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JULY 1989

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DLA-89-P81061

**Forecasting Infrequent But
Predictable Demands**

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Cameron Station, Alexandria, VA**

July 1989



DEFENSE LOGISTICS AGENCY
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FOREWORD

The Defense Logistics Agency manages some items that generally experience little or no demand. These demands are occasionally interrupted by larger demands. The DLA Directorate of Supply Operations (DLA-O) requested that the DLA Operations Research and Economic Analysis Office (DORO) perform a study to identify and categorize, if possible, those items that have definite 'LUMPY' demand patterns, quantify the magnitude of the effect of these demands on the managing commodity's supply availability, and determine the feasibility of attempting to forecast future behavior of these items. 'LUMPY' items were identified and analyzed as two distinct groups of seasonal and non-seasonal items. Approximately 6 percent of stocked items with demand can be classified as seasonal. Seasonal items tend to increase the commodity's overall supply availability and have a relatively low stock position both in terms of stock to demand ratios and stock investment. These items did not have any distinguishable characteristics that could be used to segregate them from other stocked items; however, under the concept of Multiple Forecasting they do lend themselves to relatively simple forecasting techniques. The analysis of Defense Industrial Supply Center (DISC) items experiencing 'LUMPY' but non-seasonal demand resulted in an unmanageable number of distinct categories making any kind of pattern analysis impractical. Due to the relatively few items with a sufficient number of quarterly demands which could be identified as demand spikes, further analysis was not undertaken.

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Policy and Plans

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I. INTRODUCTION. The Defense Logistics Agency (DLA) manages some items that generally experience little or no demand. These demands are occasionally interrupted by larger demands. Items with this type of demand pattern are referred to as 'LUMPY' demand items. The functional effectiveness of current models used in the development of Quarterly Forecast of Demand (QFD), Economic Order Quantity (EOQ), Variable Safety Level (VSL), and Reorder Point (ROP) for these items has never been examined.

A. Background. DLA Directorate of Supply Operations (DLA-O) requested that the DLA Operations Research and Economic Analysis Management Support Office (DORO) perform a study comparing items with 'LUMPY' demand patterns to the other items managed by the commodity and determine if improvements to the existing system are necessary.

B. Objectives. Our primary objective was to identify and categorize those items that have definite 'LUMPY' demand patterns, quantify the magnitude of the effect of these demands on the managing commodity's supply availability, and determine the feasibility of attempting to forecast future behavior of these items. If deemed necessary and feasible, an applicable forecasting technique for the items identified as 'LUMPY' would be developed. Additionally, new management approaches to 'LUMPY' demand patterns would be explored and a plan for incorporating the forecasting technique into the existing system would be developed.

C. Scope

1. DLA Integrated Data Base files were the source of item characteristic and requisitioning data ~~for FY834-FY883.~~

2. Stocked items for the Defense General Supply Center (DGSC) and Defense Industrial Supply Center (DISC) commodities were chosen.

3. Recorded recurring and non-recurring demands were used as the demand base. (SDW)

II. CONCLUSIONS

A. We were able to identify seasonal type items using autocorrelation procedures. Approximately 6 percent of the stocked DGSC and DISC items with demand were identified. These items account for approximately 5 percent of the demand quantity, requisition frequency, and stock value. Items identified by these autocorrelation procedures did not have any distinguishable characteristics that could be used to segregate them from other stocked items. In our analysis of the effect of these items on system performance, we found that these items tended to increase the commodity's overall supply availability and had a relatively low stock position both in terms of stock to demand ratios and stock investment. These items tend to be seasonal in nature and do lend themselves to relatively simple forecasting techniques.

B. The analysis of DISC items using standard deviation to identify 'LUMPY' demand items that could not be classified as seasonal did not yield any significant results. Patterns of deviation from the average demand did not fall into a manageable number of distinct categories making any kind of pattern analysis impractical. Analysis of the inter-arrival times of demand spikes was not undertaken due to the relatively few items with a sufficient number of quarterly demands exceeding the mean by one or more standard deviations. The need to examine these items on a per item basis makes categorizing and forecasting impractical for this study.

III. RECOMMENDATIONS. Under the current system, forecasting seasonal demands does not seem warranted due to their minimal impact on overall system statistics. However, use of seasonal forecasting should be addressed by the Multiple Forecasting Techniques project.

