920
5.000	3	.6860	.8745	1.0490
7.000	3	1.0490	1.2073	1.5695
9.000	3	1.2440	1.3534	1.5363
11.000	3	1.2417	1.3996	1.5363
13.000	3	.8680	1.1932	1.4207
15.000	3	.6650	.8689	.9732
17.000	3	.9730	1.1798	1.4682
19.000	3	1.1476	1.4113	1.6241
21.000	3	1.1983	1.6515	1.9321
23.000	3	1.0070	1.3570	1.9321
25.000	3	.5795	.9291	1.1207
27.000	3	.6795	.7939	.8984
29.000	3	.9037	1.1679	1.7446
31.000	3	1.1804	1.4973	1.7446
33.000	3	1.2690	1.5775	1.9267
35.000	3	.7538	1.2681	1.7819
37.000	3	.9371	1.2172	1.7819
39.000	3	.8417	1.0582	1.3703
41.000	3	.8417	1.3602	2.0647
43.000	3	1.1319	1.8405	2.3253
45.000	3	1.4759	1.8875	2.3253
47.000	3	.7365	1.2714	1.6017
49.000	3	.5869	1.0484	1.6017
51.000	3	.7332	.8235	.9565
53.000	3	.7809	.9857	1.1112
55.000	3	1.0650	1.2179	1.4623
57.000	3	1.3054	1.4492	1.5800
59.000	3	1.0293	1.1910	1.3054
61.000	3	.8367	1.0003	1.0884
63.000	3	.7766	.9572	1.2503
65.000	3	1.2503	1.5743	1.8522
67.000	3	.9418	1.2125	1.6123
69.000	3	.9418	1.1721	1.4342
71.000	3	.9058	.9252	1.1996
73.000	3	1.0025	1.0689	1.1996
75.000	3	.5537	.8506	1.0348
77.000	3	.9933	1.0779	1.1639
79.000	2	1.0791	1.2919	1.5047

Figure F-107. Three-month Moving Average - Chill



TIME VALUE	NO. OF CASES	MINIMUM VALUE	MEAN	MAXIMUM VALUE
1.000	3	.7730	.9313	1.0970
4.000	6	.6860	.9029	1.0920
7.000	6	.5860	1.1194	1.5690
10.000	6	1.2417	1.3819	1.5690
13.000	6	.5650	1.1439	1.5363
16.000	6	.5650	1.0347	1.4682
19.000	6	.9730	1.2949	1.6241
22.000	6	1.0370	1.3739	1.9321
25.000	6	.6795	1.1253	1.9321
28.000	6	.6795	1.0301	1.7446
31.000	6	.8037	1.3577	1.9267
34.000	6	.7539	1.4087	1.9267
37.000	6	.7538	1.1747	1.7819
40.000	6	.8417	1.2201	2.0647
43.000	6	.8417	1.5664	2.3253
46.000	6	.7365	1.5220	2.3253
49.000	6	.5869	1.0151	1.6017
52.000	6	.5869	.8723	1.1112
55.000	6	.7839	1.1976	1.5870
58.000	6	1.0293	1.2653	1.5870
61.000	6	.7766	1.0197	1.3054
64.000	6	.7766	1.2353	1.8522
67.000	6	.9418	1.3587	1.8522
70.000	6	.4058	1.0342	1.4042
73.000	6	.4058	.8994	1.1905
76.000	6	.5537	.9657	1.1679
79.000	4	.9933	1.1845	1.5047

Figure F-108. Six-month Moving Average - Chill



TIME VALUE	NO. OF CASES	MINIMUM VALUE	TRIMMED MINIMUM	TRIMMED MEAN	TRIMMED MAXIMUM	MAXIMUM VALUE
1.000	6	.6860	.7730	.9399	1.0490	1.0920
7.000	12	.6860	.7730	1.1459	1.5363	1.5690
13.000	12	.6650	.9660	1.2262	1.5363	1.5690
19.000	12	.5650	.9660	1.1850	1.5241	1.9321
25.000	12	.5795	.8037	1.1812	1.7446	1.9321
31.000	12	.5795	.7539	1.2323	1.7814	1.9267
37.000	12	.7538	.8417	1.2950	1.9267	2.0647
43.000	12	.7365	.8417	1.3391	2.0647	2.3253
49.000	12	.5869	.7332	1.1459	1.8612	2.3253
55.000	12	.5869	.7332	1.0658	1.4623	1.5800
61.000	12	.7766	.8367	1.2375	1.5123	1.8522
67.000	12	.4358	.7766	1.1359	1.6123	1.8522
73.000	12	.4358	.5537	1.0189	1.1996	1.4042
79.000	7	.5537	.9933	1.3481	1.1609	1.5047

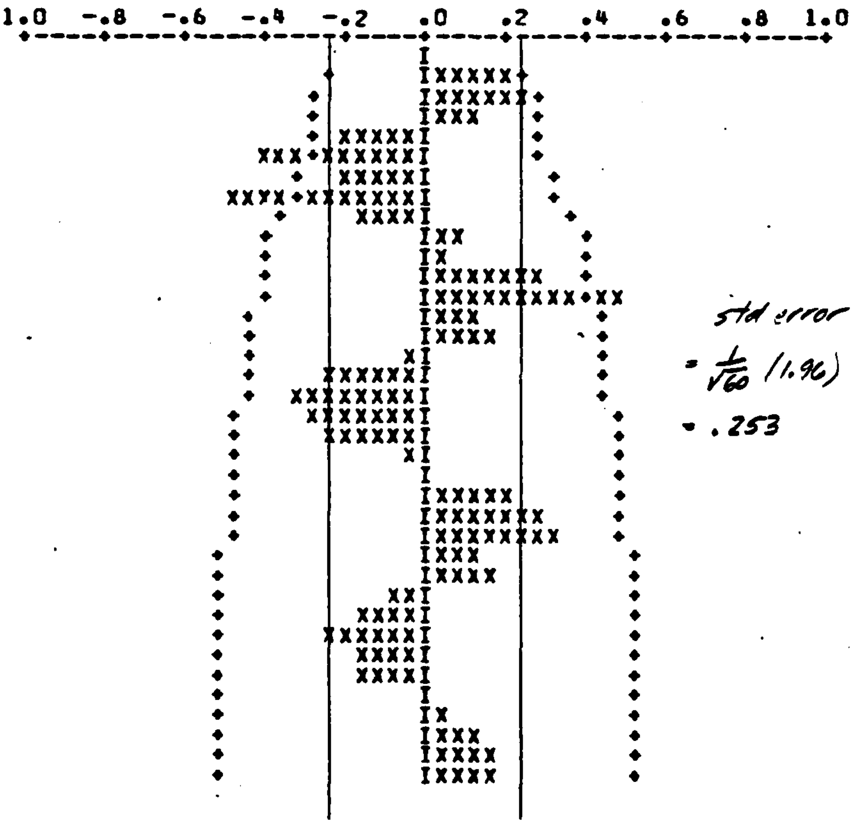
Figure F-109. Twelve-month Moving Average - Chill

AUTOCORRELATIONS

1- 12	.21	.25	.14	-.19	-.42	-.20	-.48	-.14	.06	.06	.29	.48
ST.E.	.13	.13	.14	.14	.15	.17	.17	.19	.19	.19	.19	.20
13- 24	.12	.17	-.03	-.26	-.32	-.29	-.25	-.02	.01	.19	.27	.30
ST.E.	.22	.22	.22	.22	.23	.24	.24	.25	.25	.25	.25	.25
25- 36	.12	.15	-.08	-.16	-.26	-.17	-.17	-.01	.03	.11	.14	.14
ST.E.	.26	.26	.26	.26	.26	.27	.27	.27	.27	.27	.27	.27

PLOT OF AUTOCORRELATIONS

LAG	CORR.
1	.207
2	.247
3	.136
4	-.193
5	-.419
6	-.202
7	-.485
8	-.140
9	.063
10	.059
11	.286
12	.484
13	.118
14	.165
15	-.026
16	-.256
17	-.317
18	-.291
19	-.247
20	-.024
21	.014
22	.189
23	.267
24	.300
25	.118
26	.147
27	-.081
28	-.158
29	-.258
30	-.172
31	-.170
32	-.012
33	.026
34	.112
35	.142
36	.143



std error

$= \frac{1}{\sqrt{60}}(1.96)$

$= .253$

Figure F-110. ACF - Raw Data - Chill

PARTIAL AUTOCORRELATIONS

1- 12	.21	.21	.06	-.30	-.47	-.01	-.25	.09	.18	-.02	.08	.20
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
13- 24	-.09	-.14	-.16	-.03	-.06	-.07	.20	.08	-.14	-.02	-.08	.05
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13
25- 36	-.05	.13	.08	-.05	-.02	.05	-.07	-.06	-.01	-.09	-.07	0.0
ST.E.	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13	.13

PLOT OF PARTIAL AUTOCORRELATIONS

```
             -1.0 -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG    CORR.  +----+----+----+----+----+----+----+----+----+----+
                                       I
  1     .207                     +     IXXXXX+
  2     .213                     +     IXXXXX+
  3     .056                     +     IX    +
  4    -.302                   XX+XXXXXI     +
  5    -.465               XXXXXX+XXXXXI     +
  6    -.015                     +     I     +
  7    -.245                     XXXXXXI     +
  8     .090                     +     IXX   +
  9     .185                     +     IXXXXX+
 10    -.017                     +     I     +
 11     .082                     +     IXX   +
 12     .201                     +     IXXXXX+
 13    -.094                     +   XXI     +
 14    -.137                     +  XXXI     +
 15    -.158                     + XXXXI     +
 16    -.032                     +    XI     +
 17    -.063                     +   XXI     +
 18    -.066                     +   XXI     +
 19     .199                     +     IXXXXX+
 20     .081                     +     IXX   +
 21    -.139                     +  XXXI     +
 22    -.021                     +    XI     +
 23    -.078                     +   XXI     +
 24     .053                     +     IX    +
 25    -.053                     +    XI     +
 26     .128                     +     IXXX  +
 27     .084                     +     IXX   +
 28    -.050                     +    XI     +
 29    -.022                     +    XI     +
 30     .052                     +     IX    +
 31    -.071                     +   XXI     +
 32    -.055                     +    XI     +
 33    -.009                     +     I     +
 34    -.091                     +   XXI     +
 35    -.066                     +   XXI     +
 36    -.004                     +     I     +
```

Figure F-111. PACF - Raw Data - Chill

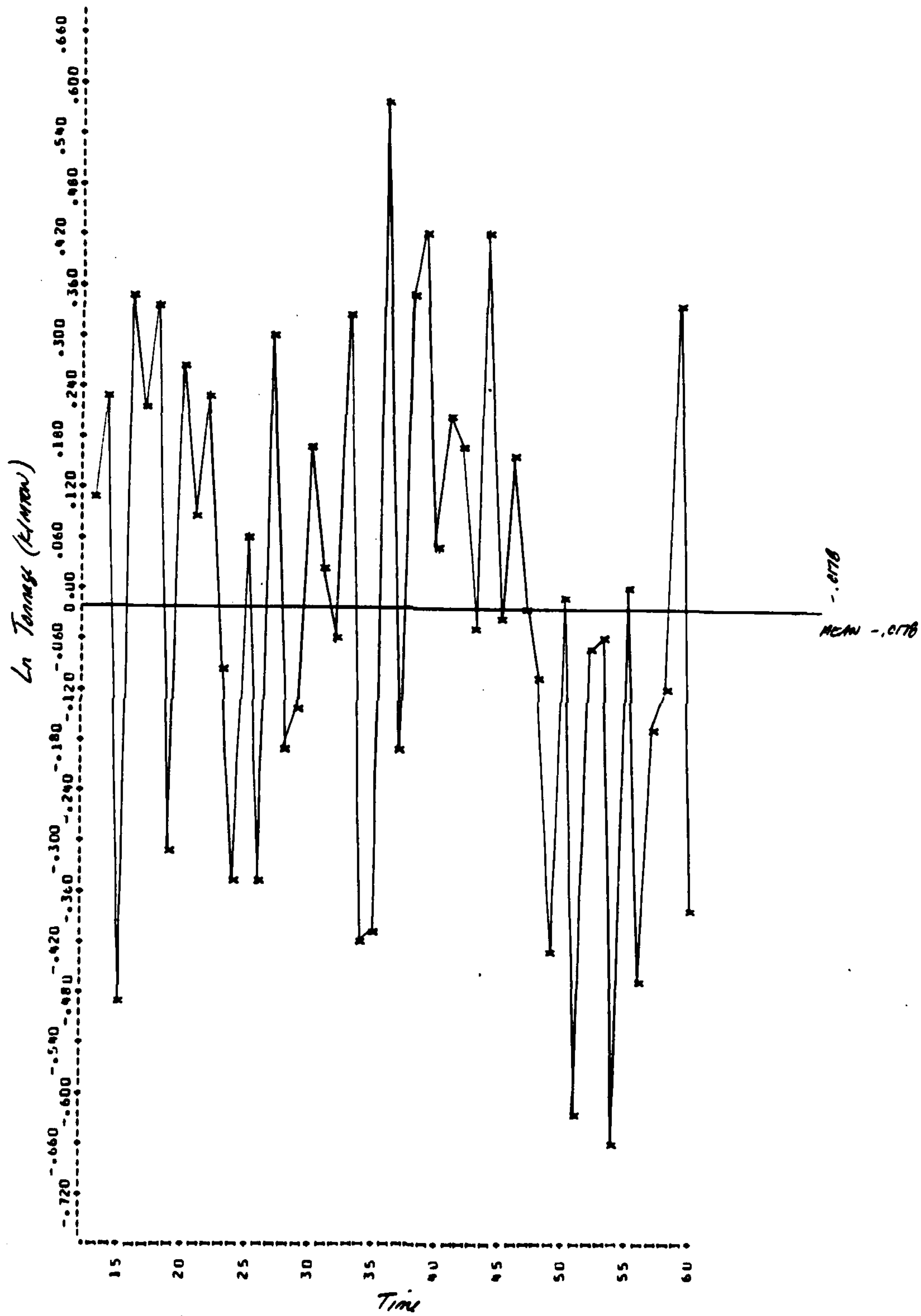


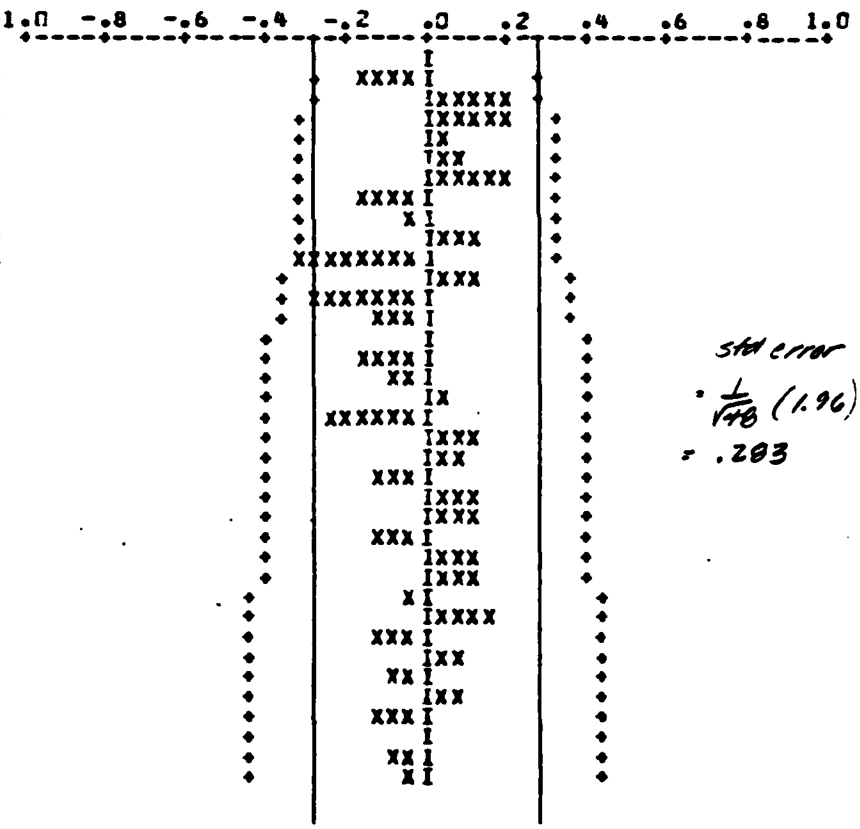
Figure F-112. Log Differenced Series (12-month lag) - Chill

