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OPTIMIZING RETAIL FERTILIZER DEALER INVENTORY LEVELS[1]

by

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Retail fertilizer firms must cope with a high degree of uncertainty in their business operations. The amount of fertilizer farmers plan to buy each year changes with fertilizer prices and the prices of grain and other crops utilizing fertilizer. Farmer's plans are, in turn, adjusted by weather conditions at planting time. The timing and relative height of the peak spring application period varies from year to year. If the planting season is too wet or too late, Midwest farmers will switch from corn to soybeans, thus reducing their fertilizer purchases for the season.

Weather also affects the ability of retail dealers to obtain supplies. In those sections of the country which receive some fertilizer shipment by barge, an extremely wet spring may delay river traffic. When a relatively high spring peak in demand occurs dealers relying on railcar or trucks for delivery of products to their business location may experience considerable delay in obtaining products.

In the late 1960's and early 1970's fertilizer manufacturers were encouraging fertilizer sales. Supplies were ample, prices were low, and credit terms were extremely lenient. With the development of shortages in the last two years, retail dealers have scrambled for supplies from any source. Cash on shipment or payment within 30 days have become standard practices. These

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(1) Contributed paper, presented at American Agricultural Economics Association Annual Meeting, Columbus, Ohio, August 1975.

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changed conditions along with the inherent uncertainty of the industry make inventory management an important factor in the success of a business.

Identifying Optimum Inventory Levels

The retail fertilizer dealer has a continuum of inventory management options available. At one extreme he can, by the time the spring season starts, have as much fertilizer in storage as he expects to sell. He'll have a lot of money tied up in facilities, in product, and in costs of handling the product. But he'll have the product available when his customers want it. At the other extreme he can operate with a minimum level of stock and rely on his suppliers to provide goods as quickly as stock is sold. With this strategy he will undoubtedly have stock-outs, temporary sales loss, dissatisfied customers, and perhaps permanently lost customers. But he will have a low level of carrying cost.

The practical level for a retail dealer's fertilizer inventory is somewhere between the extremes identified. But where? For any set of product demand, product cost, carrying cost, order cost, and cost of lost business variables, there is one level of inventory which will result in a minimization of inventory costs for the firm. While determination of minimum cost levels for a few combinations of variable values could be accomplished manually, the changing values of variables and the number of possible combinations of variable values makes this problem one which can be effectively handled with a computerized simulation model. The purpose of this paper is to identify the principal characteristics of a model developed to analyze inventory strategies and to present results obtained in applying the model to typical dealer operations.

The Computer Model

The simulation model is organized to evaluate the operations of a firm over a fiscal year. Several years operation may be simulated.[3] The firm analyzed handles dry bulk products. Inventory procedures are developed for nitrogen, phosphorus, and potash ingredients which are blended. The model is deterministic at its present stage of development. Three different seasonal demand patterns are evaluated with each computer run. Demand pattern one reflects normal seasonal demand. Pattern two is more peaked in the spring than is the normal pattern. Pattern three reflects the effect of a cold wet spring, Figure 1. With identification of random distributions for demand and other variables the model could become stochastic.

The computer program is organized to provide maximum flexibility in adapting the analysis to the dimensions of a particular firm(s). This is accomplished by reading information on characteristics of the study firm(s) and its operation. Information utilized includes:[4]