IV. METHODOLOGY. Seasonal items were identified using autocorrelation procedures. Non-seasonal items were analyzed based on coefficient of variation and standard deviation.

V. ANALYSIS

A. Data for Autocorrelation Analysis. Using eight quarters of data, FY864-FY883, seasonal items were identified using autocorrelation procedures. Stocked DGSC and DISC items with at least one demand in FY874-FY883 were selected for analysis (Table 1).

Table 1

DATA FOR AUTOCORRELATION ANALYSIS

	<u>ALL Items</u>	<u>DISC</u>	<u>DGSC</u>
Nonstocked w/no demand FY874-FY883		184123	97893
Nonstocked w/ demand FY874-FY883		28157	18051
Stocked w/no demand FY874-FY883		312819	92749
* Stocked w/ demand FY874-FY883		376610	106467
		-----	-----
Total Number of Items		901709	315160

'LUMPY' items are those items with statistically significant positive second, third or fourth autocorrelation coefficients. Items with a consistent spike every other quarter in the demand pattern have a statistically significant lag(2) autocorrelation and are labeled LUMP2. Significant lag(3) items, a spike every third quarter, are labeled LUMP3. Items with spikes once a year in the demand pattern, significant lag(4) autocorrelation items, are labeled LUMP4. Table 2 presents the number of items which fell into each category.

Table 2

'LUMPY' ITEMS

	<u>DISC</u>	<u>DGSC</u>
Stocked Items w/demand FY874-FY88	376610	106667
Number of LUMP2	1679	545
Number of LUMP3	5082	1495
Number of LUMP4	14418	4204
	-----	-----
Total 'LUMPY' Items	21179	6244

Autocorrelation procedures were also used on the 20 quarters of demand data available; however, we are confident that the items labeled as 'LUMPY' based on 8 quarters of demand data are in fact items displaying infrequent but predictable demand patterns. Autocorrelation procedures using 20 quarters of data resulted in 78 percent of the 'LUMPY' items no longer being classified as 'LUMPY', 18 percent of the 'LUMPY' items remaining in their original categories, and the redistribution of 4 percent of the 'LUMPY' items into new 'LUMPY' categories.

B. Analysis of Autocorrelated Demands. Item characteristics and supply availability data for 'LUMPY' items were compared to all, stocked only, and stocked with demand items in the commodity. 'LUMPY' demand items accounted for approximately 6 percent of both DGSC and DISC stocked items with demand. The dollar value of issuable assets for 'LUMPY' items is not disproportionate to the number of items labeled as 'LUMPY' and amounts to approximately 6 percent of the total issuable asset dollar value for both commodities (Figure 1). The stock to demand ratio (Figure 2) does not indicate that unusually large amounts of stock are maintained for 'LUMPY' demand items. The statistics presented in Figure 3 indicate that 'LUMPY' demand items experience higher supply availability than all other supply availability categories. Item characteristics of 'LUMPY' items (Figure 4) are not distinguishable from the rest of the commodity's stocked items with demand.

C. Data for Analysis Based on Standard Deviation. An additional analysis of 'LUMPY' items with non-seasonal demand patterns was initiated. Established, stocked DISC items with demand in at least three quarters between FY834 and FY883 were selected from the DISC data base (Table 3).

Figure 1

STOCK VALUE (\$ Millions)

- COMMODITY
- NSTK W/DMD
- STK W/ DMD
- LUMPY

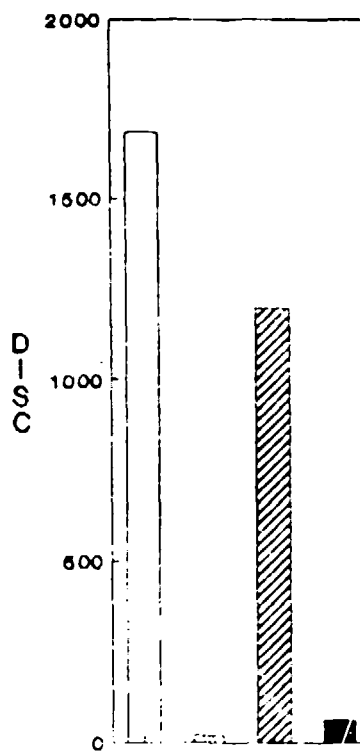
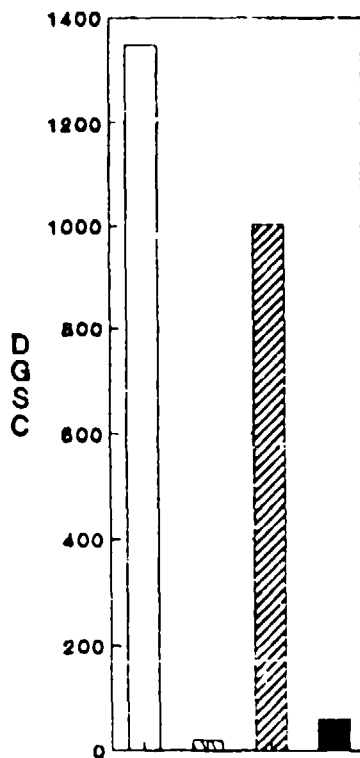