AUTOCORRELATIONS

1- 12	-.15	.22	.22	.03	.08	.18	-.14	-.04	.12	-.33	.14	-.27
ST.E.	.14	.15	.15	.16	.16	.16	.17	.17	.17	.17	.18	.18
13- 24	-.14	.02	-.17	-.07	.04	-.25	.12	.08	-.10	.10	.12	-.12
ST.E.	.19	.19	.19	.20	.20	.20	.20	.21	.21	.21	.21	.21
25- 36	.12	.12	-.05	.15	-.12	.10	-.09	.06	-.13	-.01	-.09	-.02
ST.E.	.21	.21	.21	.21	.22	.22	.22	.22	.22	.22	.22	.22

PLOT OF AUTOCORRELATIONS

LAG	CORR.
1	-.147
2	.216
3	.219
4	.031
5	.082
6	.183
7	-.141
8	-.036
9	.119
10	-.326
11	.138
12	-.273
13	-.135
14	.019
15	-.165
16	-.065
17	.038
18	-.250
19	.119
20	.081
21	-.102
22	.104
23	.123
24	-.117
25	.117
26	.116
27	-.054
28	.148
29	-.118
30	.098
31	-.093
32	.062
33	-.126
34	-.015
35	-.094
36	-.023



std error

$\cdot \frac{1}{\sqrt{48}} (1.96)$

$= .283$

Figure F-113. ACF - Lagged 12 Months

PARTIAL AUTOCORRELATIONS

1- 12	-.15	.20	.29	.07	-.02	.13	-.15	-.21	.07	-.24	.06	-.20
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14
13- 24	-.10	.10	-.05	.08	.05	-.21	.16	.03	.06	-.06	.08	-.06
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14
25- 36	-.21	.17	.07	-.07	-.10	.02	-.08	.06	-.04	-.05	-.04	-.03
ST.E.	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14	.14

PLOT OF PARTIAL AUTOCORRELATIONS

```
             -1.0  -.8  -.6  -.4  -.2   .0   .2   .4   .6   .8  1.0
LAG    CORR.   +----+----+----+----+----+----+----+----+----+----+
                                        I
  1     -.147                    +  XXXXI      +
  2      .199                    +      IXXXXX +
  3      .291                    +      IXXXXXXX
  4      .072                    +      IXX    +
  5     -.017                    +      I      +
  6      .126                    +      IXXX   +
  7     -.146                    +  XXXXI      +
  8     -.214                    + XXXXXI      +
  9      .075                    +      IXX    +
 10     -.238                    +XXXXXXI      +
 11      .059                    +      IX     +
 12     -.202                    + XXXXXI      +
 13     -.097                    +    XXI      +
 14      .101                    +      IXXX   +
 15     -.052                    +     XI      +
 16      .082                    +      IXX    +
 17      .051                    +      IX     +
 18     -.210                    + XXXXXI      +
 19      .165                    +      IXXXX  +
 20      .034                    +      IX     +
 21      .062                    +      IXX    +
 22     -.063                    +    XXI      +
 23      .077                    +      IXX    +
 24     -.057                    +     XI      +
 25     -.214                    + XXXXXI      +
 26      .168                    +      IXXXX  +
 27      .067                    +      IXX    +
 28     -.069                    +    XXI      +
 29     -.099                    +    XXI      +
 30      .013                    +      I      +
 31     -.084                    +    XXI      +
 32      .061                    +      IXX    +
 33     -.036                    +     XI      +
 34     -.049                    +     XI      +
 35     -.043                    +     XI      +
 36     -.034                    +     XI      +
```

Figure F-114. PACF - Lagged 12 Months

```
ESTIMATION BY BACKCASTING METHOD
RELATIVE CHANGE IN RESIDUAL SUM OF SQUARES LESS THAN  .1000-004

SUMMARY OF THE MODEL
OUTPUT VARIABLE -- TRANS
INPUT VARIABLES -- NOISE

VARIABLE  VAR. TYPE  MEAN      TIME     DIFFERENCES
                                                12
TRANS       RANDOM             1-  58  (1-B   )

PARAMETER VARIABLE   TYPE  FACTOR  ORDER ESTIMATE       ST. ERR.  T-RATIO
     1    TRANS       MA      1       1     .3012          .1507      2.00
     2    TRANS       MA      1       2    -.2716          .1484     -1.83
     3    TRANS       AR      1      12    -.6371          .1136     -5.61

RESIDUAL SUM OF SQUARES  =        2.189792 (BACKCASTS EXCLUDED)
DEGREES OF FREEDOM       =              31
RESIDUAL MEAN SQUARE     =         .070638
```

Figure F-115. Model Parameters - Chill

AUTOCORRELATIONS

1- 12	.04	-.04	.21	-.07	.06	.11	-.12	0.0	.07	-.21	.08	-.03
ST.E.	.13	.13	.13	.14	.14	.14	.14	.14	.14	.14	.15	.15
13- 24	-.20	.04	-.12	-.05	-.09	-.17	.04	.11	-.08	.09	.09	-.17
ST.E.	.15	.15	.15	.15	.15	.16	.16	.16	.16	.16	.16	.16
25- 36	.05	.04	.04	.03	-.09	.08	.01	0.0	-.07	-.06	-.06	0.0
ST.E.	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17

PLOT OF AUTOCORRELATIONS

-1.0 -.8 -.6 -.4 -.2 .0 .2 .4 .6 .8 1.0

LAG	CORR.	
1	.038	IX
2	-.039	XI
3	.208	IXXXXX
4	-.066	XXI
5	.064	IXX
6	.107	IXXX
7	-.120	XXXI
8	-.004	I
9	.071	IXX
10	-.208	XXXXXI
11	.083	IXX
12	-.035	XI
13	-.198	XXXXXI
14	.042	IX
15	-.124	XXXI
16	-.046	XI
17	-.088	XXI
18	-.166	XXXXI
19	.044	IX
20	.115	IXXX
21	-.084	XXI
22	.090	IXX
23	.092 .269(50)=15.63	IXX
24	-.174	XXXXI
25	.047	IX
26	.044	IX
27	.041	IX
28	.027	IX
29	-.088	XXI
30	.085	IXX
31	.005	I
32	-.005	I
33	-.069	XXI
34	-.064	XXI
35	-.058	XI
36	-.005	I

Figure F-116. Estimated Residuals - Chill

FORECAST ON VARIABLE TRANS FROM TIME PERIOD 59

PERIOD	FORECASTS		ST. ERR.	ACTUAL	ERROR
59	6.58359	.947	.26832	1.029	.082
60	7.43510	1.694	.28022	1.088	-.606
61	6.65226	.774	.28955	1.076	.302
62	6.86727	.960	.28955	.837	-.123
63	6.99583	1.092	.28955	.777	-.315
64	6.70819	.819	.28955	1.258	.439
65	7.04839	1.151	.28955	1.852	.701
66	7.39250	1.623	.28955	1.612	-.011
67	7.02959	1.129	.28955	1.083	-.046
68	7.58327	1.965	.28955	.942	-1.023
69	7.46953	1.754	.28955	1.404	-.35
70	7.25248	1.412	.28955	1.170	-.242
		15.32		14.13	MSE=.21

STANDARD ERROR = .268319 (BY CONDITIONAL METHOD)

Figure F-117. Forecast FY 82 - Chill

APPENDIX G

WINTERS MODEL INITIALIZATION AND SMOOTHING CONSTANTS

G-1. GENERAL. This section addresses initialization of model parameters and development of smoothing constants.

G-2. INITIALIZATION. Chapter 6 discussed the procedure for updating the parameters (permanent component, trend, and seasonal factor), given that initial values exist. Upon option, initial estimates of the Winters model parameters can be specified by the user. Alternatively, several heuristic algorithms have been devised to initialize parameters based on manipulation of historical data. The initialization procedure described below is due to Montgomery,[5] and is similar to the one proposed by Winters.

a. Trend Component. Assuming that data are available for m seasons, then compute the mean of all observations for the first and last of these seasons. Denote the average observation for the jth season by $\bar{x}_j$, j = 1,2,...,m. Estimate the trend in the same manner that would be used to compute a simple algebraic slope. Since there are m-1 seasons between season 1 and season m, and since there are L periods per season, then the initial estimate of the trend becomes

$$\hat{b}_2(0) = \frac{\bar{x}_m - \bar{x}_1}{(m - 1)\, L} \qquad \text{(G-1)}$$

b. Permanent Component. For initialization purposes, it is assumed that the average observation $\bar{x}_1$ for the first season occurs timewise at the middle of the season. With this in mind, the permanent component can be treated like a simple y-intercept. Writing the equation in slope-intercept form gives

$$\bar{x}_1 = \hat{a}_1(0) + \frac{L}{2}\hat{b}_2(0) \qquad \text{(G-2)}$$

Since all terms are known except for the permanent component, equation (G-2) can be rewritten as

$$\hat{a}_1(0) = \bar{x}_1 - \frac{L}{2}\hat{b}_2(0) \qquad \text{(G-3)}$$

c. Seasonal Factor. Since there are m seasons and L periods per season, seasonal factors are computed initially for each of the mL periods. Each factor is computed as the ratio of the actual observation to the average seasonally adjusted value for that season, further adjusted by the trend. The computation is

$$\hat{c}_t = \frac{x_t}{\bar{x}_i - [(L+1)/2 - j]\hat{b}_2(0)} \qquad t = 1,2,\ldots,mL \qquad \text{(G-4)}$$

where $\bar{x}_i$ is the average for a season corresponding to the t index, and j is the position of period t within the season. For example, if $1 \leq t \leq L$, then $i = 1$, and if $L + 1 \leq t \leq 2L$, then $i = 2$. Equation (G-4) produces m estimates of the seasonal factor for each period. (In the TWF Study, m was usually five, and there were five estimates for each month of the year.) The m estimates for each period (month) are averaged to produce a single estimate of the seasonal factor for each period within the season.

$$\bar{c}_t = \frac{1}{m} \sum_{k=0}^{m-1} \hat{c}_{t+kL} \qquad t = 1,2,\ldots,L \qquad \text{(G-5)}$$

Finally, the seasonal factors are normalized so that they sum to L (L = 12 in the study).

$$\hat{c}_t(0) = \bar{c}_t \frac{L}{\sum_{t=1}^{L} \bar{c}_t} \qquad t = 1,2,\ldots,L \qquad \text{(G-6)}$$

The above procedure produces estimates $\hat{a}_1(0)$, $\hat{b}_2(0)$, and $\hat{c}_t(0)$ assuming that the origin of time is immediately prior to period 1. The parameters may then be updated by the technique described in paragraph 6-5 of this report.

G-3. SMOOTHING CONSTANTS. Smoothing constants are necessary in order to combine (weight) previous estimates of parameters with their updated values. Numerical estimates of the permanent component, trend component, and seasonal factor receive the weights α, β, and γ for the current interval T. These weighted estimates are combined additively with complementary weighted values (using $1-\alpha$, $1-\beta$, and $1-\gamma$) for the previous time period or season, as appropriate. All weights are varied incrementally so that the parameters of the model ultimately provide the best fit according to some predetermined criterion, i.e., mean square error. Unlike the formal method of least squares, which uses partial derivatives to develop a set of simultaneous linear equations (normal equations) that are solved through matrix inversion, the Winters method is heuristic in nature. As such, the optimum set of smoothing constants is determined by trial and error. The coefficients lie in the interval (0,1). In order to keep computer time requirements modest, a coarse grid is tried first. Values of α, β, and γ are stepped across the unit interval in increments of 0.05 until all possible combinations of smoothing constants have been examined. The set of (α, β, γ) producing the smallest mean square error is used in the program as the basis for a second, fine-grained search. A step of 0.01 is used to search in a narrow interval about the coarse estimates of (α, β, γ) to yield refined values of the smoothing constants.

