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THE EFFECTS OF VALUATION TECHNIQUES ON HOLDING COST DURING INFLATIONARY PERIODS: A SIMULATION EXERCISE

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ABSTRACT

The purpose of this paper is to study the effects of different inventory valuation techniques on holding costs during inflationary periods by means of Monte Carlo Simulation. In the first sections of this paper the topics of simulation and inventory valuation are presented as background material. The remaining sections report on the inventory model used, the modifications made to the model, and the simulation results.

SIMULATION

The use of algorithms and heuristics depends largely upon the knowledge of the problem area and the techniques of solving problems in that discipline. While at times the distinction between an algorithm and a heuristic may not be clear cut, an algorithm in general is a well defined procedure or set of rules for solving a problem with a finite number of steps. On the other hand a heuristic uses an exploratory problem solving method in which solutions are discovered by evaluating the progress made toward the final result.[1]

One heuristic approach to solving management problems is simulation. Simulation applies a trial and error method in solving problems which do not lend themselves to mathematical analysis because of their complexity or costs. Various alternatives can be tested before massive financial commitments are made.

While a simulation provides a dynamic problem solving framework, it does not necessarily provide an optimal solution. The essence of simulation is that it allows one to reproduce a typical series of events. If enough events are simulated a mean value can be determined. This mean value purports to represent what would actually happen in practice. The simulation model is therefore a powerful teaching tool as well as a problem solving technique.

Simulation models need not be limited to steady state conditions. Both deterministic and probabilistic models exist. Classical analysis has often been concerned with deterministic models where expected values and input variables are known and where the relationship between these variables is stable over time. While deterministic models often provide insight into the basic relationships between variables, probabilistic models more closely represent actual business situations by having variables defined by probability distributions. Monte Carlo simulation involves sampling from a probability distribution by use of random numbers. The probability distribution represents possible outcomes which might occur in an uncertain environment. The use of random numbers in sampling from these distributions, allows for an artificial but realistic sequence of events to occur. The procedure allows managers to see the effects of these random influences on organizational conditions.

In Monte Carlo simulation key variables are converted to cumulative probability distributions in order to assure only one variable value will be associated with a given random number. A random number table is used to select values used in sampling the distribution. When the simulation model is computerized a pseudo random number generator is used.[2]

The accuracy of the simulation model depends entirely on the probability distribution used and the choice of the random numbers. If the probability distribution does not adequately represent the real world events then the model is useless. The results of the model may also be biased if a poor random number generator is used. Fortunately statistical tests exist for determining the accuracy of both.[3]

THE INVENTORY PROBLEM

The problems associated with inventory have been of interest to many disciplines both from a theoretical and practical viewpoint. The inventory problem is usually stated in terms of minimizing costs. A balance is desired between having enough inventory on hand to satisfy demand while minimizing the costs associated with warehousing holding costs and taxes. Inventory creates a problem because of the differences of opinions of functional groups within the organization. The sales force wants to maintain a stockpile of inventory in order to handle increases in demand. The warehouse foreman wants to reduce the costs of handling a large volume of surplus inventory. From a theoretical standpoint inventory problems can be broken down into the following classifications;[4]

1. Repetitive
   a. single order
   b. repeat order
2. Supply source
   a. outside supply
   b. inside supply
3. Knowledge of demand a. constant demand b. variable demand
4. Knowledge of lead time a. constant lead time b. variable lead tine
5. Inventory system
   a. perpetual
   b. periodic
   c. material requirement planning

[1] Thomas J. Harrison, Handbook of Industrial Control Computers (New York: John Wiley & Sons, Inc., 1975), p. 973.

[2] Richard J. Tersine, Materials Management and Inventory Systems (New York: Elsevier Publishing Company, Inc. 1976), pp. 100-250.

[3] Ibid., pp. 378-380.

[4] Ibid., p. 10.

Simulation has been used in solving problems in several of these areas. For instance simulation has been used in determining inventory ordering policy, materials requirement planning (MRP) , and in evaluating inventory replenishment and lead time policies on the overall performance of a system.5[5] While there has been a wealth of information generated concerning inventory problems both from a production management and accounting approach, there has been little research in the area of simulating the effects of different inventory valuation methods on inventory holding costs.