Figure 2

STOCK TO DEMAND RATIO

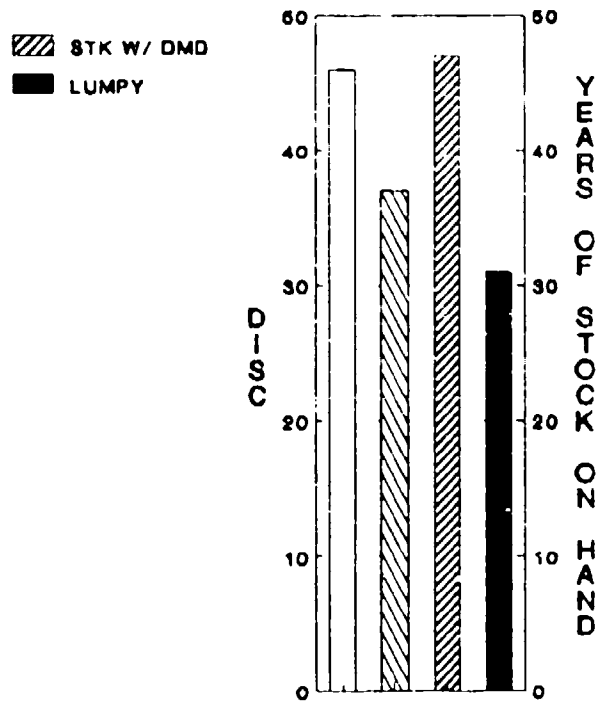
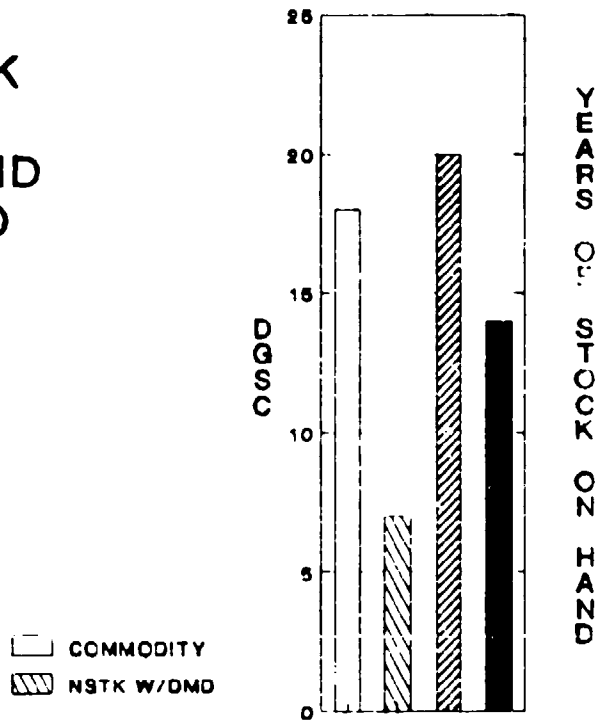