APPENDIX H

THE WINTERS METHOD COMMODITY ANALYSIS

For the nine commodities evaluated in the study, this appendix contains three exhibits each:

a. The first exhibit for each commodity displays the top 40 sets of smoothing constants obtained during the Winters model optimization process. The sets of (α , β , γ) are rank-ordered according to the residual sums of squares they produce. Since each smoothing constant is stepped across the unit interval (0,1) in increments of 0.01, there are 100^3, or one million, candidate sets of smoothing constants evaluated for each commodity. The model ultimately defined for each commodity is the one yielding the smallest residual sum of squares over the data interval defined up to, but not including, the forecast interval. This set of optimum smoothing constants is then presumed to yield the best fit over the forecast interval. It should be noted that although this selection criterion provides the best fit over the initialization interval, it does not always guarantee the best fit over the forecast interval.

b. The second exhibit for each commodity displays both the raw and fitted time series over the entire model initialization interval, i.e., up to but not including the forecast interval. For most of the nine commodities, 60 months (5 years) worth of data were used in the initialization phase to formulate the optimum model. Because transportation workload forecasting requires a lead time of at least 12 months, the parameters (permanent component, trend, and seasonal factor) from the last 12 months (usually months 49 to 60) of the initialization phase were used to produce the 12 monthly estimates of the forecast phase.

c. The third exhibit for each commodity shows the actual forecast phase. Summary statistics are provided at the end of each printout. Once the Winters model smoothing constants and parameters have been developed internally, calculation of forecasts is straightforward. For example, applying the forecast formula

$$\hat{x}_{T+\tau}(T) = \left[\hat{a}_1(T) + \hat{b}_2(T)\tau\right]\hat{c}_{T+\tau}(T+\tau-L)$$

to obtain an estimate for POVs shipped during month 67 would require use of parameters from month 55 (T=55; τ =12; L=12).

$$\hat{x}_{67}(55) = \left[40.1948 + (0.0376)(12)\right] 0.8949$$

$$= 36.37$$

ALPHA	BETA	GAMMA	RESIDUAL SUM OF SQUARES
.0400	.1500	.0000	.2156452+004
.0500	.1400	.0000	.2161700+004
.0400	.1400	.0000	.2162006+004
.0500	.1500	.0000	.2163242+004
.0400	.1500	.0100	.2164442+004
.0400	.1400	.0100	.2169780+004
.0500	.1400	.0100	.2170400+004
.0500	.1500	.0100	.2172151+004
.0400	.1500	.0200	.2172574+004
.0400	.1400	.0200	.2177697+004
.0500	.1400	.0200	.2179227+004
.0400	.1500	.0300	.2180638+004
.0500	.1500	.0200	.2181186+004
.0400	.1400	.0300	.2185753+004
.0500	.1400	.0300	.2188175+004
.0600	.1400	.0000	.2188705+004
.0300	.1500	.0000	.2189010+004
.0400	.1500	.0400	.2189229+004
.0500	.1500	.0300	.2190338+004
.0400	.1400	.0400	.2193938+004
.0300	.1500	.0100	.2195634+004
.0500	.1400	.0400	.2197238+004
.0700	.1400	.0100	.2198679+004
.0600	.1500	.0000	.2198525+004
.0300	.1400	.0000	.2199353+004
.0300	.1500	.0400	.2199602+004
.0300	.1500	.0200	.2202424+004
.0300	.1400	.0100	.2205771+004
.0600	.1400	.0200	.2207568+004
.0600	.1500	.0100	.2208121+004
.0300	.1500	.0300	.2209372+004
.0300	.1400	.0200	.2212358+004
.0300	.1500	.0400	.2216471+004
.0600	.1400	.0300	.2217168+004
.0600	.1500	.0200	.2217632+004
.0300	.1400	.0300	.2219106+004
.0200	.1400	.0400	.2226008+004
.0600	.1400	.0400	.2226674+004
.0600	.1500	.0300	.2227651+004
.0700	.1400	.0000	.2236265+004

THE OPTIMUM SMOOTHING CONSTANTS ARE

ALPHA = .0400 BETA = .1500 GAMMA = .0000

Figure H-1. Smoothing Constant Optimization Routine - POV

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FITTED MODEL	RESIDUAL
1	41.8210	44.1774	-.0694	.8786	.0000	.0000
2	35.9660	43.9387	-.0948	.9019	.0000	.0000
3	36.0050	43.8524	-.0935	.8173	.0000	.0000
4	27.0640	43.5496	-.1249	.7544	.0000	.0000
5	25.6070	43.2041	-.1580	.6755	.0000	.0000
6	34.8120	42.9724	-.1691	.8449	.0000	.0000
7	34.0600	42.6136	-.1975	.8949	.0000	.0000
8	53.1710	42.6181	-.1672	1.1202	.0000	.0000
9	64.7710	42.5069	-.1588	1.4770	.0000	.0000
10	66.2930	42.6007	-.1209	1.3623	.0000	.0000
11	49.2690	42.3329	-.1430	1.2696	.0000	.0000
12	52.1340	42.5806	-.0843	1.0034	.0000	.0000
13	34.3520	42.3603	-.1047	.8786	.0000	34.3520
14	42.2300	42.4381	-.0774	.9019	38.6046	3.6254
15	32.3950	42.2519	-.0937	.8173	34.9222	-2.5272
16	37.3910	42.4545	-.0493	.7544	31.7223	5.6687
17	23.3350	42.3870	-.0520	.6755	27.9021	.4329
18	30.8300	42.1012	-.0871	.8449	34.5928	-3.7628
19	37.0850	41.9912	-.0905	.8949	36.0131	1.0719
20	43.4380	41.7757	-.1092	1.1202	45.4937	-2.0557
21	48.7130	41.3190	-.1614	1.4770	59.9687	-11.2557
22	57.8420	41.2098	-.1535	1.3623	56.0569	1.7851
23	54.8990	41.1436	-.1404	1.2696	51.5690	3.3300
24	37.0340	40.8394	-.1650	1.0034	41.7391	-4.6751
25	40.0110	40.8689	-.1358	.8786	36.1154	3.8956
26	34.6780	40.6417	-.1495	.9019	37.4398	-2.7618
27	34.2080	40.5467	-.1414	.8173	33.6124	.5956
28	30.1880	40.3898	-.1437	.7544	31.5810	-1.3930
29	28.5490	40.3269	-.1316	.6755	28.2094	.3396
30	35.2520	40.2565	-.1224	.8449	34.6881	.5639
31	36.7740	40.1725	-.1166	.8949	36.6053	.1687
32	42.2980	39.9639	-.1304	1.1202	45.3295	-3.0315
33	57.7660	39.8046	-.1348	1.4770	58.1690	-.4030
34	47.1440	39.4673	-.1651	1.3623	53.6287	-6.4847
35	51.8800	39.3646	-.1558	1.2696	50.0974	1.7826
36	37.4080	39.1317	-.1673	1.0034	38.9909	-1.5829
37	35.8890	39.0396	-.1561	.8786	34.4773	1.4117
38	36.8110	38.9607	-.1445	.9019	35.0382	1.7728
39	34.7370	38.9638	-.1224	.8173	31.7514	2.9856
40	30.0510	38.8812	-.1164	.7544	29.1686	.8824
41	30.9360	39.0462	-.0742	.6755	26.1729	4.7631
42	38.7330	39.2469	-.0329	.8449	32.7713	5.9617
43	37.2930	39.3123	-.0182	.8949	34.6970	2.5960
44	53.3450	39.6272	.0318	1.1202	43.0152	10.3298
45	70.8400	39.9910	.0816	1.4770	56.4035	14.4360
46	54.6410	40.0741	.0818	1.3623	51.0654	3.5756
47	49.1420	40.0979	.0731	1.2696	47.6050	1.5370
48	39.1960	40.1267	.0665	1.0034	37.2493	1.9467
49	31.0530	39.9991	.0374	.8786	32.6567	-1.6037
50	37.3380	40.0909	.0455	.9019	33.5769	3.7611
51	32.0780	40.1010	.0402	.8173	30.6441	1.4339
52	28.9860	40.0725	.0299	.7544	28.2776	.7084
53	25.8230	40.0275	.0187	.6755	25.7730	.0500
54	34.3270	40.0695	.0222	.8449	32.8251	1.5019
55	38.1860	40.1948	.0376	.8949	34.9844	3.2016
56	38.3020	39.9908	.0014	1.1202	44.8182	-6.5162
57	60.5390	40.0320	.0074	1.4770	60.5134	.0256
58	52.7060	39.9854	-.0007	1.3623	55.9290	-3.2230
59	52.6520	40.0441	.0082	1.2696	52.0233	.6287
60	38.7010	39.9930	-.0007	1.0034	41.0628	-2.3618

SUM OF RESIDUALS = 67.4840 AVERAGE RESIDUAL = 1.1247 VARIANCE = 32.6351 STANDARD DEVIATION = 5.7127

MEAN ABSOLUTE DEVIATION = 2.9127

NUMBER OF RESIDUALS EXCEEDING TWO STANDARD DEVIATIONS = 2

Figure H-2. Output of the Initialization Phase - POV

LENGTH OF THE SEASON IS 12 PERIODS FORECAST LEAD TIME IS 12 PERIODS

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FORECAST	ERROR	TRACKING SIGNALS CUM. ERROR	TRACKING SIGNALS SMOOTHED ERROR
61	33.6640	39.9251	-.0106	.8786	35.5391	-1.8751	-.6675	-.0668
62	42.0160	40.1811	.0292	.9019	36.6526	5.3634	1.1383	.1200
63	35.0200	40.3159	.0451	.8173	33.1677	1.8523	1.8146	.1753
64	30.7990	40.3796	.0479	.7544	30.5006	.2984	2.1051	.1845
65	28.0000	40.4665	.0540	.6755	27.1883	.8117	2.5986	.2111
66	38.2140	40.7108	.0623	.8449	34.0788	4.1352	3.9952	.3339
67	40.3110	40.9632	.1078	.8949	36.3737	3.9373	5.2159	.4281
68	47.2010	41.1136	.1142	1.1202	44.8172	2.3838	6.1607	.4778
69	57.0710	41.1242	.0986	1.4776	59.2584	-2.1874	5.4747	.3575
70	61.1440	41.3751	.1215	1.3023	54.4588	6.6852	6.9506	.4997
71	51.1920	41.4496	.1144	1.2696	50.9658	.2262	7.7412	.5039
72	45.4200	41.7121	.1366	1.0034	40.1198	5.3002	8.8430	.5896

SUM OF FORECAST ERRORS = 27.1312 MEAN FORECAST ERROR = 2.2609 VARIANCE = 8.5216 STANDARD DEVIATION = 2.9192

ROOT MEAN SQUARE ERROR = 3.5949 MEAN OBSERVATION = 42.5210

MEAN ERROR AS FRACTION OF MEAN OBSERVATION = .0532 RMS ERROR AS FRACTION OF MEAN OBSERVATION = .0845

Figure H-3. Output of Forecasting Phase - POV

ALPHA	BETA	GAMMA	RESIDUAL SUM OF SQUARES
.0200	.0100	.0000	.2737672+005
.0200	.0100	.0100	.2738988+005
.0300	.0100	.0000	.2740359+005
.0200	.0100	.0200	.2740609+005
.0200	.0100	.0300	.2742710+005
.0200	.0100	.0400	.2745268+005
.0300	.0100	.0100	.2745476+005
.0300	.0100	.0200	.2750715+005
.0300	.0100	.0300	.2756273+005
.0300	.0000	.0000	.2759750+005
.0300	.0000	.0100	.2762060+005
.0300	.0100	.0400	.2762070+005
.0300	.0000	.0200	.2764756+005
.0300	.0000	.0300	.2767619+005
.0400	.0000	.0000	.2769008+005
.0300	.0000	.0400	.2771235+005
.0400	.0000	.0100	.2773582+005
.0400	.0100	.0000	.2777746+005
.0200	.0000	.0400	.2778094+005
.0400	.0000	.0200	.2778398+005
.0200	.0000	.0300	.2778404+005
.0200	.0000	.0200	.2779306+005
.0200	.0000	.0100	.2780630+005
.0200	.0000	.0000	.2783007+005
.0400	.0000	.0300	.2783444+005
.0400	.0100	.0100	.2784377+005
.0400	.0000	.0400	.2788712+005
.0400	.0100	.0200	.2791155+005
.0100	.0000	.0000	.2793063+005
.0100	.0100	.0400	.2795684+005
.0400	.0100	.0300	.2798072+005
.0100	.0000	.0100	.2798733+005
.0100	.0100	.0300	.2800739+005
.0500	.0000	.0200	.2804564+005
.0400	.0100	.0400	.2805125+005
.0100	.0100	.0200	.2806719+005
.0500	.0000	.0300	.2810548+005
.0100	.0100	.0100	.2813672+005
.0100	.0000	.0400	.2816681+005
.0100	.0100	.0000	.2821652+005

THE OPTIMUM SMOOTHING CONSTANTS ARE

ALPHA = .0200 BETA = .0100 GAMMA = .0000

Figure H-4. Smoothing Constant Optimization Routine - General Cargo

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FITTED MODEL	RESIDUAL
1	169.6850	149.6588	-.0219	.9503	.0000	.0000
2	136.5980	149.5693	-.0225	.9340	.0000	.0000
3	137.1570	149.5147	-.0229	.9271	.0000	.0000
4	118.3890	149.3778	-.0240	.8234	.0000	.0000
5	117.1380	149.2094	-.0254	.8382	.0000	.0000
6	156.7930	149.1635	-.0257	1.0583	.0000	.0000
7	155.4170	149.0886	-.0261	1.0596	.0000	.0000
8	149.0790	148.7913	-.0289	1.1002	.0000	.0000
9	151.3190	148.5652	-.0306	1.0816	.0000	.0000
10	153.6160	148.4037	-.0321	1.0894	.0000	.0000
11	164.4400	148.3877	-.0320	1.1023	.0000	.0000
12	175.5320	148.7782	-.0278	1.0357	.0000	.0000
13	102.8350	147.9396	-.0359	.9503	.0000	102.8350
14	152.1220	148.2032	-.0329	.9340	139.4390	12.6830
15	155.6140	148.5640	-.0289	.9271	138.3590	17.2550
16	131.8680	148.7676	-.0266	.8234	122.7540	9.1140
17	127.9600	148.8194	-.0258	.8382	124.8093	3.1507
18	170.9940	149.0493	-.0233	1.0583	157.5279	13.4661
19	184.4550	149.5271	-.0183	1.0596	157.6414	26.8136
20	195.2790	150.0686	-.0127	1.1002	163.3190	31.9600
21	185.6250	150.4872	-.0083	1.0816	160.3138	25.3112
22	192.7660	151.0083	-.0030	1.0894	161.2488	31.5172
23	183.7000	151.3182	.0001	1.1023	163.1439	20.5561
24	172.3100	151.6192	.0031	1.0357	153.7500	18.5600
25	159.2710	151.9417	.0063	.9503	140.1822	19.0888
26	152.8860	152.1830	.0086	.9340	138.0475	14.8385
27	141.4420	152.1991	.0087	.9271	137.4102	4.0318
28	136.8760	152.4885	.0115	.8234	122.2259	14.6501
29	132.2370	152.6053	.0126	.8382	124.4787	7.7583
30	191.2660	153.1803	.0182	1.0583	157.4374	33.8286
31	171.9870	153.3808	.0200	1.0596	158.2064	13.7806
32	183.2010	153.6631	.0226	1.1002	164.9383	18.2627
33	190.8690	154.1413	.0272	1.0816	162.6603	28.2087
34	194.2460	154.6513	.0320	1.0894	164.4664	29.7796
35	191.2590	155.0599	.0358	1.1023	166.7981	24.4609
36	157.4220	155.0336	.0352	1.0357	157.0759	.3461
37	146.0310	155.0406	.0349	.9503	144.4662	1.5648
38	160.8880	155.4193	.0383	.9340	142.2295	18.6585
39	162.2110	155.8478	.0422	.9271	141.1990	21.0120
40	141.5720	156.2111	.0454	.8234	125.6662	15.9058
41	140.5560	156.4853	.0477	.8382	128.0381	12.5179
42	153.6900	156.3069	.0455	1.0583	162.3355	-8.6455
43	158.9700	156.2259	.0442	1.0596	162.7763	-3.8063
44	171.5310	156.2629	.0441	1.1002	169.3589	2.1721
45	169.7890	156.3204	.0443	1.0816	167.0739	2.7151
46	167.3760	156.3102	.0437	1.0894	168.8936	-1.5176
47	171.1330	156.3319	.0435	1.1023	171.3949	-.2619
48	145.8010	156.0633	.0404	1.0357	161.0110	-15.2100
49	163.0200	156.4124	.0435	.9503	147.7373	15.2827
50	130.6710	156.1250	.0402	.9340	145.5848	-14.9138
51	130.6380	155.8601	.0371	.9271	144.9546	-14.3166
52	117.4170	155.6314	.0344	.8234	129.0664	-11.6494
53	136.1090	155.8002	.0358	.8382	131.6438	4.4652
54	157.6270	155.6983	.0344	1.0583	165.9906	-8.3636
55	159.7460	155.6332	.0334	1.0596	166.0985	-6.3525
56	164.3520	155.5410	.0322	1.1002	172.5028	-8.1508
57	151.8720	155.2700	.0291	1.0816	169.6523	-17.7803
58	147.9970	154.9102	.0252	1.0894	170.8536	-22.8566
59	153.9760	154.6304	.0222	1.1023	172.8990	-18.9230
60	157.7460	154.6056	.0217	1.0357	162.1423	-4.3963

