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CALCULATION OF PERCENT ERROR TABLES FOR USE IN THE RIMSTOP IMPL--ETC(U)
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CALCULATION OF PERCENT ERROR TABLES FOR USE IN THE RIMSTOP IMPLEMENTATION

U.S. ARMY
INVENTORY
RESEARCH
OFFICE

SEPTEMBER 1980

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

Demand variability is measured at the wholesale level by percent forecast errors. This work develops percent error tables based on the earlier wholesale level work for use at the retail level with the implementation of the RIMSTOP program.

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SUMMARY

Background

The computation of variable safety levels requires an estimate of the variability of lead time demand. Earlier work by the Inventory Research Office* found that a good way of determining the variability was the percent error of forecasted demand over the lead time stratified by extended price and item frequency.

Purpose and Objectives

The purpose of this work was to develop percent error tables based on earlier wholesale level work using retail level data. These tables are to be used in the implementation of the variable safety level computation as part of the RIMSTOP effort.

Scope

Percent errors for secondary items were measured using 2-year data bases from the 3rd Armored Division in Germany and the 82nd ABN Division, Ft. Bragg, NC. The percent error and stratification procedures were those used in earlier wholesale level work.

Findings & Conclusions

The percent errors found for the two divisions were consistent with those found at the wholesale level after adjustments were made using an empirical factor to compensate for shorter lead times. A comparison of the two divisions' percent errors showed that, while different, they were similar enough to conclude that one table could be used by all divisions in computing safety level quantities.

*"Estimation of Demand Variability Parameters," May 1974, A. Kaplan, IRO #183.

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CHAPTER I

METHODOLOGY

1.1 Measurement of Percent Errors

Retail level demands were used to compute the Percent Error (PCER) for 11 cells defined by each item's extend price and annual frequency of demand. Percent Error is defined as:

$$PCER = \frac{|F - A|}{F}$$

where F = forecasted demand using a 12-month moving average.

A = actual demand in the order and ship time (30 days)

Any trends in the data base can result in biased PCERs. Therefore, non-parametric tests were performed on the data to determine if trends might exist so that necessary corrections could be made before computing the PCER Table.

Theoretically, PCER should only change in a stationary process due to the length of the lead time. Classical statistical theory uses the following correction:

$$PCER(m) = \left(\frac{m}{K}\right)^{-.5} PCER(k)$$

where PCER(k) is the known PCER for k lead time and PCER(m) is the unknown percent error for lead time m.

However, in Kaplan's work (reference 1) an empirical estimation procedure was derived and tested using simulation. This correction factor is:

$$PCER(m) = \left(\frac{m}{k}\right)^{-.117} PCER(k)$$

Since the wholesale PCER's are based on a nine month lead time, we compared the PCER's derived for the retail data with a one month lead time to the wholesale PCERs using the following correction:

$$PCER(1) = \left(\frac{1}{9}\right)^{-.117} PCER(9)$$

1.2 Data Base

The data used for this work were the X05 Demand Summary files for the 82nd Airborne Division and the 3rd Armored Division. Two years of data from January 1978 through December 1979 were used. These data represent all requisitions for secondary items, excluding QSS (Quick Supply Store) and reparables, ordered by the PLL units within the division structure.

CHAPTER II

RESULTS

2.1 Results - 82nd ABN Division

The initial work was done using the 82nd ABN data. The 3rd AD data were used to verify these results.

The first step was to determine if any trends were apparent in the data. If so, they must be removed so that results will not be biased. The time series of demand quantities and extended price were plotted (Attachment 1). Though the series appear very erratic, a downward trend appeared possible. This was further substantiated using a non-parametric Cox and Stuart trend test. There are several ways to correct for data trends. In the wholesale work adjustment factors were applied to the data. However, since we had plenty of data to work with, we chose that segment of data where no trend was evident visually or indicated by using the Cox and Stuart trend test. This time frame was months 5 through 25.

Using these months, the following PCER table was computed.

TABLE 1

<table>
<tr><th>Extended Price</th><th>< $200</th><th>> $200</th></tr>
<tr><td>Frequency</td><td></td><td></td></tr>
<tr><td>< 5</td><td>2.09</td><td>1.63</td></tr>
<tr><td>< 9</td><td>1.78</td><td>1.35</td></tr>
<tr><td>< 17</td><td>1.44</td><td>1.26</td></tr>
<tr><td>< 33</td><td>1.17</td><td>1.01</td></tr>
<tr><td>< 63</td><td colspan="2">.865</td></tr>
<tr><td>< 122</td><td colspan="2">.704</td></tr>
<tr><td>≥ 122</td><td colspan="2">.477</td></tr>
</table>

2.2 Comparison of Wholesale and 82nd ABN PCERs

As stated earlier, PCERs should change with the length of the lead time demand. Therefore, the above results should be close to the wholesale PCER adjusted from nine months to one month using

$$PCER(1) = \left(\frac{1}{9}\right)^{-.117} PCER(9)$$

This comparison is seen in Table 2.

TABLE 2

Extended Price	≤ 200		> 200	
Frequency				
< 5	2.09	(2.19)	1.63	(1.66)
< 9	1.78	(1.63)	1.35	(1.31)
< 17	1.44	(1.32)	1.26	(1.02)
< 33	1.17	(1.17)	1.01	(.84)
< 63	.865	(.743)		
< 122	.704	(.606)		
≥ 122	.477	(.528)		

where (   ) is the adjusted wholesale PCER.

As can be seen, the values are quite similar which leads us to conclude that retail PCER computed from the 82nd ABN Division are valid.

2.3 Results - 3rd Armored Division

We wished to further confirm the results using another division which is different from the 82nd. We chose the 3rd Armored because it was an overseas division, the equipment was completely different from the 82nd and the demand was much heavier. The same procedures were repeated to compute the PCERs. The only difference was that no trend appeared, even though demand patterns fluctuated wildly. These results are compared with the 82nd PCER (in brackets).

TABLE 3

Extended Price	≤ 200		> 200	
Frequency				
< 5	2.14	[2.09]	1.76	[1.63]
< 9	1.92	[1.78]	1.45	[1.35]
< 17	1.61	[1.44]	1.25	[1.26]
< 33	1.29	[1.17]	1.02	[1.01]
< 63	.936	[.865]		
< 122	.780	[.704]		
≥ 122	.581	[.477]		

Though differences are evident, we feel they are sufficiently close to warrant the use of one percent error table for all divisions when computing safety levels.

2.4 Conclusion

The Percent Error Table (Table 1) should be used in the computation of variable safety levels in the RIMSTOP implementation.

CHAPTER III

SIGNIFICANCE TESTING

The conclusion that the 82nd ABN PCER table could be used by all retail installations was based on a visual inspection of the differences between the 82nd ABN and 3rd Armor Divisions with further support based on the adjusted wholesale PCER table. However, a rigorous comparison using a statistical test is desirable. We chose a two sample t-Test for the differences in means to make this evaluation. The test was performed on each cell of the PCER table from the 82nd and 3rd Armor Divisions PCERs.

Let

$\bar{X}_1$ = 3rd AD cell mean

$\bar{X}_2$ = 82nd ABN cell mean

and the standard deviation of the fifference in means be

$$S_{\bar{X}_1 - \bar{X}_2} = \frac{\sigma_1 2}{n_1} + \frac{\alpha_2 2}{n_2}$$

where

σ_1 = standard deviation of 3rd AD cell PCER

$_2$ = standard deviation of the 82nd ABN cell PCER

n_1 = number of observation in 3rd AD cell

n_2 = number of observation in the 82nd AD cell

The hypothesis we wish to test is

H_0: $\bar{X}_1 - \bar{X}_2 = 0$; no difference in PCER values for the cell

H_1: $\bar{X}_1 - \bar{X}_2 \neq 0$; a significant difference

The computed means and standard deviations for the 82nd ABN and 3rd AD PCER (in brackets) are as follows:

	< 200						≥ 200		
	Mean	Std					Mean	Std	
< 5	2.09	10.7	[2.14 10.6]				1.63	4.9	[1.76 24.3]
< 9	1.78	5.7	[1.92 9.3]				1.35	2.1	[1.45 5.7]
< 17	1.44	3.4	[1.61 6.8]				1.26	2.4	[1.25 2.5]
< 33	1.17	1.9	[1.29 2.8]				1.01	1.4	[1.02 1.9]
< 63				.865	1.4	[.936 1.4]			
< 122				.704	.95	[.780 1.21]			
≥ 122				.477	.51	[.581 .65]			

The resulting T statistics are:

	< 200		≥ 200
< 5	.485		.419
< 9	1.53		1.28
< 17	1.97		.204
< 33	2.06		1.05
< 63		2.08	
< 122		2.23	
≥ 122		4.52	

Using a very stringent significance level of 98%, we can only reject the H_0 hypothesis that there is no difference in the PCER values in the cell labelled 122. Had we chosen a lesser significance level of 90%, however, the H_0 hypothesis would have been rejected in the following:

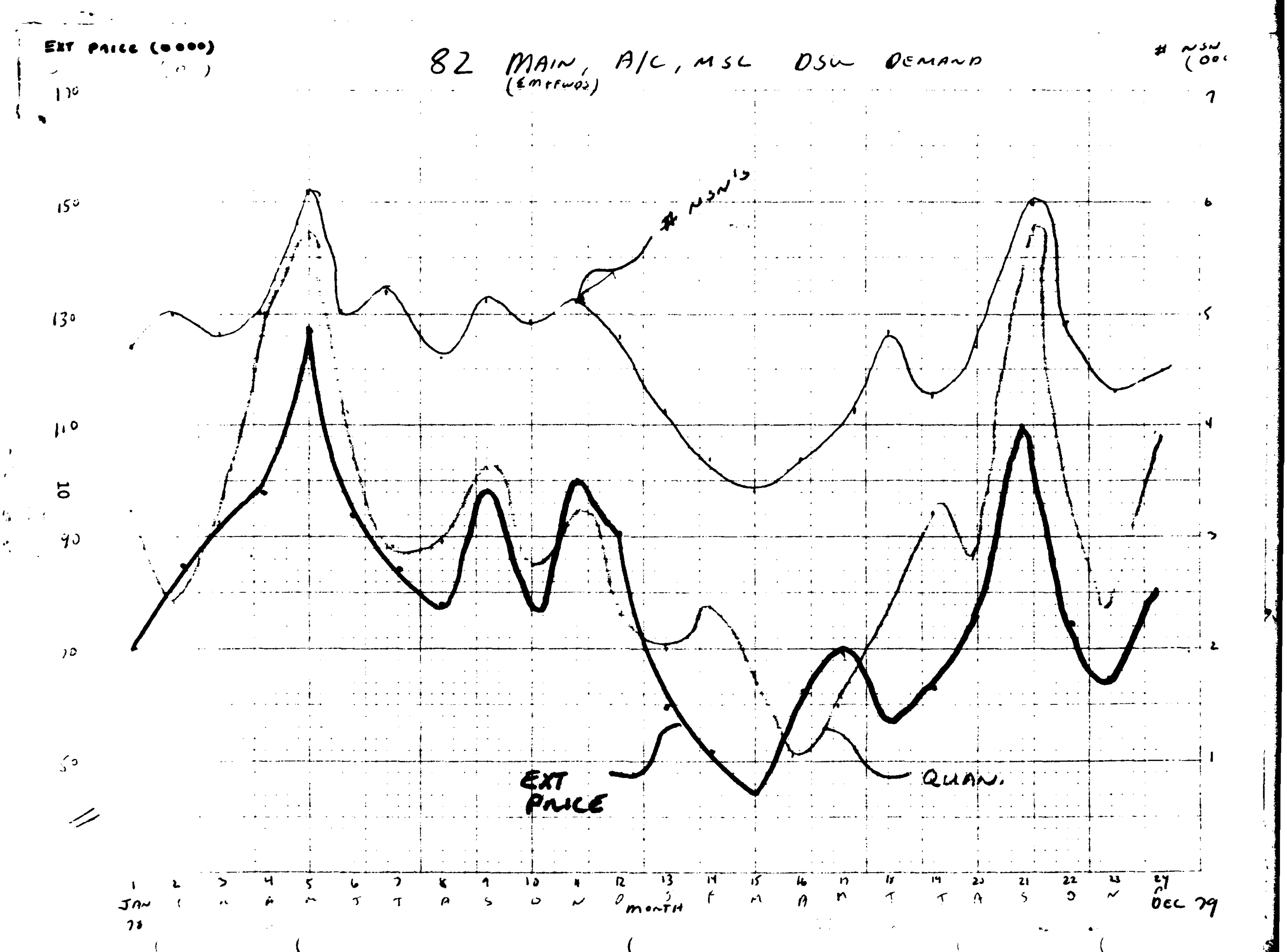
Ext Price < 200, frequency 17, < 200 frequency 33
and frequency 63, 122 and ≥ 122.

A possible breakdown in the t-test may occur in the higher frequency cells. One assumption when using the T-test is that the sampling distribution $\bar{X}_1 - \bar{X}_2$ may be approximated by a normal distribution. We know that the distribution of X_1 and X_2, the PCERs within a cell, is bounded below by 0, unbounded above with a large spike at PCER 1 due to the large number of zero demand observed in a particular month. However, with a "large" number of observations the distribution of $\bar{X}_1 - \bar{X}_2$ approximates the normal.

The problem occurs in the higher frequency cells where "few" observations are made. The result could be a greater number of observations falling in the tails of the distribution thus causing the T statistic to conclude real differences between the PCER values.

We feel confident however in retaining the conclusion that one PCER table is adequate for all divisions since most of the items fall in the lower frequency cells and if there was any true difference in the higher frequency classes, little degradation of performance or cost would result.

We plan however to continue to verify our single PCER table conclusion since the statistical significance results are not conclusive. This will be accomplished using the simulator to be developed as part of the RIMSTOP effort.



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