Figure 3

SUPPLY AVAILABILITY PERCENTAGES

COMMODITY
NSTK W/DMD

STK W/ DMD
LUMPY

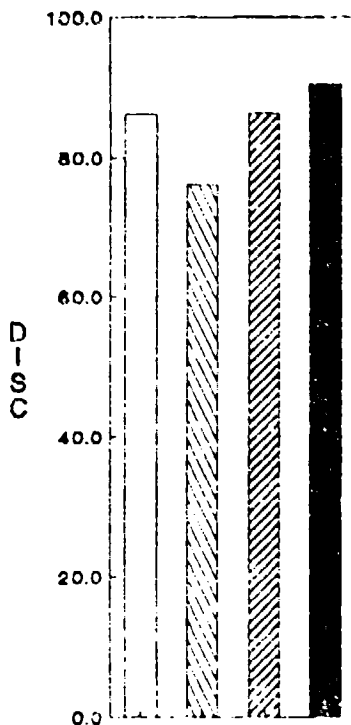
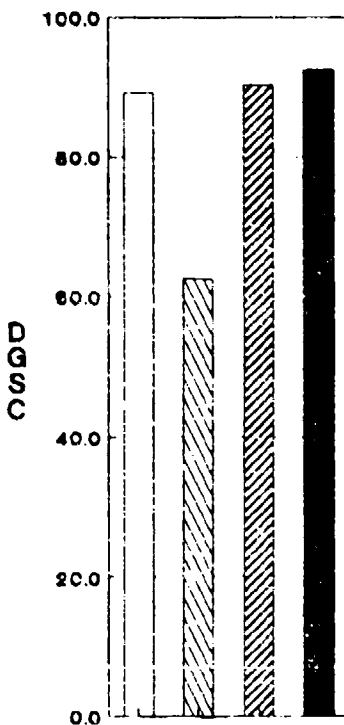


Figure 4

ITEM CHARACTERISTICS

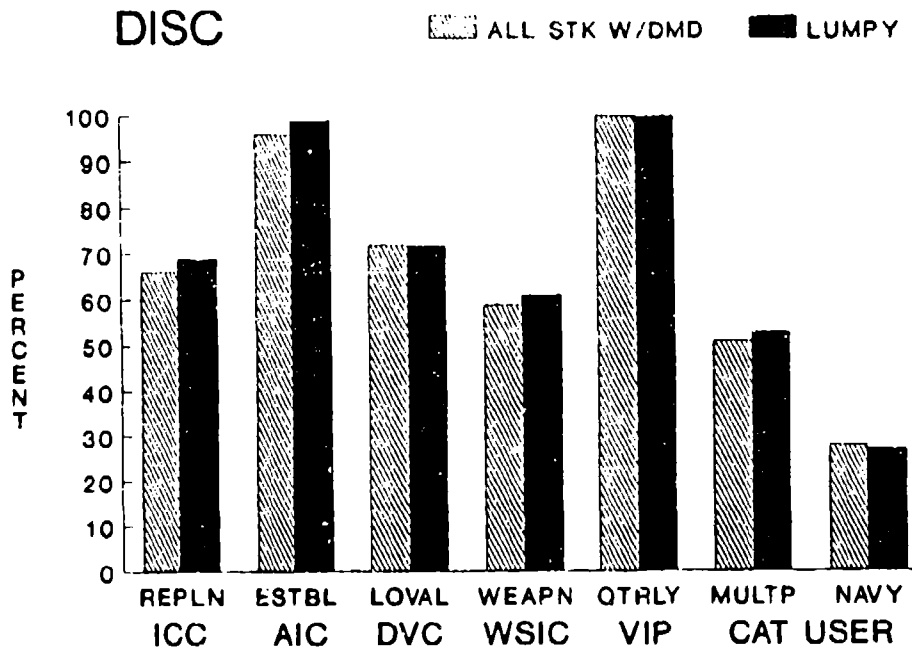
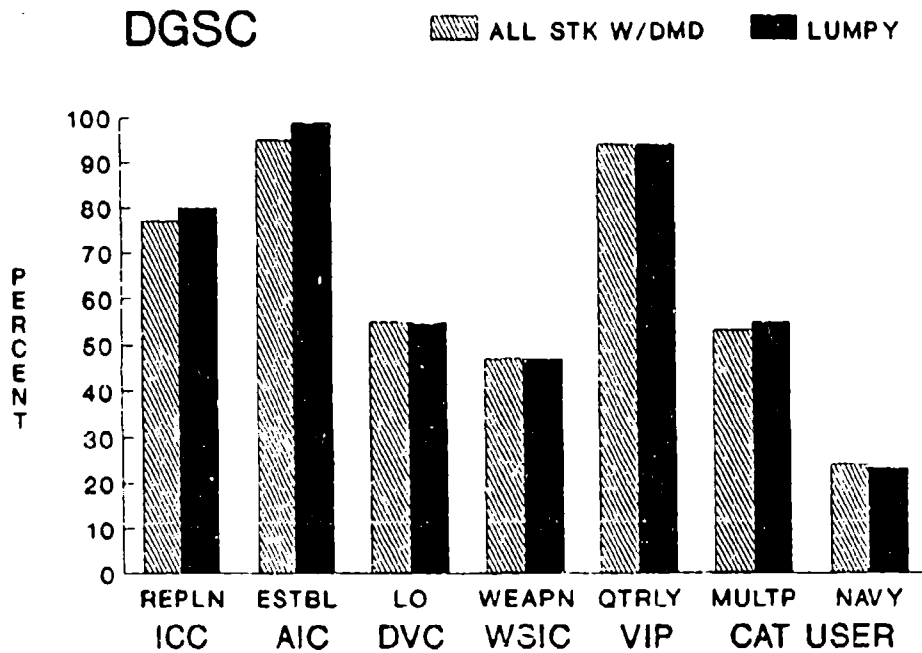