SUM OF RESIDUALS = 459.4[illegible]65   AVERAGE RESIDUAL = 7.6568   VARIANCE = 347.4981   STANDARD DEVIATION = 18.6413

MEAN ABSOLUTE DEVIATION = 12.8949

NUMBER OF RESIDUALS EXCEEDING TWO STANDARD DEVIATIONS = 1

Figure H-5. Output of the Initialization Phase - General Cargo

LENGTH OF THE SEASON IS 12 PERIODS   FORECAST LEAD TIME IS 12 PERIODS

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FORECAST	ERROR	TRACKING SIGNALS CUM. ERROR	TRACKING SIGNALS SMOOTHED ERROR
[illegible]	14[illegible].[illegible]970	154.6558	.0[illegible]26	.9503	149.1387	-.6417	-.0720	-.0072
[illegible]	143.0620	154.7677	.0[illegible]29	.9340	146.2644	2.3976	.1446	.0152
[illegible]	1[illegible]2.[illegible]01[illegible]	154.5795	.0246	.[illegible]271	144.9389	7.3521	.8549	.0847
[illegible]	141.7340	155.3472	.0[illegible]82	.6234	128.4804	13.2536	2.0706	.1981
[illegible]	14[illegible].[illegible]330	155.7427	.0319	.[illegible]782	130.9496	14.6834	3.3191	.3041
[illegible]	177.4771	156.[illegible]132	.0343	1.0583	165.2361	12.2709	4.3783	.3833
67	2[illegible]7.[illegible]660	156.3463	.0423	1.0596	165.3334	42.3326	6.3818	.5633
6[illegible]	1[illegible]4.[illegible]580	157.0967	.0443	1.1002	171.5507	12.5073	7.3481	.6019
6[illegible]	1[illegible]5.[illegible]460	157.4236	.0472	1.0816	168.3197	16.9263	8.3800	.6487
7[illegible]	1[illegible].5320	157.8193	.0507	1.0894	169.0869	21.4451	9.4087	.6985
71	171.8230	157.8302	.0503	1.1023	170.7416	1.0814	10.4536	.7039
7[illegible]	16[illegible].1660	157.9701	.0512	1.0357	160.4306	7.7654	11.5164	.7185

SUM OF FORECAST ERRORS = 151.1759   MEAN FORECAST ERROR = 12.5980   VARIANCE = 132.2041   STANDARD DEVIATION = 11.4980

ROOT MEAN SQUARE ERROR = 16.7301   MEAN OBSERVATION = 168.4631

MEAN ERROR AS FRACTION OF MEAN OBSERVATION = .0748   RMS ERROR AS FRACTION OF MEAN OBSERVATION = .0993

Figure H-6. Output of Forecasting Phase - General Cargo

ALPHA	BETA	GAMMA	RESIDUAL SUM OF SQUARES
.0000	1.0000	.0000	.1665667+003
.0000	.9900	.0000	.1665672+003
.0000	1.0000	.0100	.1672367+003
.0000	.9900	.0100	.1672371+003
.0000	1.0000	.0200	.1679112+003
.0000	.9900	.0200	.1679115+003
.0000	1.0000	.0300	.1685900+003
.0000	.9900	.0300	.1685904+003
.0000	1.0000	.0400	.1692730+003
.0000	.9900	.0400	.1692734+003
.0100	.9900	.0000	.2251116+003
.0100	1.0000	.0000	.2260601+003
.0100	.9900	.0100	.2261653+003
.0100	1.0000	.0100	.2270660+003
.0100	.9900	.0200	.2272475+003
.0100	1.0000	.0200	.2281304+003
.0100	.9900	.0300	.2283080+003
.0100	1.0000	.0300	.2291932+003
.0100	.9900	.0400	.2293671+003
.0100	1.0000	.0400	.2302543+003
.0200	.9900	.0000	.3060605+003
.0200	.9900	.0100	.3076241+003
.0200	1.0000	.0000	.3081452+003
.0200	.9900	.0200	.3091971+003
.0200	1.0000	.0100	.3097249+003
.0200	.9900	.0300	.3107797+003
.0200	1.0000	.0200	.3113149+003
.0200	.9900	.0400	.3123713+003
.0200	1.0000	.0300	.3129139+003
.0200	1.0000	.0400	.3145622+003
.0300	.9900	.0000	.4355235+003
.0300	.9900	.0100	.4372434+003
.0300	.9900	.0200	.4389568+003
.0300	.9900	.0300	.4406627+003
.0300	1.0000	.0000	.4407079+003
.0300	.9900	.0400	.4423613+003
.0300	1.0000	.0100	.4424109+003
.0300	1.0000	.0200	.4441064+003
.0300	1.0000	.0300	.4457942+003
.0300	1.0000	.0400	.4474734+003

THE OPTIMUM SMOOTHING CONSTANTS ARE

ALPHA = .0000 BETA = 1.0000 GAMMA = .0000

Figure H-7. Smoothing Constant Optimization Routine - HHG

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FITTED MODEL	RESIDUAL
1	8.2500	9.4076	-.0725	.9026	.0000	.0000
2	5.4450	9.3351	-.0725	.6399	.0000	.0000
3	7.0060	9.2626	-.0725	.7864	.0000	.0000
4	5.8850	9.1901	-.0725	.9760	.0000	.0000
5	5.9310	9.1177	-.0725	.6393	.0000	.0000
6	5.7190	9.0452	-.0725	.7969	.0000	.0000
7	7.2490	8.9727	-.0725	.6979	.0000	.0000
8	6.4770	8.9002	-.0725	.8337	.0000	.0000
9	11.9690	8.8277	-.0725	1.3107	.0000	.0000
10	13.7880	8.7552	-.0725	1.5483	.0000	.0000
11	10.8700	8.6627	-.0725	1.8106	.0000	.0000
12	11.9530	8.6103	-.0725	1.0577	.0000	.0000
13	7.9610	8.5378	-.0725	.9026	.0000	7.9610
14	5.6590	8.4653	-.0725	.6399	5.4170	.2420
15	7.8850	8.3928	-.0725	.7864	6.6004	1.2846
16	5.7300	8.3203	-.0725	.9760	8.1209	-2.3909
17	5.6180	8.2478	-.0725	.6393	5.2728	.3452
18	8.1030	8.1754	-.0725	.7969	6.5148	1.5882
19	5.1060	8.1029	-.0725	.6979	5.6550	-.5490
20	8.8290	8.0304	-.0725	.8337	6.6947	2.1343
21	12.1880	7.9579	-.0725	1.3107	10.4305	1.7575
22	13.5640	7.8854	-.0725	1.5483	12.2091	1.3549
23	15.4560	7.8129	-.0725	1.8106	14.1462	1.3098
24	5.8870	7.7405	-.0725	1.0577	8.1867	-2.2997
25	7.3840	7.6680	-.0725	.9026	6.9208	.4632
26	5.4260	7.5955	-.0725	.6399	4.8604	.5656
27	5.4550	7.5230	-.0725	.7864	5.9163	-.4613
28	12.3590	7.4505	-.0725	.9760	7.2720	5.0870
29	4.6770	7.3780	-.0725	.6393	4.7167	-.0397
30	6.0820	7.3056	-.0725	.7969	5.8217	.2603
31	5.0920	7.2331	-.0725	.6979	5.0480	.0440
32	5.3370	7.1606	-.0725	.8337	5.9696	-.6326
33	8.1520	7.0881	-.0725	1.3107	9.2904	-1.1384
34	10.3260	7.0156	-.0725	1.5483	10.8624	-.5364
35	9.8740	6.9431	-.0725	1.8106	12.5714	-2.6974
36	7.5020	6.8707	-.0725	1.0577	7.2668	.2352

SUM OF RESIDUALS = 13.8873 AVERAGE RESIDUAL = .3858 VARIANCE = 3.4538 STANDARD DEVIATION = 1.8584

MEAN ABSOLUTE DEVIATION = .9827

NUMBER OF RESIDUALS EXCEEDING TWO STANDARD DEVIATIONS = 2

Figure H-8. Output of the Initialization Phase - HHG

LENGTH OF THE SEASON IS 12 PERIODS   FORECAST LEAD TIME IS 12 PERIODS

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FORECAST	ERROR	TRACKING SIGNALS CUM. ERROR	TRACKING SIGNALS SMOOTHED ERROR
37	6.4010	6.7982	-.0725	.9026	6.1357	.2653	.2912	.0291
38	7.3680	6.7257	-.0725	.6399	4.3038	3.0642	2.9561	.2933
39	8.7320	6.6532	-.0725	.7864	5.2323	3.4997	5.0080	.4746
40	6.2160	6.5807	-.0725	.9760	6.4230	-.2070	5.3063	.4532
41	6.4020	6.5082	-.0725	.6393	4.1607	2.3213	6.5988	.5443
42	5.4340	6.4358	-.0725	.7969	5.1286	.3054	7.3972	.5555
43	4.9680	6.3633	-.0725	.6979	4.4410	.5470	8.3016	.5761
44	6.2470	6.2908	-.0725	.6337	5.2445	1.0025	9.2910	.6126
45	9.9190	6.2183	-.0725	1.3107	8.1504	1.6665	10.2780	.6659
46	10.1790	6.1458	-.0725	1.5483	9.5157	.6633	11.3395	.6851
47	8.3730	6.0733	-.0725	1.8106	10.9965	-2.6885	7.9649	.3395
48	7.5130	6.0009	-.0725	1.0577	6.3468	1.1562	8.9525	.3985

SUM OF FORECAST ERRORS = 11.5980   MEAN FORECAST ERROR = .9665   VARIANCE = 2.6469   STANDARD DEVIATION = 1.6259

ROOT MEAN SQUARE ERROR = 1.8332   MEAN OBSERVATION = 7.3064

MEAN ERROR AS FRACTION OF MEAN OBSERVATION = .1323   RMS ERROR AS FRACTION OF MEAN OBSERVATION = .2509

Figure H-9. Output of Forecasting Phase - HHG

ALPHA	BETA	GAMMA	RESIDUAL SUM OF SQUARES
.0000	.8900	.0000	.1224654+005
.0000	.9000	.0000	.1224656+005
.0000	.8900	.0100	.1232437+005
.0000	.9000	.0100	.1232439+005
.0000	.8900	.0200	.1240184+005
.0000	.9000	.0200	.1240186+005
.0000	.8900	.0300	.1247694+005
.0000	.9000	.0300	.1247896+005
.0000	.8900	.0400	.1255568+005
.0000	.9000	.0400	.1255569+005
.0100	.8900	.0000	.5137646+005
.0100	.8900	.0100	.5144456+005
.0100	.8900	.0200	.5149444+005
.0100	.8900	.0300	.5152681+005
.0100	.8900	.0400	.5154631+005
.0100	.9000	.0000	.5207419+005
.0100	.9000	.0100	.5213635+005
.0100	.9000	.0200	.5218389+005
.0100	.9000	.0300	.5221154+005
.0100	.9000	.0400	.5222208+005
.0200	.8900	.0400	.7772438+005
.0200	.8900	.0300	.7785537+005
.0200	.8900	.0200	.7798682+005
.0200	.8900	.0100	.7810782+005
.0200	.9000	.0400	.7816768+005
.0200	.8900	.0000	.7823565+005
.0200	.9000	.0300	.7828672+005
.0200	.9000	.0200	.7840633+005
.0200	.9000	.0100	.7852764+005
.0200	.9000	.0000	.7864613+005
.0400	.9000	.0400	.8451678+005
.0400	.8900	.0400	.8474710+005
.0400	.9000	.0300	.8509282+005
.0400	.8900	.0300	.8531601+005
.0400	.9000	.0200	.8557180+005
.0400	.8900	.0200	.8589148+005
.0400	.9000	.0100	.8625401+005
.0400	.8900	.0100	.8646783+005
.0400	.9000	.0000	.8683973+005
.0400	.8900	.0000	.8734743+005

THE OPTIMUM SMOOTHING CONSTANTS ARE

ALPHA = .0000 BETA = .8900 GAMMA = .0000

Figure H-10. Smoothing Constant Optimization Routine - Coal

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FITTED MODEL	RESIDUAL
1	61.7490	47.9115	-.2827	.8873	.0000	.0000
2	39.8610	47.6288	-.2827	.8125	.0000	.0000
3	58.9880	47.3461	-.2827	.9436	.0000	.0000
4	21.2340	47.0634	-.2827	.7127	.0000	.0000
5	42.2440	46.7606	-.2827	.9675	.0000	.0000
6	55.2310	46.4579	-.2827	1.1560	.0000	.0000
7	39.9020	46.2152	-.2827	1.1061	.0000	.0000
8	40.6600	45.9325	-.2827	1.0634	.0000	.0000
9	58.0030	45.6498	-.2827	1.3628	.0000	.0000
10	60.9250	45.3670	-.2827	1.1604	.0000	.0000
11	59.1300	45.0843	-.2827	1.2019	.0000	.0000
12	19.3400	44.8016	-.2827	.6257	.0000	.0000
13	30.2670	44.5189	-.2827	.8873	.0000	30.2670
14	18.5990	44.2362	-.2827	.8125	35.9433	-17.3443
15	20.9670	43.9534	-.2827	.9436	41.4755	-20.5085
16	32.4480	43.6707	-.2827	.7127	31.1247	1.3233
17	17.5330	43.3890	-.2827	.9675	41.9767	-24.4437
18	35.4080	43.1053	-.2827	1.1560	49.8310	-14.4230
19	40.2750	42.8226	-.2827	1.1061	47.3673	-7.0923
20	41.3810	42.5398	-.2827	1.0634	45.2363	-3.8553
21	63.1420	42.2571	-.2827	1.3628	57.5898	5.5522
22	16.4230	41.9744	-.2827	1.1604	48.7059	-32.2829
23	17.5960	41.6917	-.2827	1.2019	50.1081	-32.5121
24	14.7770	41.4090	-.2827	.6257	25.9090	-11.1320
25	20.4500	41.1262	-.2827	.8873	36.4927	-16.0427
26	21.3720	40.8435	-.2827	.8125	33.1867	-11.8147
27	22.1760	40.5608	-.2827	.9436	38.2741	-16.0981
28	21.5210	40.2781	-.2827	.7127	28.7067	-7.1857
29	45.8590	39.9954	-.2827	.9675	38.6945	7.1645
30	44.6730	39.7127	-.2827	1.1560	45.9090	-1.2360
31	55.6230	39.4299	-.2827	1.1061	43.6146	12.0084
32	58.0270	39.1472	-.2827	1.0634	41.6286	16.3984
33	57.4620	38.8645	-.2827	1.3628	52.9662	4.4958
34	60.8510	38.5818	-.2827	1.1604	44.7692	16.0818
35	58.0400	38.2991	-.2827	1.2019	46.0306	12.0094
36	19.4920	38.0163	-.2827	.6257	23.7863	-4.2943
37	21.5640	37.7336	-.2827	.8873	33.4823	-11.9183
38	42.7610	37.4509	-.2827	.8125	30.4301	12.3309
39	46.2650	37.1682	-.2827	.9436	35.0728	11.1922
40	40.7350	36.8855	-.2827	.7127	26.2888	14.4462
41	41.9670	36.6028	-.2827	.9675	35.4122	6.5548
42	43.8660	36.3201	-.2827	1.1560	41.9870	1.8790
43	37.8610	36.0373	-.2827	1.1061	39.8620	-2.0010
44	46.1380	35.7546	-.2827	1.0634	38.0210	8.1170
45	57.7500	35.4719	-.2827	1.3628	48.3426	9.4074
46	44.2760	35.1892	-.2827	1.1604	40.8326	3.4434
47	61.9430	34.9065	-.2827	1.2019	41.9532	19.9898
48	44.7790	34.6238	-.2827	.6257	21.6636	23.1154
49	41.7800	34.3410	-.2827	.8873	30.4719	11.3081
50	39.9490	34.0583	-.2827	.8125	27.6735	12.2755
51	41.5780	33.7756	-.2827	.9436	31.8715	9.7065
52	19.6390	33.4929	-.2827	.7127	23.8708	-4.2318
53	42.9240	33.2102	-.2827	.9675	32.1300	10.7940
54	43.0600	32.9275	-.2827	1.1560	38.0651	4.9949
55	34.3070	32.6448	-.2827	1.1061	36.1094	-1.8024
56	16.0400	32.3620	-.2827	1.0634	34.4134	-18.3734
57	17.9520	32.0793	-.2827	1.3628	43.7191	-25.7671
58	42.1530	31.7966	-.2827	1.1604	36.8959	5.2571
59	36.4900	31.5139	-.2827	1.2019	37.8757	-1.3857
60	19.2550	31.2312	-.2827	.6257	19.5409	-.2859

SUM OF RESIDUALS = -15.9183 AVERAGE RESIDUAL = -.2653 VARIANCE = 164.7487 STANDARD DEVIATION = 12.8354

MEAN ABSOLUTE DEVIATION = 9.[illegible]691

NUMBER OF RESIDUALS EXCEEDING TWO STANDARD DEVIATIONS = 4

Figure H-11. Output of the Initialization Phase - Coal

LENGTH OF THE SEASON IS 12 PERIODS   FORECAST LEAD TIME IS 12 PERIODS

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FORECAST	ERROR	TRACKING SIGNALS CUM. ERROR	TRACKING SIGNALS SMOOTHED ERROR
61	19.8880	30.9465	-.2827	.6873	27.4616	-7.5736	-.8323	-.0832
62	64.1160	30.6658	-.2827	.8125	24.9173	39.1990	2.6116	.2674
63	41.7760	30.3831	-.2827	.9436	28.6702	13.1358	3.6638	.3451
64	19.0280	30.1003	-.2827	.7127	21.4529	-2.4249	3.7670	.3173
65	40.9160	29.8176	-.2827	.9675	28.8478	12.0662	4.8058	.3892
66	38.1470	29.5349	-.2827	1.1560	34.1432	4.0038	5.5160	.4129
67	19.1970	29.2522	-.2827	1.1061	32.3567	-13.1597	4.1711	.2414
68	33.0850	28.9695	-.2827	1.0634	30.8058	2.2792	4.7570	.2597
69	41.5670	28.6868	-.2827	1.3626	39.0955	2.4715	5.4117	.2786
70	19.1030	28.4041	-.2827	1.1604	32.9593	-13.8563	3.7246	.0958
71	19.4050	28.1214	-.2827	1.2019	33.7983	-14.3933	2.1366	-.0593
72	19.7120	27.8386	-.2827	.6257	17.4182	2.2938	2.5605	-.0334

SUM OF FORECAST ERRORS = 24.0135   MEAN FORECAST ERROR = 2.0011   VARIANCE = 224.9176   STANDARD DEVIATION = 14.9973

ROOT MEAN SQUARE ERROR = 14.4976   MEAN OBSERVATION = 31.3283

MEAN ERROR AS FRACTION OF MEAN OBSERVATION = .0639   RMS ERROR AS FRACTION OF MEAN OBSERVATION = .4628

Figure H-12. Output of Forecasting Phase - Coal

ALPHA	BETA	GAMMA	RESIDUAL SUM OF SQUARES
.0200	.0100	.0000	.3740632+004
.0200	.0100	.0100	.3762219+004
.0100	.0100	.0000	.3762405+004
.0200	.0000	.0000	.3763193+004
[illegible]	.0100	.0000	.3764707+004
.0300	.0000	.0000	.3773082+004
.0100	.0100	.0100	.3781030+004
.0200	.0100	.0200	.3783939+004
[illegible]	.0000	.0100	.3784013+004
[illegible]	.0100	.0100	.3786704+004
.0100	.0000	.0000	.3789443+004
[illegible]	.0000	.0100	.3795274+004
.0100	.0100	.0200	.3801459+004
.0400	.0000	.0000	.3803952+004
[illegible]	.0000	.0200	.3804951+004
[illegible]	.0100	.0300	.3805771+004
.0100	.0000	.0100	.3807922+004
[illegible]	.0100	.0200	.3808835+004
.0400	.0100	.0000	.3811217+004
[illegible]	.0000	.0200	.3816961+004
.0100	.0100	.0300	.3821252+004
.0400	.0000	.0100	.3825577+004
[illegible]	.0000	.0300	.3825990+004
.0100	.0000	.0200	.3826605+004
.0200	.0100	.0400	.3827698+004
[illegible]	.0100	.0300	.3831078+004
.0400	.0100	.0100	.3832932+004
[illegible]	.0000	.0300	.3839724+004
[illegible]	.0100	.0400	.3841200+004
.0100	.0000	.0300	.3845473+004
[illegible]	.0000	.0000	.3845478+004
[illegible]	.0000	.0400	.3947115+004
.0400	.0000	.0200	.3847295+004
[illegible]	.0100	.0400	.3853412+004
.0400	.0100	.0200	.3854793+004
[illegible]	.0000	.0400	.3850546+004
[illegible]	.0000	.0400	.3864513+004
[illegible]	.0000	.0100	.3866751+004
.0400	.0000	.0300	.3869065+004
[illegible]	.0100	.0000	.3869670+004

THE OPTIMUM SMOOTHING CONSTANTS ARE

ALPHA = .0200 BETA = .0100 GAMMA = .0000

Figure H-13. Smoothing Constant Optimization Routine - Ammunition

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FITTED MODEL	RESIDUAL
1	25.2770	16.4325	-.0638	.9893	.0000	.0000
2	18.6050	16.6094	-.0614	.6551	.0000	.0000
3	5.6570	16.3551	-.0633	.8483	.0000	.0000
4	8.4300	16.2763	-.0634	.5434	.0000	.0000
5	21.6070	16.4348	-.0612	.7911	.0000	.0000
6	15.3480	16.4361	-.0606	.7872	.0000	.0000
7	6.6960	16.2273	-.0621	.7468	.0000	.0000
8	14.5050	16.0389	-.0633	1.4725	.0000	.0000
9	19.5950	15.9576	-.0635	1.2998	.0000	.0000
10	19.0710	15.9442	-.0630	1.0365	.0000	.0000
11	11.3190	15.7373	-.0645	1.3029	.0000	.0000
12	24.7990	15.6829	-.0644	1.5272	.0000	.0000
13	18.6330	15.6629	-.0637	.9893	.0000	18.6330
14	7.9900	15.5507	-.0644	.6551	10.3976	-2.4076
15	21.9550	15.6942	-.0623	.8483	13.2303	8.7247
16	11.0740	15.7268	-.0614	.5434	8.4302	2.6438
17	12.1960	15.6605	-.0614	.7911	12.4210	-.2250
18	11.5160	15.5797	-.0616	.7872	12.3654	-.8494
19	16.0170	15.6366	-.0604	.7468	11.5620	4.4550
20	16.7200	15.4918	-.0613	1.4725	22.4983	-5.7783
21	16.9510	15.3827	-.0618	1.2998	19.7508	-2.7998
22	15.4440	15.3125	-.0618	1.0365	15.7417	-.2977
23	14.8000	15.1729	-.0626	1.3029	19.4957	-4.6957
24	10.4450	14.9448	-.0643	1.5272	22.7712	-12.3262
25	9.7970	14.7610	-.0653	.9893	14.7590	-4.9620
26	16.8710	14.9365	-.0631	.6551	9.6802	7.1908
27	9.0940	14.7904	-.0639	.8483	12.6794	-3.5854
28	15.9010	15.0173	-.0610	.5434	8.1451	7.7559
29	19.5020	15.1592	-.0590	.7911	11.8065	7.6955
30	27.9130	15.4985	-.0550	.7872	11.6816	16.2314
31	18.9490	15.6421	-.0530	.7468	11.1357	7.8133
32	39.4100	15.8127	-.0507	1.4725	21.7291	17.6809
33	20.6080	15.7638	-.0507	1.2998	19.0312	1.5768
34	30.3930	15.9852	-.0480	1.0365	15.1018	15.2912
35	19.8860	15.9238	-.0481	1.3029	18.7893	1.0967
36	30.8180	15.9617	-.0473	1.5272	21.6457	9.1723
37	9.6240	15.7997	-.0485	.9893	13.8484	-4.2244
38	9.8730	15.7288	-.0487	.6551	9.2885	.5845
39	17.9400	15.7894	-.0476	.8483	11.8968	6.0432
40	8.6190	15.7443	-.0475	.5434	7.7622	.8568
41	.5150	15.3958	-.0505	.7911	11.4254	-10.9104
42	6.4820	15.2031	-.0520	.7872	11.6806	-5.1986
43	11.6870	15.1611	-.0519	.7468	11.2066	.4804
44	23.4550	15.1256	-.0517	1.4725	22.3877	1.0673
45	16.0200	15.0189	-.0523	1.2998	19.6985	-3.6785
46	12.3600	14.9058	-.0529	1.0365	15.9710	-3.6110
47	25.8790	14.9532	-.0519	1.3029	19.9938	5.8852
48	22.4910	14.8978	-.0519	1.5272	23.5099	-1.0189
49	13.4870	14.8217	-.0521	.9893	15.0461	-1.5591
50	1.6280	14.5239	-.0546	.6551	9.9207	-8.2927
51	9.1090	14.3946	-.0553	.8483	12.9105	-3.6015
52	1.2350	14.0979	-.0576	.5434	8.2449	-7.0099
53	10.9080	14.0351	-.0578	.7911	11.7004	-.7924
54	5.5410	13.8386	-.0592	.7872	11.4764	-5.9354
55	6.1860	13.6695	-.0603	.7468	10.8573	-4.6713
56	22.2600	13.6323	-.0600	1.4725	21.3591	.9009
57	24.6130	13.6865	-.0589	1.2998	18.7066	5.9064
58	7.0730	13.4915	-.0603	1.0365	14.7919	-7.7189
59	23.8430	13.5296	-.0593	1.3029	18.6712	5.1718
60	27.3330	13.5578	-.0584	1.5272	21.8007	5.5323

SUM OF RESIDUALS = 52.0402 AVERAGE RESIDUAL = .8673 VARIANCE = 40.7527 STANDARD DEVIATION = 6.3838

MEAN ABSOLUTE DEVIATION = 4.4123

NUMBER OF RESIDUALS EXCEEDING TWO STANDARD DEVIATIONS = 4

Figure H-14. Output of the Initialization Phase - Ammunition

LENGTH OF THE SEASON IS 12 PERIODS   FORECAST LEAD TIME IS 12 PERIODS

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FORECAST	ERROR	TRACKING SIGNALS CUM. ERROR	TRACKING SIGNALS SMOOTHED ERROR
61	.6620	13.2429	-.0610	.9893	14.0445	-13.3825	-2.5205	-.2521
62	17.5570	13.4542	-.0583	.6551	9.0847	8.4723	-.8728	-.0635
63	5.4820	13.2573	-.0596	.8463	11.6480	-6.1660	-1.9501	-.1652
64	6.4560	13.1713	-.0599	.5434	7.2837	-.8277	-2.2916	-.1785
65	7.3930	13.0361	-.0607	.7911	10.5550	-3.1620	-3.0185	-.2335
66	21.0270	13.2502	-.0579	.7872	10.3341	10.6929	-.7863	.0061
67	17.2280	13.3898	-.0559	.7468	9.6679	7.5601	.5532	.1365
68	17.2190	13.3010	-.0563	1.4725	19.0241	-1.8051	.2576	.0983
69	42.9030	13.6400	-.0523	1.2998	16.8707	26.0323	3.6885	.4141
70	20.3420	13.7085	-.0511	1.0365	13.2337	7.1083	4.6653	.4739
71	10.3940	13.5438	-.0522	1.3029	16.6987	-6.3047	3.8706	.3432
72	12.6490	13.3873	-.0533	1.5272	19.6347	-6.9857	2.9246	.2140

SUM OF FORECAST ERRORS = 21.2322   MEAN FORECAST ERROR = 1.7693   VARIANCE = 113.9560   STANDARD DEVIATION = 10.6750

ROOT MEAN SQUARE ERROR = 10.3726   MEAN OBSERVATION = 14.9427

MEAN ERROR AS FRACTION OF MEAN OBSERVATION = .1184   RMS ERROR AS FRACTION OF MEAN OBSERVATION = .6942

Figure H-15. Output of Forecasting Phase - Ammunition

ALPHA	BETA	GAMMA	RESIDUAL SUM OF SQUARES
.0000	.0000	.0000	.2431589+005
.0000	.0100	.0000	.2431589+005
.0000	.0000	.0100	.2449286+005
.0000	.0100	.0100	.2449286+005
.0000	.0000	.0200	.2467207+005
.0000	.0100	.0200	.2467207+005
.0100	.0000	.0000	.2471109+005
.0100	.0100	.0000	.2478240+005
.0000	.0100	.0300	.2485335+005
.0000	.0000	.0300	.2485335+005
.0100	.0000	.0100	.2488754+005
.0100	.0100	.0100	.2496068+005
.0000	.0100	.0400	.2503653+005
.0000	.0000	.0400	.2503653+005
.0100	.0000	.0200	.2506587+005
.0200	.0000	.0000	.2512101+005
.0100	.0100	.0200	.2514082+005
.0100	.0000	.0300	.2524591+005
.0200	.0000	.0100	.2529436+005
.0200	.0100	.0000	.2529501+005
.0100	.0100	.0300	.2532266+005
.0100	.0000	.0400	.2542749+005
.0200	.0000	.0200	.2546931+005
.0200	.0100	.0100	.2547090+005
.0100	.0100	.0400	.2550603+005
.0300	.0000	.0000	.2551875+005
.0200	.0000	.0300	.2564569+005
.0200	.0100	.0200	.2564636+005
.0300	.0000	.0100	.2568776+005
.0300	.0100	.0000	.2580378+005
.0200	.0000	.0400	.2582335+005
.0200	.0100	.0300	.2582722+005
.0300	.0000	.0200	.2585815+005
.0400	.0000	.0000	.2589279+005
.0300	.0100	.0100	.2597536+005
.0200	.0100	.0400	.2600732+005
.0300	.0000	.0300	.2602975+005
.0400	.0000	.0100	.2605713+005
.0300	.0100	.0200	.2614626+005
.0300	.0000	.0400	.2620245+005

THE OPTIMUM SMOOTHING CONSTANTS ARE

ALPHA = .0000 BETA = .0000 GAMMA = .0000

Figure H-16. Smoothing Constant Optimization Routine - Special

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FITTED MODEL	RESIDUAL
1	103.1570	56.8662	-.0698	1.3510	.0000	.0000
2	58.8710	56.7964	-.0698	.9311	.0000	.0000
3	39.4600	56.7265	-.0698	1.0358	.0000	.0000
4	20.4770	56.6567	-.0698	.8144	.0000	.0000
5	39.8540	56.5868	-.0698	.8785	.0000	.0000
6	31.7930	56.5170	-.0698	.9097	.0000	.0000
7	41.1710	56.4472	-.0698	.9003	.0000	.0000
8	43.1400	56.3773	-.0698	1.0104	.0000	.0000
9	63.5140	56.3075	-.0698	.9389	.0000	.0000
10	71.2890	56.2376	-.0698	1.0699	.0000	.0000
11	90.1430	56.1678	-.0698	1.2253	.0000	.0000
12	67.3350	56.0979	-.0698	.9347	.0000	.0000
13	81.1700	56.0281	-.0698	1.3510	.0000	81.1700
14	35.1170	55.9583	-.0698	.9311	52.1052	-16.9882
15	35.6830	55.8884	-.0698	1.0358	57.8870	-22.2040
16	35.5450	55.8186	-.0698	.8144	45.4570	-9.9120
17	39.0760	55.7487	-.0698	.8785	48.9743	-9.8983
18	46.1390	55.6789	-.0698	.9097	50.6532	-4.5142
19	39.6840	55.6091	-.0698	.9003	50.0646	-10.3806
20	45.7730	55.5392	-.0698	1.0104	56.1187	-10.3457
21	47.0490	55.4694	-.0698	.9389	52.0817	-5.0327
22	48.9940	55.3995	-.0698	1.0699	59.2716	-10.2776
23	71.4610	55.3297	-.0698	1.2253	67.7959	3.6651
24	34.8690	55.2598	-.0698	.9347	51.6492	-16.7802
25	86.1510	55.1900	-.0698	1.3510	74.5610	11.5900
26	47.3930	55.1202	-.0698	.9311	51.3248	-3.9318
27	92.1620	55.0503	-.0698	1.0358	57.0189	35.1431
28	61.2190	54.9805	-.0698	.8144	44.7744	16.4446
29	75.7660	54.9106	-.0698	.8785	48.2380	27.5280
30	89.7010	54.8408	-.0698	.9097	49.8908	39.8102
31	71.4100	54.7710	-.0698	.9003	49.3100	22.1000
32	97.9750	54.7011	-.0698	1.0104	55.2718	42.7032
33	60.3280	54.6313	-.0698	.9389	51.2947	9.0333
34	51.0960	54.5614	-.0698	1.0699	58.3750	-7.2790
35	54.6590	54.4916	-.0698	1.2253	66.7689	-12.1099
36	64.1870	54.4217	-.0698	.9347	50.8659	13.3211
37	34.2000	54.3519	-.0698	1.3510	73.4287	-39.2287
38	68.9290	54.2821	-.0698	.9311	50.5444	18.3846
39	50.7160	54.2122	-.0698	1.0358	56.1509	-5.4349
40	62.8360	54.1424	-.0698	.8144	44.0919	18.7441
41	41.7540	54.0725	-.0698	.8785	47.5018	-5.7478
42	48.8690	54.0027	-.0698	.9097	49.1283	-.2593
43	35.9820	53.9329	-.0698	.9003	48.5555	-12.5735
44	42.7400	53.8630	-.0698	1.0104	54.4250	-11.6850
45	45.3660	53.7932	-.0698	.9389	50.5078	-5.1218
46	79.0210	53.7233	-.0698	1.0699	57.4783	21.5427
47	54.1670	53.6535	-.0698	1.2253	65.7420	-11.5750
48	51.7480	53.5836	-.0698	.9347	50.0825	1.6655
49	72.3280	53.5138	-.0698	1.3510	72.2965	.0315
50	46.7730	53.4440	-.0698	.9311	49.7641	-2.9911
51	77.3000	53.3741	-.0698	1.0358	55.2828	22.0172
52	39.0460	53.3043	-.0698	.8144	43.4094	-4.3634
53	52.0460	53.2344	-.0698	.8785	46.7655	5.2805
54	41.8100	53.1646	-.0698	.9097	48.3659	-6.5559
55	64.5550	53.0947	-.0698	.9003	47.8010	16.7540
56	57.8100	53.0249	-.0698	1.0104	53.5781	4.2319
57	43.3390	52.9551	-.0698	.9389	49.7209	-6.3819
58	40.2290	52.8852	-.0698	1.0699	56.5816	-16.3526
59	60.6740	52.8154	-.0698	1.2253	64.7151	-4.0411
60	42.0650	52.7455	-.0698	.9347	49.2992	-7.2342

SUM OF RESIDUALS = 131.5603 AVERAGE RESIDUAL = 2.1993 VARIANCE = 325.0415 STANDARD DEVIATION = 18.0299

MEAN ABSOLUTE DEVIATION = 11.[illegible]060

NUMBER OF RESIDUALS EXCEEDING TWO STANDARD DEVIATIONS = 4

Figure H-17. Output of the Initialization Phase - Special

LENGTH OF THE SEASON IS 12 PERIODS FORECAST LEAD TIME IS 12 PERIODS

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FORECAST	ERROR	TRACKING SIGNALS CUM. ERROR	TRACKING SIGNALS SMOOTHED ERROR
61	91.3830	52.6757	-.0698	1.3510	71.1642	20.2188	1.6335	.1634
62	41.0210	52.6059	-.0698	.9311	48.9837	-7.9627	1.0268	.0857
63	32.7280	52.5360	-.0698	1.0358	54.4147	-21.6867	-.7304	-.0966
64	21.8590	52.4662	-.0698	.6144	42.7269	-20.8679	-2.2105	-.2342
65	17.8240	52.3963	-.0698	.6785	46.0292	-28.2052	-3.8600	-.3767
66	23.5261	52.3265	-.0698	.9097	47.6034	-24.0774	-5.1457	-.4702
67	24.9940	52.2566	-.0698	.9003	47.0464	-22.0524	-6.2947	-.5404
68	25.4000	52.1868	-.0698	1.0104	52.7313	-27.3313	-7.4484	-.6113
69	30.0900	52.1170	-.0698	.9389	48.9343	-18.8443	-8.4582	-.6524
70	44.2220	52.0471	-.0698	1.0699	55.6849	-11.4629	-9.4381	-.6755
71	70.0030	51.9773	-.0698	1.2253	63.6881	6.3149	-9.6835	-.6098
72	66.8270	51.9074	-.0698	.9347	48.5158	18.3112	-8.4311	-.4293

SUM OF FORECAST ERRORS = -137.6457 MEAN FORECAST ERROR = -11.4705 VARIANCE = 297.2146 STANDARD DEVIATION = 17.2399

ROOT MEAN SQUARE ERROR = 20.1002 MEAN OBSERVATION = 40.8231

MEAN ERROR AS FRACTION OF MEAN OBSERVATION = -.2810 RMS ERROR AS FRACTION OF MEAN OBSERVATION = .4924

Figure H-18. Output of the Forecasting Phase - Special

ALPHA	BETA	GAMMA	RESIDUAL SUM OF SQUARES
.0500	.0000	.0000	.8157288+002
.[illegible]100	.0000	.0000	.8156373+002
.[illegible]400	.0100	.0000	.8162324+002
.[illegible]400	.0000	.0000	.8169[illegible]79+002
.[illegible]700	.0000	.0000	.8171627+002
.[illegible]00	.0100	.0000	.8176192+002
.[illegible]300	.0100	.0000	.8180094+002
.[illegible]	.0000	.0100	.8193405+002
.[illegible]	.0000	.0000	.81946[illegible]4+002
.[illegible]	.0000	.0100	.8197487+002
.[illegible]400	.0100	.0100	.8202[illegible]24+002
.[illegible]700	.0100	.0000	.8206615+002
.[illegible]400	.0000	.0100	.8207756+002
.[illegible]700	.0000	.0100	.8213204+002
.[illegible]	.0100	.0100	.8217686+002
.[illegible]	.0000	.0000	.8217731+002
.[illegible]	.0100	.0100	.8217956+002
.[illegible]	.0000	.0000	.8223332+002
.[illegible]	.0000	.0200	.8233499+002
.[illegible]	.0000	.0100	.8236538+002
.[illegible]	.0000	.0200	.8238544+002
.0400	.0100	.0200	.8243283+002
.[illegible]700	.0100	.0000	.8245671+002
.[illegible]400	.0000	.0200	.8245992+002
.[illegible]600	.0100	.0100	.8248326+002
.0[illegible]00	.0000	.0100	.8252294+002
.[illegible]700	.0000	.0200	.8254713+002
.[illegible]	.0100	.0200	.8255904+002
.[illegible]200	.0100	.0000	.8258738+002
.[illegible]	.0100	.0200	.8259[illegible]98+002
.[illegible]900	.0000	.0100	.8265043+002
.[illegible]	.0000	.0300	.8273574+002
.[illegible]	.0000	.0200	.8278205+002
.[illegible]600	.0000	.0300	.8279546+002
.0400	.0100	.0300	.8283704+002
.[illegible]	.0000	.0300	.8284286+002
.[illegible]200	.0000	.0200	.8287084+002
.[illegible]700	.0100	.0100	.8287452+002
.[illegible]	.0100	.0200	.8289955+002
.[illegible]	.0100	.0000	.8290001+002

THE OPTIMUM SMOOTHING CONSTANTS ARE

ALPHA = .0500 BETA = .0000 GAMMA = .0000

Figure H-19. Smoothing Constant Optimization Routine - CONEX

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FITTED MODEL	RESIDUAL
1	4.5660	4.2179	.0397	1.1035	.0000	.0000
2	4.7970	4.2483	.0397	1.1783	.0000	.0000
3	4.0850	4.3153	.0397	.8452	.0000	.0000
4	3.4350	4.3763	.0397	.7187	.0000	.0000
5	3.0350	4.3779	.0397	.8304	.0000	.0000
6	4.6190	4.4059	.0397	1.1044	.0000	.0000
7	5.4030	4.4818	.0397	1.0454	.0000	.0000
8	6.9250	4.6034	.0397	1.1243	.0000	.0000
9	2.7400	4.5771	.0397	.8246	.0000	.0000
10	3.4360	4.5285	.0397	1.2058	.0000	.0000
11	5.4230	4.5625	.0397	1.1171	.0000	.0000
12	4.5850	4.6452	.0397	.9025	.0000	.0000
13	5.3320	4.6923	.0397	1.1035	.0000	5.3320
14	7.5000	4.8137	.0397	1.1783	5.5676	1.9324
15	4.8090	4.8952	.0397	.8452	4.0500	.7590
16	3.0080	4.8975	.0397	.7187	3.4877	-.4797
17	4.4840	4.9603	.0397	.8304	4.0313	.4527
18	4.9550	4.9744	.0397	1.1044	5.3925	-.4375
19	5.3120	5.0175	.0397	1.0454	5.1835	.1285
20	4.5180	5.0053	.0397	1.1243	5.7114	-1.1934
21	4.7760	5.0824	.0397	.8246	4.1675	.6085
22	6.8900	5.1517	.0397	1.2058	6.0352	.8548
23	4.5300	5.1346	.0397	1.1171	5.6520	-1.1220
24	3.0410	5.0841	.0397	.9025	4.6226	-1.5816
25	4.9920	5.0939	.0397	1.1035	5.7038	-.7118
26	4.7090	5.0767	.0397	1.1783	6.2338	-1.5248
27	2.4590	5.0061	.0397	.8452	4.5402	-2.0812
28	3.5360	5.0396	.0397	.7187	3.8623	-.3263
29	4.1390	5.0746	.0397	.8304	4.5149	-.3759
30	6.3030	5.1439	.0397	1.1044	6.0203	.2827
31	4.5670	5.1429	.0397	1.0454	5.7435	-1.1765
32	5.0770	5.1493	.0397	1.1243	6.1633	-1.0863
33	2.8100	5.1000	.0397	.8246	4.5841	-1.7741
34	6.9620	5.1714	.0397	1.2058	6.7867	.1753
35	6.6080	5.2464	.0397	1.1171	6.2688	.3392
36	5.3200	5.3165	.0397	.9025	5.0187	.3013
37	5.1520	5.3219	.0397	1.1035	6.1470	-.9950
38	5.0690	5.3086	.0397	1.1783	6.5438	-1.4748
39	3.1950	5.2700	.0397	.8452	4.6339	-1.4389
40	3.4650	5.2853	.0397	.7187	3.9644	-.4994
41	3.7070	5.2820	.0397	.8304	4.6098	-.9028
42	5.6340	5.3107	.0397	1.1044	6.2076	-.5736
43	4.5470	5.3004	.0397	1.0454	5.8746	-1.3276
44	5.2680	5.3074	.0397	1.1243	6.3252	-1.0572
45	4.6010	5.3558	.0397	.8246	4.5986	.0024
46	6.3580	5.3922	.0397	1.2058	6.8104	-.4524
47	6.2410	5.4397	.0397	1.1171	6.3936	-.1526
48	5.1700	5.4919	.0397	.9025	5.2284	-.0584
49	6.6990	5.5536	.0397	1.1035	6.3986	.3004
50	6.6250	5.5995	.0397	1.1783	6.8171	-.1921
51	6.5710	5.7460	.0397	.8452	4.8569	1.7141
52	4.3210	5.7971	.0397	.7187	4.1410	.1800
53	5.5640	5.8800	.0397	.8304	4.7820	.7820
54	6.1660	5.9029	.0397	1.1044	6.3917	-.2257
55	6.6960	5.9658	.0397	1.0454	6.0392	.6566
56	6.7180	6.0040	.0397	1.1243	6.5029	.2151
57	6.8410	6.1564	.0397	.8246	4.8120	2.0290
58	7.9620	6.2165	.0397	1.2058	7.0767	.8853
59	6.1880	6.2203	.0397	1.1171	6.6395	-.4215
60	5.5840	6.2564	.0397	.9025	5.3967	.1973

SUM OF RESIDUALS = -5.5144 AVERAGE RESIDUAL = -.0919 VARIANCE = 1.2152 STANDARD DEVIATION = 1.1024

MEAN ABSOLUTE DEVIATION = .6962

NUMBER OF RESIDUALS EXCEEDING TWO STANDARD DEVIATIONS = 1

Figure H-20. Output of the Initialization Phase - CONEX

LENGTH OF THE SEASON IS 12 PERIODS   FORECAST LEAD TIME IS 12 PERIODS

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FORECAST	ERROR	TRACKING SIGNALS CUM. ERROR	TRACKING SIGNALS SMOOTHED ERROR
61	5.7680	6.2518	.0397	1.1035	6.6598	-.6918	-.9943	-.0994
62	5.6200	6.2154	.0397	1.1763	7.1598	-1.5398	-2.8604	-.2772
63	6.3060	6.3155	.0397	.8452	5.2592	1.0468	-1.4685	-.1115
64	4.2890	6.3358	.0397	.7187	4.5088	-.2198	-1.8776	-.1376
65	5.4150	6.3828	.0397	.8304	5.2786	.1364	-1.8463	-.1150
66	6.7180	6.4056	.0397	1.1044	7.0458	-.3278	-2.4516	-.1596
67	5.6220	6.3922	.0397	1.0454	6.7348	-1.1068	-3.8801	-.2931
68	6.0430	6.3791	.0397	1.1243	7.2861	-1.2431	-5.2525	-.4131
69	5.3790	6.4241	.0397	.8246	5.4697	-.0907	-5.8912	-.4179
70	7.4990	6.4516	.0397	1.2058	8.0705	-.5715	-6.8388	-.4677
71	8.4320	6.5441	.0397	1.1171	7.4816	.9504	-5.2144	-.2685
72	7.1730	6.6521	.0397	.9025	6.0767	1.0963	-3.4570	-.0809

SUM OF FORECAST ERRORS = -2.5615   MEAN FORECAST ERROR = -.2135   VARIANCE = .7985   STANDARD DEVIATION = .8936

ROOT MEAN SQUARE ERROR = .8817   MEAN OBSERVATION = 6.2058

MEAN ERROR AS FRACTION OF MEAN OBSERVATION = -.0344   RMS ERROR AS FRACTION OF MEAN OBSERVATION = .1421

Figure H-21. Output of the Forecasting Phase - CONEX

ALPHA	BETA	GAMMA	RESIDUAL SUM OF SQUARES
.0000	.0000	.0000	.1420587+002
.0000	.0100	.0000	.1420587+002
.0100	.0100	.0000	.1429075+002
.0100	.0000	.0000	.1429619+002
.0000	.0000	.0100	.1430023+002
.0000	.0100	.0100	.1430023+002
.0100	.0100	.0100	.1439063+002
.0000	.0000	.0200	.1439309+002
.0000	.0100	.0200	.1439309+002
.0100	.0000	.0100	.1439717+002
.0200	.0000	.0000	.1443698+002
.0200	.0100	.0000	.1444791+002
.0000	.0000	.0300	.1448446+002
.0000	.0100	.0300	.1448446+002
.0100	.0100	.0200	.1448921+002
.0100	.0000	.0200	.1449448+002
.0200	.0000	.0100	.1453616+002
.0200	.0100	.0100	.1455077+002
.0000	.0000	.0400	.1457435+002
.0000	.0100	.0400	.1457435+002
.0100	.0100	.0300	.1459591+002
.0100	.0000	.0300	.1459614+002
.0300	.0000	.0000	.1459761+002
.0200	.0000	.0200	.1463759+002
.0300	.0100	.0000	.1464118+002
.0200	.0100	.0200	.1465183+002
.0100	.0100	.0400	.1468095+002
.0100	.0000	.0400	.1468417+002
.0300	.0000	.0100	.1469932+002
.0200	.0000	.0300	.1473528+002
.0300	.0100	.0100	.1474478+002
.0200	.0100	.0300	.1475110+002
.0400	.0000	.0000	.1476429+002
.0300	.0000	.0200	.1479924+002
.0200	.0000	.0400	.1483124+002
.0300	.0100	.0200	.1484654+002
.0400	.0100	.0000	.1494747+002
.0200	.0100	.0400	.1484661+002
.0400	.0000	.0100	.1486536+002
.0200	.0000	.0300	.1499736+002

THE OPTIMUM SMOOTHING CONSTANTS ARE

ALPHA = .0000 BETA = .0000 GAMMA = .0000

Figure H-22. Smoothing Constant Optimization Routine - Freeze

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FITTED MODEL	RESIDUAL
1	1.8250	1.7660	.0134	.8398	.0000	.0000
2	1.3770	1.7794	.0134	.8911	.0000	.0000
3	1.7140	1.7929	.0134	1.0638	.0000	.0000
4	1.9970	1.8063	.0134	.9619	.0000	.0000
5	1.0200	1.8197	.0134	.8521	.0000	.0000
6	1.6920	1.8331	.0134	1.0121	.0000	.0000
7	1.7470	1.8465	.0134	1.0922	.0000	.0000
8	2.1050	1.8599	.0134	1.2560	.0000	.0000
9	2.2800	1.8733	.0134	1.0147	.0000	.0000
10	1.5510	1.8867	.0134	1.0056	.0000	.0000
11	2.1680	1.9001	.0134	1.0918	.0000	.0000
12	2.5210	1.9135	.0134	.9189	.0000	.0000
13	1.2970	1.9270	.0134	.8398	.0000	1.2970
14	1.4330	1.9404	.0134	.8911	1.7291	-.2961
15	3.2220	1.9538	.0134	1.0638	2.0784	1.1436
16	1.5630	1.9672	.0134	.9619	1.8922	-.3292
17	1.6250	1.9806	.0134	.8521	1.6878	-.0678
18	2.1730	1.9940	.0134	1.0121	2.0182	.1548
19	2.4830	2.0074	.0134	1.0922	2.1924	.2906
20	2.5750	2.0208	.0134	1.2560	2.5382	.0368
21	2.1260	2.0342	.0134	1.0147	2.0641	.0619
22	2.7360	2.0476	.0134	1.0056	2.0591	.6769
23	2.2490	2.0610	.0134	1.0918	2.2502	-.0012
24	2.1560	2.0745	.0134	.9189	1.9062	.2498
25	1.6030	2.0879	.0134	.8398	1.7534	-.1504
26	2.0650	2.1013	.0134	.8911	1.8725	.1925
27	2.4760	2.1147	.0134	1.0638	2.2496	.2264
28	1.8540	2.1281	.0134	.9619	2.0470	-.1930
29	2.6210	2.1415	.0134	.8521	1.8249	.7961
30	1.9940	2.1549	.0134	1.0121	2.1810	-.1870
31	2.6010	2.1683	.0134	1.0922	2.3682	.2328
32	2.8080	2.1817	.0134	1.2560	2.7403	.0677
33	2.0960	2.1951	.0134	1.0147	2.2274	-.1314
34	2.1960	2.2086	.0134	1.0056	2.2209	-.0249
35	2.6780	2.2220	.0134	1.0918	2.4259	.2521
36	1.2050	2.2354	.0134	.9189	2.0541	-.8491
37	1.7050	2.2488	.0134	.8398	1.8886	-.1836
38	2.5100	2.2622	.0134	.8911	2.0159	.4941
39	1.8490	2.2756	.0134	1.0638	2.4208	-.5718
40	2.2930	2.2890	.0134	.9619	2.2018	.0912
41	1.6580	2.3024	.0134	.8521	1.9620	-.3040
42	2.5910	2.3158	.0134	1.0121	2.3439	.2471
43	2.5100	2.3292	.0134	1.0922	2.5439	-.0339
44	2.6220	2.3427	.0134	1.2560	2.9424	-.3204
45	2.5330	2.3561	.0134	1.0147	2.3907	.1423
46	2.5180	2.3695	.0134	1.0056	2.3827	.1353
47	1.8560	2.3829	.0134	1.0918	2.6015	-.7455
48	2.0110	2.3963	.0134	.9189	2.2019	-.1909
49	2.3420	2.4097	.0134	.8398	2.0237	.3183
50	2.0530	2.4231	.0134	.8911	2.1593	-.1063
51	1.9490	2.4365	.0134	1.0638	2.5919	-.6429
52	2.5430	2.4499	.0134	.9619	2.3566	.1864
53	2.3660	2.4633	.0134	.8521	2.0991	.2669
54	2.5250	2.4767	.0134	1.0121	2.5068	.0182
55	2.5640	2.4902	.0134	1.0922	2.7196	-.1556
56	3.7430	2.5036	.0134	1.2560	3.1445	.5985
57	2.0030	2.5170	.0134	1.0147	2.5540	-.5510
58	2.1440	2.5304	.0134	1.0056	2.5445	-.4005
59	3.2400	2.5438	.0134	1.0918	2.7772	.4628
60	2.2490	2.5572	.0134	.9189	2.3498	-.1008

SUM OF RESIDUALS = 2.1029 AVERAGE RESIDUAL = .0350 VARIANCE = .1463 STANDARD DEVIATION = .3925

MEAN ABSOLUTE DEVIATION = .2530

NUMBER OF RESIDUALS EXCEEDING TWO STANDARD DEVIATIONS = 4

Figure H-23. Output of the Initialization Phase - Freeze

LENGTH OF THE SEASON IS 12 PERIODS   FORECAST LEAD TIME IS 12 PERIODS

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FORECAST	ERROR	TRACKING SIGNALS CUM. ERROR	TRACKING SIGNALS SMOOTHED ERROR
61	3.3200	2.5706	.0134	.8398	2.1588	1.1612	3.3776	.3378
62	2.3480	2.5840	.0134	.8911	2.3027	.0453	3.8430	.3473
63	2.2250	2.5974	.0134	1.0638	2.7631	-.5561	1.9161	.1251
64	3.5710	2.6108	.0134	.9615	2.5114	1.0596	4.1608	.3539
65	2.5640	2.6243	.0134	.8521	2.2363	.3277	5.0613	.4038
66	3.0120	2.6377	.0134	1.0121	2.6696	.3424	6.0018	.4553
67	3.3070	2.6511	.0134	1.0922	2.8954	.9116	7.3469	.5662
68	4.0760	2.6645	.0134	1.2560	3.3966	.7294	8.4448	.6327
69	2.9530	2.6779	.0134	1.0147	2.7173	.2357	9.4152	.6519
70	3.6630	2.6913	.0134	1.0056	2.7063	.9567	10.3735	.7132
71	2.7140	2.7047	.0134	1.0916	2.9529	-.2389	10.4458	.6319
72	2.1840	2.7181	.0134	.9189	2.4977	-.3137	10.1325	.5236

SUM OF FORECAST ERRORS = 4.6589   MEAN FORECAST ERROR = .3882   VARIANCE = .3354   STANDARD DEVIATION = .5792

ROOT MEAN SQUARE ERROR = .6769   MEAN OBSERVATION = 3.0347

MEAN ERROR AS FRACTION OF MEAN OBSERVATION = .1279   RMS ERROR AS FRACTION OF MEAN OBSERVATION = .2231

Figure H-24. Output of Forecasting Phase - Freeze

ALPHA	BETA	GAMMA	RESIDUAL SUM OF SQUARES
.0200	.0100	.0000	.5243611+001
.0[illegible]00	.0000	.0000	.5250443+001
.0100	.0000	.0000	.5255757+001
.0100	.0100	.0000	.5257069+001
.0300	.0100	.0000	.5257933+001
.0100	.0100	.0100	.5264[illegible]60+001
.0100	.0000	.0000	.5257105+001
.0200	.0000	.0100	.5270653+001
.0400	.0000	.0000	.5274[illegible]83+001
.0100	.0100	.0100	.5275[illegible]96+001
.0[illegible]00	.0000	.0100	.5277457+001
.0[illegible]00	.0100	.0100	.528[illegible]522+001
.0100	.0000	.0100	.5285410+001
.0300	.0100	.0200	.5286453+001
.0400	.0100	.0000	.5288439+001
.0[illegible]00	.0000	.0200	.5291620+001
.0100	.0100	.0200	.5295342+001
.0400	.0000	.0100	.5297388+001
.0300	.0000	.0200	.5299468+001
.0[illegible]00	.0000	.0000	.5302996+001
.0300	.0100	.0200	.5303415+001
.0100	.0000	.0200	.5304147+001
.0[illegible]00	.0100	.0300	.530[illegible]38[illegible]+001
.0300	.0100	.0100	.5311[illegible]28+001
.0[illegible]00	.0000	.0300	.5312734+001
.0100	.0100	.0300	.5315[illegible]94+001
.0[illegible]00	.0100	.0000	.532[illegible]65+001
.0[illegible]00	.0000	.0000	.5320065+001
.0400	.0000	.0200	.5320176+001
.0300	.0000	.0300	.5321781+001
.0100	.0000	.0300	.5323302+001
.0[illegible]00	.0000	.0100	.5326[illegible]12+001
.0300	.0100	.0300	.5326[illegible]0+001
.0100	.0100	.0000	.5328753+001
.0[illegible]00	.0100	.0400	.5330[illegible]31+001
.0[illegible]00	.0000	.0400	.5334184+001
.0[illegible]00	.0100	.0100	.5334[illegible]51+001
.0[illegible]00	.0000	.0100	.5334[illegible]51+001
.0100	.0100	.0400	.5335[illegible]41+001
.0400	.0100	.0200	.53354[illegible]4+001

THE OPTIMUM SMOOTHING CONSTANTS ARE

ALPHA = .0200 BETA = .0100 GAMMA = .0000

Figure H-25. Smoothing Constant Optimization Routine - Chill

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FITTED MODEL	RESIDUAL
1	1.2420	1.2763	-.0044	.7757	.0000	.0000
2	1.4210	1.2709	-.0044	1.1644	.0000	.0000
3	1.0340	1.2696	-.0044	.7267	.0000	.0000
4	.9660	1.2667	-.0043	.7220	.0000	.0000
5	.6650	1.2553	-.0044	.7323	.0000	.0000
6	.9730	1.2539	-.0044	.6929	.0000	.0000
7	1.0980	1.2493	-.0044	.8877	.0000	.0000
8	1.4680	1.2429	-.0044	1.2830	.0000	.0000
9	1.1480	1.2379	-.0044	.9480	.0000	.0000
10	1.6240	1.2317	-.0044	1.4193	.0000	.0000
11	1.3980	1.2226	-.0045	1.4050	.0000	.0000
12	1.9320	1.2249	-.0044	1.2429	.0000	.0000
13	1.1340	1.2253	-.0044	.7757	.0000	1.1340
14	1.0070	1.2138	-.0044	1.1644	1.4184	-.4114
15	1.1010	1.2155	-.0044	.7267	.8846	.2164
16	.6800	1.2057	-.0044	.7220	.8769	-.1969
17	.8980	1.2018	-.0044	.7323	.8804	.0176
18	.8040	1.1966	-.0044	.6929	.8323	-.0283
19	.9540	1.1898	-.0045	.8877	1.0622	-.1082
20	1.7450	1.1689	-.0044	1.2830	1.5266	.2184
21	1.1800	1.1856	-.0044	.9480	1.1233	.0567
22	1.5370	1.1793	-.0044	1.4193	1.6727	-.1357
23	1.9270	1.1788	-.0044	1.4050	1.6422	.2848
24	1.2690	1.1713	-.0044	1.2429	1.4565	-.1875
25	.7540	1.1630	-.0045	.7757	.9098	-.1558
26	1.7810	1.1660	-.0044	1.1644	1.3513	.4297
27	.9070	1.1633	-.0044	.7267	.8451	.0619
28	.9620	1.1624	-.0043	.7220	.8321	.1299
29	1.3700	1.1723	-.0042	.7323	.8411	.5269
30	.8420	1.1691	-.0042	.6929	.7923	.0497
31	1.1740	1.1680	-.0041	.8877	1.0088	.1652
32	2.0650	1.1728	-.0041	1.2830	1.4572	.6078
33	1.1310	1.1692	-.0041	.9480	1.0739	.0571
34	2.3250	1.1746	-.0040	1.4193	1.5983	.7267
35	1.8610	1.1738	-.0039	1.4050	1.5822	.2788
36	1.4760	1.1702	-.0039	1.2429	1.3899	.0861
37	.7370	1.1619	-.0040	.7757	.8607	-.1237
38	1.6020	1.1623	-.0039	1.1644	1.2964	.3056
39	.5870	1.1514	-.0040	.7267	.8073	-.2203
40	.9570	1.1509	-.0040	.7220	.8017	.1553
41	.7330	1.1441	-.0040	.7323	.8216	-.0886
42	.7810	1.1398	-.0040	.6929	.7753	.0057
43	1.1110	1.1381	-.0040	.8877	.9927	.1183
44	1.0650	1.1281	-.0040	1.2830	1.4422	-.3772
45	1.1260	1.1253	-.0040	.9480	1.0623	.0637
46	1.4620	1.1195	-.0040	1.4193	1.5997	-.1377
47	1.5800	1.1156	-.0040	1.4050	1.5828	-.0028
48	1.3050	1.1104	-.0040	1.2429	1.3959	-.0909

SUM OF RESIDUALS = 3.4331 AVERAGE RESIDUAL = .0715 VARIANCE = .0722 STANDARD DEVIATION = .2688

MEAN ABSOLUTE DEVIATION = .1659

NUMBER OF RESIDUALS EXCEEDING TWO STANDARD DEVIATIONS = [illegible]

Figure H-26. Output of the Initialization Phase - Chill

LENGTH OF THE SEASON IS 12 PERIODS FORECAST LEAD TIME IS 12 PERIODS

PERIOD	OBSERVATION	PERMANENT COMPONENT	TREND	SEASONAL FACTOR	FORECAST	ERROR	TRACKING SIGNALS CUM. ERROR	TRACKING SIGNALS SMOOTHED ERROR
49	1.0270	1.1167	-.0040	.7757	.6644	.1646	.9930	.0993
[illegible]	1.[illegible]30	1.1033	-.0040	1.1644	1.2985	-.2105	-.2697	-.0366
51	1.[illegible]760	1.1069	-.0040	.7267	.8019	.2741	1.2634	.1237
52	.3370	1.1040	-.0039	.7220	.7967	.0403	1.6119	.1427
53	.7770	1.0993	-.0040	.7723	.8077	-.0257	1.5923	.1227
54	1.2530	1.1097	-.0038	.6929	.7566	.5014	3.9715	.3575
55	1.[illegible]520	1.1255	-.0036	.6877	.9681	.8839	6.3340	.5784
56	1.6120	1.1246	-.0036	1.2830	1.3853	.2267	7.3022	.6163
57	1.[illegible]330	1.1214	-.0036	.9480	1.0212	.0618	8.1632	.6251
[illegible]	.9420	1.1068	-.0037	1.4193	1.5202	-.5782	4.9736	.2768
59	1.4040	1.1030	-.0037	1.4050	1.4994	-.0954	4.9378	.2284
6[illegible]	1.1790	1.0961	-.0037	1.2429	1.3197	-.1497	4.5266	.1523

SUM OF FORECAST ERRORS = 1.0935 MEAN FORECAST ERROR = .0911 VARIANCE = .1366 STANDARD DEVIATION = .3697

ROOT MEAN SQUARE ERROR = .3655 MEAN OBSERVATION = 1.1773

MEAN ERROR AS FRACTION OF MEAN OBSERVATION = .0774 RMS ERROR AS FRACTION OF MEAN OBSERVATION = .3104

Figure H-27. Output of Forecasting Phase - Chill

APPENDIX I

SPONSOR'S COMMENTS

DALO-TSP-C11 (30 Jan 84) 1st Ind
SUBJECT: Transportation Workload Forecasting (TWF) Study

DA Washington, D.C. 20310 (DALO-TSP-C11) 2 MAR 1984

TO: Director, US Army Concepts Analysis Agency, ATTN: CSCA-SPP, 8120 Woodmont Avenue, Bethesda, MD 20814

Completed Study Critique is furnished. There was one editorial comment, which is listed on a separate page and attached to the critique sheet.

FOR THE DEPUTY CHIEF OF STAFF FOR LOGISTICS:

1 Encl
as

BERNARD J. CLARK
Colonel, GS
Chief, Performance Management Division
Directorate of Transportation, Energy and Troop Support

2

DEPARTMENT OF THE ARMY
US ARMY CONCEPTS ANALYSIS AGENCY
8120 WOODMONT AVENUE
BETHESDA, MARYLAND 20814

REPLY TO
ATTENTION OF
CSCA-SPP

30 JAN 1984

SUBJECT: Transportation Workload Forecasting (TWF) Study

Deputy Chief of Staff
for Logistics
Department of the Army
ATTN: DALO-TSP
Washington, DC 20310

1. Reference:

a. Letter, DALO-TSP-C11, 11 May 1983, subject: Transportation Workload Forecasting (TWF) Study.

b. Letter, DACS-DMO, 19 October 1983, subject: Responsibility of Study Performing and Study Sponsoring Organizations.

2. The Deputy Chief of Staff for Logistics requested that the US Army Concepts Analysis Agency study US Army transportation workload forecasting and develop procedures to improve the system.

3. Attached are several copies of our Draft Study Report which describe the study approach, the current forecasting system, and several alternative systems and methods that should result in improved forecasts of over-ocean cargo transportation requirements. These drafts are being provided IAW reference b in order to obtain your comments prior to publication of the final report of study. A suggested Study Critique Sheet is provided for your use as you desire.

4. Request that your comments be provided to CAA within 30 days after receipt of the draft report. Your comments, if any, and our response to comments, if any, will be included in the final report if they are provided to CAA prior to our planned publication date.

David C. Hardison

2 Incl
as

DAVID C. HARDISON
Director

STUDY CRITIQUE

(This document may be modified to add more space for responses to questions.)

1. Were there any editorial comments? YES. If so, please list on separate page and attach to the critique sheet.

2. Was the work accomplished in a timely manner? YES. If not, please comment.

3. Does the work report address adequately the issues planned for the analysis? YES. If not, please comment.

4. Were appropriate analysis techniques used? YES. If not, please comment.

5. Are the findings fully supported by good analysis based on sound assumptions? YES. If not, please explain.

6. Does the report contain the preferred level of details of the analysis? YES. If not, please comment.

7. Is the written material fully satisfactory in terms of clarity of presentation, completeness, and style? YES. If not, please comment.

STUDY CRITIQUE (CONTINUED)

8. Are all Figures and Tables clear and helpful to the reader? YES. If not, please comment. ____________

____

____

9. Does the report satisfy fully the expectations that were present when the work was directed? YES. If not, please explain how not.

____

____

____

10. Will the Findings in this report be helpful to the organization which directed that the work be done? YES. If so, please indicate how, and if not, please explain why not. ____________

____

____

11. Judged overall, how do you rate the study? (circle one)

Poor Fair Average Good Excellent

PARAGRAPH 6-8a should read as follows:

a. Transportation arrangements for DOD-sponsored household goods (HHG) are made by MTMC, using primarily two methods: freight forward (Code 4), and those that are MSC processed (Code 5). Freight forward shipments are shipments of HHG that are contracted with private carriers from door-to-door; shipments of HHG that are shipped using the assets of MSC are Code 5 shipments. Additionally, some HHG are returned to CONUS via MAC when cargo space is available.

APPENDIX J

DISTRIBUTION

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Commander-in-Chief US Army, Europe & Seventh Army ATTN: AEAGX-OR (Mr. Dwarkin) APO New York 09403	1
Commander US Army Materiel Development and Readiness Command, DACSM-PST 5001 Eisenhower Avenue Alexandria, VA 22333	2
Commander US Army Communications Command, CC-LOG-TS Fort Huachuca, AZ 85613	1
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Addressee	Number of copies
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GLOSSARY

1. ABBREVIATIONS, ACRONYMS, AND SHORT TERMS

AAFES	Army and Air Force Exchange Service
AFAC	US Army Finance and Accounting Center
AFLC	US Air Force Logistics Center
AR	autoregressive
ARFCOS	Armed Forces Courier Service
ARIMA	autoregressive integrated moving average
ARMA	autoregressive moving average
ASD(I&L)	Assistant Secretary of Defense (Installations and Logistics)
CAA	US Army Concepts Analysis Agency
DARCOM	US Army Materiel Development and Readiness Command
DTS	Defense Transportation System
EEA	essential elements of analysis
HHG	household goods
ICP	inventory control point
IRO	Inventory Research Office
K/MTON	thousands of measurement tons
LSC	Logistics Support Contractor
LIF	logistics intelligence file
LSAO	Logistics Systems Analysis Office
MA	moving
MAC	Military Airlift Command

MECHTRAM	mechanization of selected transportation movement reports
MILPERCEN	US Army Military Personnel Center
MPSA	Military Postal Service Agency
MSC	Military Sealift Command
MSE	mean square error
MTON	measurement tons
NAVMTO	Navy Material Transport Office
NMTO	Naval Material Transport Office
POD	port of debarkation
POE	port of embarkation
POV	privately owned vehicle
TAC	transportation account code
TAEDP	total Army equipment distribution program
TWF	transportation workload forecasting
USAMSSA	US Army Management System Support Agency
USARJ	US Army Japan

2. MODELS, ROUTINES, AND SIMULATIONS

Box-Jenkins	A flexible class of linear statistical models that are used to fit stochastic time series data and produce forecasts
Winters	A three-parameter exponential smoothing method that is used to adjust smoothed forecasts to reflect seasonality

CAA	TRANSPORTATION WORKLOAD FORECASTING (TWF) STUDY	ONE SHEET STUDY GIST CAA-SR-84-2

THE PRINCIPAL FINDINGS of the work reported herein are as follows:

(1) The transportation workload forecasting system has produced inaccurate forecasts resulting in inefficient Military Sealift Command (MSC) industrial fund operations.

(2) Accurate forecasting of cargo transportation requirements can be accomplished by forecasting at a single activity.

(3) Either HQ Military Traffic Management Command (MTMC) or HQ, US Army Materiel Development and Readiness Command (DARCOM) is a suitable location for a single point forecasting activity.

(4) The Box-Jenkins and Winters Forecasting Models can provide accurate forecasts when used in conjunction with program information.

(5) Changes to the allocation of transportation account codes and requirements for forecasting shipping mode are also required to improve forecasting accuracy.

THE MAIN ASSUMPTION on which the work reported herein rests is that transportation workload forecasting requirements, contained in JCS Publication 15, would not be changed.

THE PRINCIPAL LIMITATIONS of this work which may affect the findings are as follows:

(1) Only the forecasting of peacetime over-ocean surface cargo transportation requirements was evaluated.

(2) Historical lift data was extracted exclusively from MSC records and could not be validated from Army sources.

THE SCOPE OF THE STUDY was taken to include an analysis of the Army's long-range cargo transportation requirements forecasting process and its impact on budgets and transportation costs.

THE STUDY OBJECTIVE was to develop cost effective systems and methods for improving the forecasting of Army over-ocean surface cargo transportation requirements.

THE BASIC APPROACH followed in this study can be defined as: research was conducted into the nature and extent of the forecasting problem, to identify its impact, and its systemic and methodological causes. Several alternative systems were evaluated based on their relative costs and efficiency. Then a series of mathematical techniques was evaluated for suitability as forecasting tools. Two of the techniques, the Box-Jenkins and Winters models, were used to forecast the 1982 cargo transportation requirements based on 1977 to 1981 MSC cargo lift data.

REASONS FOR PERFORMING THE STUDY are mainly as follows: recent forecasts of Army over-ocean surface cargo transportation requirements have been inaccurate. As a consequence MSC industrial funds have incurred significant losses and the MSC controlled fleet was not efficiently utilized for cargo transport. This study was directed to develop methods to improve the forecasts.

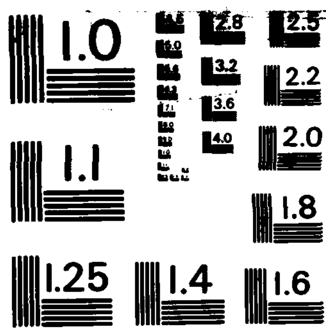
THE STUDY SPONSOR was the Deputy Chief of Staff for Logistics, who also established the objectives and monitored the study activities.

THE STUDY EFFORT was directed by LTC James N. Keenan, Strategy, Concepts and Plans Directorate.

COMMENTS AND QUESTIONS may be directed to CAA, ATTN: Assistant Director for Strategy, Concepts and Plans.

AD-A139 872 TRANSPORTATION WORKLOAD FORECASTING (TWF) STUDY(U) ARMY CONCEPTS ANALYSIS AGENCY BETHESDA MD J N KEENAN ET AL. JAN 84 CAA-SR-84-2 4/4

UNCLASSIFIED F/G 15/5 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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THE STUDY OBJECTIVE was to develop cost effective systems and methods for improving the forecasting of Army over-ocean surface cargo transportation requirements.

THE BASIC APPROACH followed in this study can be defined as: research was conducted into the nature and extent of the forecasting problem, to identify its impact, and its systemic and methodological causes. Several alternative systems were evaluated based on their relative costs and efficiency. Then a series of mathematical techniques was evaluated for suitability as forecasting tools. Two of the techniques, the Box-Jenkins and Winters models, were used to forecast the 1982 cargo transportation requirements based on 1977 to 1981 MSC cargo lift data.

REASONS FOR PERFORMING THE STUDY are mainly as follows: recent forecasts of Army over-ocean surface cargo transportation requirements have been inaccurate. As a consequence MSC industrial funds have incurred significant losses and the MSC controlled fleet was not efficiently utilized for cargo transport. This study was directed to develop methods to improve the forecasts.

THE STUDY SPONSOR was the Deputy Chief of Staff for Logistics, who also established the objectives and monitored the study activities.

THE STUDY EFFORT was directed by LTC James N. Keenan, Strategy, Concepts and Plans Directorate.

COMMENTS AND QUESTIONS may be directed to CAA, ATTN: Assistant Director for Strategy, Concepts and Plans.

CAA	TRANSPORTATION WORKLOAD FORECASTING (TWF) STUDY	ONE SHEET STUDY GIST CAA-SR-84-2

THE PRINCIPAL FINDINGS of the work reported herein are as follows:

(1) The transportation workload forecasting system has produced inaccurate forecasts resulting in inefficient Military Sealift Command (MSC) industrial fund operations.

(2) Accurate forecasting of cargo transportation requirements can be accomplished by forecasting at a single activity.

(3) Either HQ Military Traffic Management Command (MTMC) or HQ, US Army Materiel Development and Readiness Command (DARCOM) is a suitable location for a single point forecasting activity.

(4) The Box-Jenkins and Winters Forecasting Models can provide accurate forecasts when used in conjunction with program information.

(5) Changes to the allocation of transportation account codes and requirements for forecasting shipping mode are also required to improve forecasting accuracy.

THE MAIN ASSUMPTION on which the work reported herein rests is that transportation workload forecasting requirements, contained in JCS Publication 15, would not be changed.

THE PRINCIPAL LIMITATIONS of this work which may affect the findings are as follows:

(1) Only the forecasting of peacetime over-ocean surface cargo transportation requirements was evaluated.

(2) Historical lift data was extracted exclusively from MSC records and could not be validated from Army sources.

THE SCOPE OF THE STUDY was taken to include an analysis of the Army's long-range cargo transportation requirements forecasting process and its impact on budgets and transportation costs.

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CAA (Concepts Analysis Agency, United States Army)	TRANSPORTATION WORKLOAD FORECASTING (TWF) STUDY	ONE SHEET STUDY GIST CAA-SR-84-2

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