A. Balance sheet information which indicates the firm's financial strength and beginning inventory position.

B. Operating information which identifies cost and price relationships for the firm.

C. Capacity information for storing and transporting fertilizer products.

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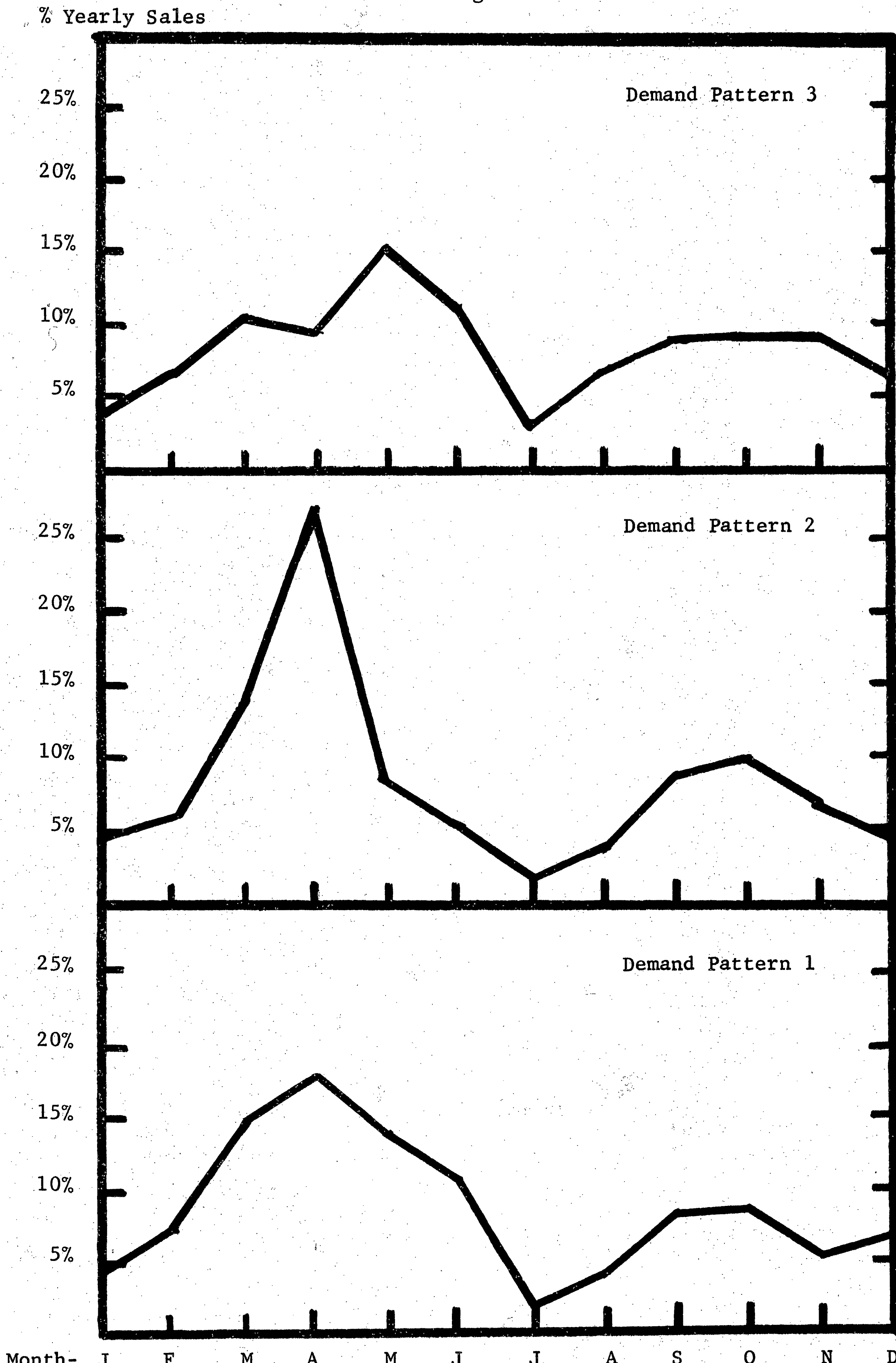
(3) This capability was built into the model to allow for later implementation of stochastic demand and lead-time patterns. At the present stage this capability allows the user to work with averages thus minimizing the effect of year end inventory fluctuations.

(4) See input information sheet, pages 6-8 for a complete listing of data input.

DEMAND PATTERNS FOR RETAIL FERTILIZER INVENTORY MODEL
Figure 1



Information Generated by the Program

Each run of the program provides the user with the following monthly information:

(a) cash at the end of the month.

(b) accounts receivable at the end of the month.

(c) sales for the month.

(d) accounts payable at the end of the month.

(e) interest expense for the month.

(f) shortages which would have occurred in nitrogen, phosphorus, potash products.

(g) maximum inventory position within the month for nitrogen, phosphorus, potash

A yearly summary is generated which provides information on:

(a) total cost for product purchase and inventory expenses.

(b) cost of ordering.

(c) opportunity cost for funds.

(d) cost of being out of goods.

(e) cost of goods sold.

(f) interest expense

(g) shortages--by product - nitrogen, phosphorus, potash.

(h) maximum inventory position within the year for nitrogen, phosphorus, potash

Application of the Model

In order to test the sensitivity of inventory costs to changes in values of key cost variables, analysis was conducted on data which reflects the operation of a "typical" midwest fertilizer dealer's business.

The study firm had yearly sales of 4000 tons of dry mixed fertilizer. The variable values for his current operation were:

A. Balance Sheet Information

1. Minimum desired cash balance	$15,000
2. Credit restriction	
Total assets at start of analysis	
Short term bank credit	$300,000
3. Inventory at start of analysis	
Nitrogen products	300 tons
Phosphorus products	300 tons
Potash products	450 tons

B. Operating Information

1. Total demand	4,000 tons
2. Percentage of sales for cash	10 percent
3. Bad debts as a percentage of sales	.2 percent
4. Variable cash expense as percentage of sales	8 percent
5. Fixed monthly cash expenses	$800
6. Cash discounts available from manufacturers	0 percent
7. Cost per ton product purchased	
Nitrogen products	$135.00
Phosphorus products	$146.00
Potash products	$ 50.26
8. Freight cost per ton	
Nitrogen products	$ 8.00
Phosphorus products	$ 15.00
Potash products	$ 20.00

9.	Order cost per order	
	Nitrogen products	$ 0
	Phosphorus products	$ 0
	Potash products	$ 0
10.	Cost of capital for internal funds	10 percent
11.	Interest cost for borrowed funds	10 percent
12.	Selling price per ton	
	Nitrogen products	$175.00
	Phosphorus products	$210.00
	Potash products	$108.00
13.	Fixed facilities cost per year	$1,000.
14.	Shortage cost per ton	
	Nitrogen products	$ 6.00
	Phosphorus products	$ 6.00
	Potash products	$ 6.00
15.	Policy used when product short	
	Borrow	X
	Lose sale	
16.	Policy used in paying supplies	
	Cash	X
	Supplier credit	
17.	Collection policy on sales	
	Average collection period	30 days
	Aging schedule	
	Month 1	
	Month 2	
	Month 3	

18. Lead-time for receipts from manufacturers

Nitrogen products	7 days
Phosphorus products	14 days
Potash products	21 days

19. Seasonal discounts per ton

	Nitrogen	Phosphorus	Potash
January	$	$	$
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

20. Quantity discounts per ton

	Nitrogen	Phosphorus	Potash
January	$	$	$
February			
March			
April			
May			
June			
July			
August			
September			
October			
November			
December			

C. Capacity Information

1. Storage capacity

Nitrogen products	300 tons
Phosphorus products	300 tons
Potash products	450 tons

2. Shipping capacity per car/truck

Nitrogen products	100 tons
Phosphorus products	100 tons
Potash products	100 tons

The operating policy used by this firm was to meet demand requirements under average conditions (demand pattern 1). In order to accomplish this, management planned to have the following order quantities and minimum levels of product in inventory:

	Order Quantities			Order Levels		
	Nitrogen	Phosphorus tons	Potassium	Nitrogen[1]	Phosphorus[1] tons	Potassium[1]
January	100	100	100	30	45	80
February	100	100	200	50	80	140
March	100	100	200	65	100	175
April	100	100	200	65	100	175
May	100	100	100	50	75	130
June	100	100	100	25	35	75
July	100	100	100	15	25	50
August	100	100	100	30	50	90
September	100	100	100	30	50	90
October	100	100	100	30	50	90
November	100	100	100	20	40	75
December	100	100	100	20	40	75

Given the specifications listed, the cost of maintaining the inventory for this dealer amounts to $3580 per year (Table I). This is composed of $2580 of carrying cost. By definition there would be no shortage cost. Fixed costs would be $1000. If demand pattern two were to occur, the dealer would experience an increase in both carrying cost and shortage cost. The increase in carrying costs would occur because more goods would be available than needed

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[1]These minimum monthly inventory levels were set at levels which allowed replacement of product during the lead-time and order quantity levels specified. Calculation of these values was done by a separate subroutine within the program.

in part of the year. Shortages would be experienced during the spring peak. At his shortage cost of $6 per ton, he would have nearly $1500 in extra transportation costs. With demand pattern three occurring he would experience carrying cost similar to those of pattern two, $2637. He would, however, have a lower shortage cost, $629.

Table I

Yearly Cost of Maintaining Inventory - Base Situation

(Operating Policy 1)

Demand pattern	Carrying cost	Shortage cost	Fixed cost	Total cost
1	$2580	$ 0	$1000	$3580
2	2626	1469	1000	5096
3	2637	629	1000	4266

Changing Operating Policy

By using the order quantity and order level specification in operating policy one, the fertilizer retailer would experience stockouts on occasion. By shifting those values a system can be developed which avoids stockouts regardless of which demand pattern prevails. Order quantities and order levels which will accomplish this objective are as follows:

	Order Quantities			Order Levels		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
January	100	100	100	30	45	80
February	100	100	200	50	75	140
March	100	200	200	100	150	260
April	100	200	200	100	150	260
May	100	100	100	55	85	150
June	100	100	100	40	65	115
July	100	100	100	20	40	70
August	100	100	100	30	50	95
September	100	100	100	30	55	100
October	100	100	100	30	55	100
November	100	100	100	30	55	100
December	100	100	100	20	40	75

This system will have higher carrying costs. But how much will the dealer pay in order to provide this higher service level? The cost increases calculated for this service level range from $773 for demand pattern three to $864 for demand pattern two, (Table II).

Table II

Yearly Cost of Maintaining Inventory

(Operating Policy 2)

Demand pattern	Carrying cost	Shortage cost	Fixed cost	Total cost
1	$3384	0	$1000	$4384
2	3489	0	1000	4489
3	3411	0	1000	4411

Change in Shortage Costs

In the base situation, Table I, the dealer was able to borrow product from a neighboring dealer. His extra cost was $6 per ton for extra transportation. If he had not been able to make the sales specified in demand patterns two and three, he would have incurred shortage costs of $26 per ton for nitrogen, $32.20 for phosphorus, and $29.10 for potash.[(5)] With normal demand (Pattern 1) he would have no change from his base situation (Table I). For demand patterns two and three shortage costs would be substantially higher; $7126 for pattern two and $3065 for pattern three; (Table III).

[(5)]These values equal selling price less variable expense.

Table III

Yearly Cost of Maintaining Inventory - Shortage

Cost $26/ton

(Operating Policy 1)

Demand pattern	Carrying cost	Shortage cost	Fixed cost	Total cost
1	$2581	$ 0	$1000	$3581
2	2626	7127	1000	10,753
3	2637	3064	1000	6702

Under this set of conditions the $800 extra cost of using operating policy two would result in a considerable improvement in profits for the firm, except when demand pattern 1 occurred.

Changes in Product Delivery Lead-time

In the base situation the dealer could expect to have delivery of product in seven days for nitrogen, fourteen days for phosphorus, and twenty-one days for potash. Extension of these lead-times without changing the order level causes an increase in stockout occurrences. Carrying costs will be reduced. For the situation where the lead-time for each product was increased by three days, total costs ranged from $4327 to $6151, Table IV.

Table IV

Yearly Cost of Maintaining Fertilizer Inventory - Lead-time 10-17-24

(Operating Policy 1)

Demand pattern	Carrying cost	Shortage cost	Fixed cost	Total cost
1	$2241	$1086	$1000	$4327
2	2419	2731	1000	6151
3	2411	1606	1000	5017

The elimination of shortages for the normal demand situation could be accomplished by extending order quantities and/or order levels. The combination of order quantities and order levels listed below is one means for getting this task accomplished:

	Order Quantities			Order Levels		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
January	100	100	100	40	50	90
February	100	200	200	70	95	155
March	200	200	200	135	175	300
April	100	200	200	135	150	300
May	100	100	200	80	100	170
June	100	100	100	60	75	130
July	100	100	100	30	45	80
August	100	100	100	40	65	110
September	100	100	200	40	70	115
October	100	100	200	40	70	115
November	100	100	100	40	65	110
December	100	100	100	30	50	80

Cost levels which would prevail after this adjustment would be $500 higher for the normal demand pattern, but lower for demand patterns two and three, (Table V).

Table V

Yearly Cost of Maintaining Fertilizer Inventory

(Lead-time 10-17-21, no stockout with normal demand)

Demand pattern	Carrying cost	Shortage cost	Fixed cost	Total cost
1	$3821	$ 0	$1000	$4821
2	3818	182	1000	5000
3	3762	0	1000	4762

Change in Product Cost and Interest Costs

The increases in the cost of fertilizer in the last few years have resulted in dealers having more dollars tied up in inventory and consequently higher financing costs. With higher costs for carrying inventory a dealer may minimize total inventory costs by reducing inventory level and letting the frequency of stockouts increase. Each 10% increase in the cost of fertilizer caused total inventory costs to increase by about eight percent. With the cost of shortages at $6 per ton, the dealer could be short by about 40 tons more and maintain the same profit level.

Interest costs for financing have risen to record levels in the last two years. Just as with increases in product costs, there are some tradeoffs which the dealer may wish to make to reduce inventory carrying costs. Each 1% change in interest charges causes a 7-8% change in inventory carrying costs. More stockouts can be tolerated if costs for inventory maintenance are to be minimized. At $6 per ton for shortage costs, 40 more tons of shortage would leave the dealer no worse off.

Summary and Conclusions

Because of the inherent uncertainty in their business, retail fertilizer dealers experience frequent changes in the variables affecting their business. Many of these changes directly affect their cost of maintaining inventories. Management of inventory is, consequently, an important factor in business success. The computer simulation model described in this paper is designed to assist researchers and managers in answering the "what if" questions which the industry faces in adjusting to changed conditions.

The model was used to test the effect of several key variables on the costs of maintaining inventory for a representative 4000 ton per year retail fertilizer firm. Variables tested included: (1) operating policy with regard to shortages, (2) shortage costs, (3) product delivery lead-times, (4) product cost, and (5) interest costs. Several of these factors encourage conservative order policies with high safety stocks. Among these are low interest rates, low product cost, long lead-time, high shortage cost, and lenient supplier credit terms. Factors which encourage low safety stocks are high interest rates, high product cost, short lead-times, and low shortage costs. Of these variables, the analysis suggests that lead-time and shortage costs exert the most influence in determining which order policy is preferred. Despite high interest rates and high product costs, long lead-times and high shortage costs would indicate that a policy which entails high safety stocks would result in lower inventory costs than a policy which minimizes safety stocks.