Table 3

ALL ESTABLISHED (FY843) STOCKED DISC ITEMS

Total Established Stocked Items	446878
Exclusions	
No quarter w/demand FY834-FY883	66757
One quarter w/demand FY834-FY883	36377
Two quarters w/demand FY834-FY883	29013
Previously identified as 'LUMPY'	16221

Number analyzed based on standard deviation	298510

We used the demand history from the first to the last quarter with recorded demand in the FY834-FY883 interval to calculate the mean, standard deviation, and coefficient of variation. (Leading and trailing zero demands were eliminated prior to the calculation.) For the items showing no seasonal pattern in demand, a three character code (CODE) based on the number of times a demand deviated from the mean and the magnitude of that deviation was developed. The left most character of the code represents the number of demands equal to or greater than the mean plus one standard deviation but less than the mean plus two standard deviations; the number of demands equal to or greater than the mean plus two standard deviations but less than the mean plus three standard deviations is represented by the second character of the code; and the number of demands equal to or greater than the mean plus three standard deviations are represented by the third character of the code. Quarterly demands smaller than the mean plus one standard deviation were ignored. The resulting codes were then categorized in terms of the coefficient of variation. The coefficient of variation is a measure of the size of the standard deviation in comparison to the mean. The coefficient of variation (V) = standard deviation / mean, never exceeded 4 and was coded '0' for standard deviations greater than zero but less than the mean; '1' for standard deviations greater than or equal to the mean but less than two times the mean, ..., '4' for standard deviations equal to or greater than four times the mean but less than five times the mean. Table 4 displays the number of items falling into each category combination of CODE and coefficient of variation (V). The total column represents the total number of items and the number of identified unique standard deviation patterns (PATTPN) resulting from the demand streams for those items by CODE category. These statistics are further summarized in Table 5. Table 5 is a crosstabulation of the number of quarters with demand greater to or equal to the mean plus one standard deviation (NUMSTD) by the coefficient of variation (V).

Table 4

STANDARD DEVIATION BY COEFFICIENT OF VARIATION

CODE			V					TOTAL	
1	2	3	0	1	2	3	4		
S	S	S							
T	T	T							
D	D	D	NSN	NSN	NSN	NSN	NSN	NSN	PATTRN
1	0	0	3147	5671	96	.	.	9914	17
2	0	0	1798	6238	21	.	.	8057	186
3	0	0	4528	5366	75	.	.	9969	1095
4	0	0	6802	3917	16	.	.	10735	3909
5	0	0	2856	1668	.	.	.	4524	3710
6	0	0	372	313	.	.	.	685	674
7	0	0	16	65	.	.	.	81	81
8	0	0	3	11	.	.	.	14	14
9	0	0	.	5	.	.	.	5	5
6	1	0	.	19	.	.	.	19	19
5	1	0	43	170	.	.	.	213	213
4	1	0	1357	2049	.	.	.	3406	3270
4	2	0	.	2	.	.	.	2	2
4	0	1	.	16	.	.	.	16	16
3	1	0	9064	12235	86	.	.	21385	11746
3	2	0	20	143	.	.	.	163	162
3	0	1	69	905	103	.	.	1077	1023
2	1	0	16175	22684	1136	.	.	39995	3405
2	2	0	709	2829	68	.	.	3606	3158
2	1	1	.	.	3	.	.	3	3
2	0	1	1499	8821	2291	.	.	12611	3172
1	1	0	6793	17528	3367	.	.	27688	380
1	2	0	3404	12355	1559	.	.	17318	3258
1	3	0	2	64	3	.	.	69	68
1	1	1	11	338	196	.	.	545	506
1	0	1	4001	20828	12518	419	.	37766	380
0	1	0	825	10617	5661	72	.	17175	20
0	2	0	2592	11677	5096	2	.	19367	190
0	3	0	24	688	500	.	.	1212	590
0	1	1	163	2848	2797	20	.	5828	374
0	0	1	1998	13002	19632	8245	376	43253	20
ALL			68271	164072	55224	8758	376	296701	41666