Among those who have done research in this area are Bastable and Merriwether, who used simulation to study the extent to which inventory profits overstated reported profits in an inflationary economy under FIFO. Compound Interest Tables were used to simulate price level changes. From their study it was determined that FIFO measurements may produce significant overstatements in income determination.

> The inflation rate, the length of the holding period, gross profits and pretax profit margins affect the relative magnitude of holding gains and may exaggerate reported profits.[6]

Management decisions based on alternative inventory valuation techniques have also been tested through simulation.[7] An earlier study done by Liberman in 1958 determined an inventory depletion policy through simulation of various valuation techniques.[8]

VALUATION TECHNIQUES

As previously mentioned the inventory problem is usually stated in terms of minimizing costs. Inventory costs can be divided into three groups: order, carrying, and stockout cost.

Order costs originate from expenses in issuing a purchase order to an outside supplier or an internal production unit. Stockout costs (depletion costs) result from external and internal shortages. External shortages occur when a customer of the organization does not have his order filled. An internal shortage occurs when a group within the organization does not have its order filled. Holding costs (carrying costs) originate from many sources. They include such items as capital costs, taxes, and insurance.[9]

Holding costs not only vary with the physical quantity of inventory but also with the value of the inventory as well. In preparing the balance sheet and income statement, the accountant has traditionally been concerned with the valuation techniques used in order to determine ending inventory value and Costs of Goods Sold. The accounting procedure used will determine when and how there is a change in assets and when these assets are transformed into Costs and expenses. It is generally recognized that matching Costs with revenue is desirable. During periods of rapid price change revenues may become exaggerated due to the difference between purchase and selling price of an item. Inventory profits, the results of this differential, are eroded when the inventory must be replenished.

The three most common methods of inventory valuation are LIFO, FIFO. and Average Cost. The method chosen will depend on several factors but once a method is chosen it becomes difficult to change to another method due to tax regulations and the accountant's desire for consistency.

FIFO, the most widely used technique assumes that materials are issued from the oldest supply in stock and units issued are costed at the oldest cost listed. The materials on hand are the most recent purchased. This technique tends to produce a favorable view of inventory on the balance sheet, but tends to distort Cost of Goods Sold on the income statement. In periods of rap- id price change FIFO does not match costs with revenues.

Another technique used is LIFO, which assumes the most current costs of goods sold be charged to Cost of Goods Sold. Under LIFO the costs of units remaining in inventory represents the oldest items in stock, and the inventory issued is costed at the latest costs. The most recently acquired stock of inventory is consumed first. LIFO is effective in matching current revenues with replacement costs. However, LIFO distorts inventory value on the balance sheet which in turn distorts current assets and current ratio among others. LIFO is often favored during inflationary periods because it reduces taxable income. High turnover rates, it should be mentioned, mediate the advantages of LIFO since costs would tend to match revenues more closely.

The final method of inventory valuation to be discussed is the Average Cost Method. Using the Average method, a simple, weighted, or moving average is calculated for the period. As would be expected the average method reduces extreme fluctuations in value and thus responds more gradually to price changes. When there is rapid price movement the Average Cost Method fails to represent price adequately.

INSIM

In order to show what effects different valuation techniques have on holding costs, a simulation model called INSIM was used. Written in Fortran, INSIM allows for simulation of up to 1000 periods. Each period represents a week. The user must initially define the following variables:

NP	Number of Periods
VII	Value of an Inventory Item
BIL	Beginning Inventory Level
RP	Reorder Point
RQ	Reorder Quantity
OC	Order Costs
RC	Receiving Costs
SOC	Stock Out Costs
AIR	Annual Interest Rate
NLT	Number of Lead Times
NDG	Number of Demand Quantities

[5] Roy D. Harris and Michael J. Maggard, Computer Models in Operations Management (New York: Harper & Row Publishing Co.. Inc. 1977), pp. 23-205.

[6] C. W. Bastable, "FIFO in an Inflationary Environment," Journal of Accountancy, Vol. 139, March 1975. pp. 49-55.

[7] N. Dopuch and J. Ronsen, "Effects of Alternative Inventory Valuation Methods--An Experimental Study," Journal of Accounting Research, Vol. 11, pp. 191-197.

[8] G. J. Liberman, LIFO vs. FIFO in Inventory Depletion Management," Management Science, April 1958.

[9] Martin K. Starr, Production Management Systems and Synthesis (Englewood Cliffs, N.J.: Prentice Hall, Inc. 1972), pp. 273-276.

In addition, the user must specify the various demand variables and lead times along with their respective cumulative probabilities. A pseudo random number generator is used to sample the probability distributions. An internal clock function is used to derive the seed tar the random number generator.

In the simplest case total is a function of:

TOTAL COST = RECEIVING COST + ORDER COST
+ STOCK OUT COST + HOLDING COST

where HOLDING COST = [(HI + EI/2) * VII * AIR] /52

However, in order to study the effects of inflation on the holding cost function, VII was allowed to vary. Thus the user must also specify:

IFR	Inflation Rate
TR	Tax Rate
IVT	Inventory Valuation Method

The inflation rate IFR is used to compute a new price at the end of every fourth period. Where

NEW PRICE = OLD PRICE + (OLD PRICE * IFR/12)

Because the value of an inventory item is no longer constant, holding costs become a function of the accounting technique used to determine the value of ending inventory.

Each period a Price Quantity matrix (PQ) is searched in order to satisfy backlog and demand. The user controls the

$$HC = \sum_{i=1}^{NDP} (BI_i \cdot BP_i + EI_i \cdot EP_i) /2 * AIR) / 52$$

where NDP = Number of price changes
BI = Beginning inventory quantity
BP = Beginning price
EI = Ending inventory quantity
EP = Ending inventory price

order of the search by indicating one of the following valuation techniques: FIFO, LIFO, or Average Cost. At every price level, demand is subtracted from quantity until all of demand and backlog is satisfied or until the inventory is depleted. Given that higher inventory values mean higher taxes, the valuation techniques can be compared on the basis of their tax advantage. Each method is compared with the Average Cost method to calculate the Tax Advantage in the following manner:

TAX ADVANTAGE = EIV - EIA) * TR) / 52

With the flew addition of Tax Advantage to the Total Cost function, the equation can now be expressed as follows:

TOTAL COST = ORDER COST + RECEIVING COST
+ STOCK OUT COST + HOLDING COST
- TAX ADVANTAGE

While it is not unreasonable to assume that inflation would impact order and receiving costs as well, for the purpose of this study order and receiving costs were assumed to be constant for two reasons. Order costs and receiving costs to a large extent represent labor costs, and these costs in the short run are fixed. In addition, by holding these two costs constant, the impact of inflation on the holding cost function is not obfuscated.

The simulation model was tested by varying several parameters. The following three cases show the impact of three valuation techniques assuming three different inflation rates: 4 percent, 8 percent. and 12 percent.

In all cases the following parameters were held constant:

NP = 100	VII = 5.00	BIL = 100	RP = 500
RQ = 500	OC = 5.00	RC = 5.00	SOC = 5.00
AIR = .05	NLT = 3	NDQ = 5	TR = .50

The following distributions were assumed for lead time and demand:

Demand	Cumulative frequency	Lead time	Cumulative frequency
121	.15	1	.15
131	.39	2	.36
141	.66	3	1.00
151	.89		
161	1.00		

The following table shows the results of simulation after 100 periods at different inflation rates on holding cost and tax advantage:

	4%		8%		12%	
	HC	TA	HC	TA	HC	TA
LIFO	315.00	2.12	326.97	4.32	339.51	6.66
FIFO	315.98	(.42)	328.85	(.86)	342.39	(1.32)
Average	315.96	.00	328.80	.00	342.33	.00

At the lower inflation rate LIFO, FIFO and Average cost differences were very low. LIFO, as expected, showed a positive tax advantage at all levels of inflation.

This demonstration suggests that the valuation technique may not be significant for small firms such as the one tested. However due to the monotonically increasing tax advantage function, the valuation technique may become significant at higher volumes of inventory or when the holding Costs represent a large percent of total cost.

CONCLUSIONS

The purpose of this paper has not been to show the superiority of one valuation technique over another. The accounting technique used depends on other variables as well as the inflation rate. Rather, the purpose of this paper has been to show the use of the simulation model as a tool in quantifying the holding cost and tax advantage during periods of changing prices given variable demand and lead times.

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