Table 5

TABLE OF NUMSTD BY V

NUMSTD FREQUENCY PERCENT	V-COEFFICIENT OF VARIATION					TOTAL
	0	1	2	3	4	
0	1407	286	0	0	0	1693
	0.47	0.10	0.00	0.00	0.00	0.57
1	5970	30290	25389	8317	376	70342
	2.00	10.15	8.51	2.79	0.13	23.56
2	15347	59119	23799	441	0	98706
	5.14	19.80	7.97	0.15	0.00	33.07
3	25753	50252	5757	0	0	81762
	8.63	16.83	1.93	0.00	0.00	27.39
4	16649	19950	279	0	0	36878
	5.58	6.68	0.09	0.00	0.00	12.35
5	4233	3876	0	0	0	8109
	1.42	1.30	0.00	0.00	0.00	2.72
6	416	485	0	0	0	901
	0.14	0.16	0.00	0.00	0.00	0.30
7	16	84	0	0	0	100
	0.01	0.03	0.00	0.00	0.00	0.03
8	3	11	0	0	0	14
	0.00	0.00	0.00	0.00	0.00	0.00
9	0	5	0	0	0	5
	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	69794	164358	55224	8758	376	298510
	23.38	55.06	18.50	2.93	0.13	100.00

D. Analysis Based on Standard Deviation. Forty percent of the non-seasonal items had only 3 or 4 data points across the entire 20 quarters that could be identified as demand spikes; 57 percent of the items had fewer than 3 quarterly demands that exceeded the mean by one standard deviation or more. Twenty quarters of data are insufficient to define a distribution of inter-arrival times for infrequent demands based on deviation from the mean. Pattern analysis of the more than 40 thousand unique standard deviation patterns is impractical due to sheer numbers. No further analysis of demand data based on standard deviation was conducted.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE July 1989	3. REPORT TYPE AND DATES COVERED		
4. TITLE AND SUBTITLE Forecasting Infrequent but Predictable Demands			5. FUNDING NUMBERS	
6. AUTHOR(S) Patrick F. Miller Benedict C. Roberts				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Defense Logistics Agency Operations Research and Economic Analysis Office Cameron Station Alexandria, VA 22304-6100			8. PERFORMING ORGANIZATION REPORT NUMBER DLA-89-P81061	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Defense Logistics Agency Cameron Station Alexandria, VA 22304-6100			10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Public Release; Unlimited Distribution			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) The Defense Logistics Agency manages some items that generally experience little or no demand. These demands are occasionally interrupted by larger demands. This study was performed to identify and categorize those items that have definite "lumpy" demand patterns, quantify the magnitude of the effect of these demands on the managing commodity's supply availability, and determine the feasibility of attempting to forecast future behavior of these items. "Lumpy" items were identified and analyzed as two distinct groups of seasonal and nonseasonal items. Approximately 6 percent of stocked items with demand can be classified as seasonal. Seasonal items tend to increase the commodity's overall supply availability and have a relatively low stock position both in terms of stock to demand ratios and stock investment. These items did not have any distinguishable stocked items; however, under the concept of Multiple Forecasting, they do lend themselves to relatively simple forecasting techniques. The analysis of Defense Industrial Supply Center items experiencing "lumpy" but nonseasonal demand resulted in an unmanageable number of distinct categories making any kind of pattern analysis impractical.				
14. SUBJECT TERMS Supply, Forecasting, Demand Patterns			15. NUMBER OF PAGES 15	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT	