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A comparison of inventory carrying cost in literature and in practice

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A comparison of inventory carrying cost in literature and in practice

by

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This is to certify that the Master's thesis of

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Signatures have been redacted for privacy

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CHAPTER 1: INTRODUCTION

Early Carrying Cost Calculations

Inventory carrying cost is an issue that has been talked about by people in the logistics field for seventy-five years or more.[1,2,3] One of the earliest references to carrying cost is made by Mitchell[4] in 1927. He cited the cost then as 10% for "interest on the investment, insurance, etc." An example included in his text added a storage cost of about 15%. Walter[5] proposes that this may be where the original rule of thumb of 25% originated.

Alford and Bangs

Alford and Bangs give one of the most well known early estimates of carrying costs in their production handbook of 1944.[6] This number was given as 25% and contained a 10% cost for obsolescence, 6% cost of interest, 5% cost of depreciation as well as small costs for handling, storage, taxes, insurance and transportation.[7] The categories and percentages are shown in Table 1

Alford and Bangs referred to writings by Parish[8] that stated that for stores or stocks in an industrial concern, a charge of 25% per annum of the cost of inventory is considered reasonable on active items.

Thomas

Thomas proposed a range of 19 1/2% - 26 1/2%[9] in his 1970 inventory control guidebook. His categories included the cost of money, storage space, deterioration

prevention, damage and deterioration, pilferage, obsolescence, and insurance. Thomas's highest costs are the cost of money at 10-15% and obsolescence at 5%. His percentages are shown in Table 2.

Table 1

Inventory carrying cost percentages of Alford and Bangs

Category	Percent
Storage	.25%
Insurance	.25%
Taxes	.50%
Transportation	.50%
Handling and Distribution	2.50%
Depreciation	5.0%
Interest	6.0%
Obsolescence	10.0%
Total	**25.0%**

Source: Production Handbook, Alford and Bangs, 1944, p.396-7

Lambert, et al.

Lambert and Quinn referred to inventory in a 1981 article as the largest single investment in assets of most manufacturers, wholesalers and retailers.[10] If this is true, then the accurate measure of inventory carrying costs must be important for these same

manufacturers, wholesalers and retailers. This would lead one to believe then, that these companies take great pains to compute their carrying cost to make decisions regarding holding, transporting and sale of inventories. According to Lambert and Quinn, this is not the case.[11] Their research showed that, of managers that do use carrying costs for decision making, most use estimates, textbook percentages or industry averages. They further stated that many corporations do not calculate inventory-carrying costs (ICC's) even though these costs are both real and substantial.

Table 2

Carrying cost percentages reported by Thomas

Category	Percent
Cost of Money	10-15%
Storage Space	1-3%
Prevention of Deterioration	1%
Damage and Deterioration	1%
Pilferage	Negligible
Obsolescence	5%
Insurance	1 1/2%
Total	**19 1/2-26 1/2%**

Source: Inventory Control in Production and Manufacturing, Adin Thomas, 1970, p.55

A survey conducted by the American Productivity and Quality Center (APQC) [12] in 1999 seemed to somewhat dispute Lambert's findings. This survey showed higher

awareness of ICC's. The study found that all logistics managers surveyed calculated inventory carrying cost. However, in support of Lambert it found that there was no consistent carrying cost percentage used and all used a different set of elements in calculating carrying costs. Findings by the 1993 Intermodal Index also support Lamberts' statements.[13] Survey results of the 93 Index show that 37% of traffic managers did not know what was contained in their inventory carrying costs and over 30% did not know what their inventory carrying cost percentage was. Of those managers that did know their carrying costs, most did not use it to select transportation modes and carriers.

A 1996 survey by Distribution[14] shows a trend in inventory reduction. It showed that most readers surveyed were working at reducing their inventories to some extent (see Table 3). Does it seem prudent to reduce inventory levels without knowing ones true carrying cost and what effect the reduction will have on total costs?

Lambert and Quinn[15] argued against inventory reduction without an accurate assessment of carrying costs stating that, "the magnitude of inventory carrying costs and the fact that inventory levels are influenced by the configuration of the physical distribution system demonstrates the need for an accurate assessment of inventory carrying costs to be made within the firm." They also stated that, "the arbitrary reduction of inventories in the absence of technological change or changes in the physical distribution system may actually erode corporate profit performance. The increased cost of transportation or lost sales contribution could far exceed the savings in inventory carrying costs."

Table 3

Percentage and degree of inventory reduction of Distribution magazine survey respondents.

Percent of Respondents	Degree of Inventory Reduction
12%	0-5%
23%	6-10%
13%	11-15%
10%	16-20%
4%	21-25%
9%	Over 25%
Remainder	No Response

Source: Distribution Magazine, July 1997, No.8, p.18

Lambert and Quinn make the point that "if 25% was an accurate number in 1951, how could it be accurate in 1981 when during that period, the prime interest rate has fluctuated between 3 and 20 percent?"[16] To dispute the 25% figure, Lambert and LaLonde propose a range of 14 to 43% from data received in one survey they conducted in which the cost of capital ranged from 8 to 40%.[17]

Two case studies by LaLonde and Lambert[18] in 1977 may provide additional weight for their argument. One study was of a food products manufacturer and the other study was of an industrial chemical manufacturer. Lambert and LaLonde found inventory carrying costs of 33.89% and 5.47% respectively when doing a detailed analysis of costs. If these companies were reducing their inventories based on the old standard of 25%,

they would either be cutting inventories needlessly or not cutting enough. Either way, if the goal of the organization is to have the least total cost of inventory, then its goals are not being met.

Lambert and Mentzer[19] stated in 1979 that, "accurate assessment of inventory carrying costs is essential to a variety of distribution decisions. The number of warehouses to be maintained, the configuration of these facilities, transportation and inventory policy are all affected by inventory carrying costs." They also stated that, "without an accurate assessment of inventory carrying costs, it is unlikely that a company would choose the distribution policies that would maximize profits. (Moreover), inventory carrying costs are essential if cost tradeoff analysis is to be conducted with other components (such as) cost of lost sales, transportation costs, warehousing costs and lot quantity costs."

An additional study in 1979 by Lambert and Mentzer[20] found that 68% of companies used inventory-carrying costs for finished inventory, but only 34.9% used ICC for raw materials and 28.6% for work-in-process inventories.

Porter

Another researcher that views carrying costs as hard to pin down is Porter. She states in a 1995 article that, "few corporations have the tools for quantifying real inventory cost and this ambiguity in overhead accounting makes it difficult for firms to distinguish between winning and losing enterprises." [21]

Even though it seems that a hard and fast rule for calculating inventory-carrying cost does not exist, companies are still emphasizing reduction of inventories as a primary

goal. Porter[22] comments that, "despite some inflation-related lapses into hedge stockpiling, long-term supply management emphasis remains on reducing purchased inventory." To back this up she cited the inventory to shipments ratio, which has dropped from a high of 1.95 in 1982, to an all-time low of 1.35 in 1995.[23]

Walter

Walter[24] seems to agree with Lambert and Quinn and with Lambert and Mentzer, stating in a 1999 paper that "sound costing methodology for assessing inventory carrying costs is important as academic material to be studied and applied by future generations of policy makers." In his studies, Walter found an inventory carrying cost for farm equipment dealers in Iowa to be around 14% with an approximate 12% cost of capital.[25]

Gautham

Gautham[26] recently presented his estimate of inventory carrying costs at 35%, which included a capital cost of 25%. Other costs included were insurance, pilferage and spoilage, obsolescence and deterioration, and storage and handling. Gautham's carrying cost breakdown is shown in Table 4.

Table 4

Carrying cost percentages reported by Gautham

Category	Percent
Capital Costs	25%
Insurance	1%
Pilferage and Spoilage	2%
Obsolescence and Deterioration	1%
Storage and Handling	6%
Total	**35%**

Source: Dr. Gautham, University of Houston,
Web Notes, www.uh.edu/~gsubrama/Metrics.html

REM Associates

REM Associates cited an even broader range of 15 to 55% in a 2001 article.[27] They expanded this range to 25 to 55% with the category breakdowns including cost of money, deterioration and pilferage, obsolescence, clerical and inventory control costs, warehousing, insurance and taxes. REM Associates uses a cost of money of from 6-12% and an obsolescence cost of 6-12%. Their percentages are shown in Table 5.

Table 5

Carrying costs reported by REM Associates

Category	Percent
Cost of Money	6-12%
Deterioration and Pilferage	3-6%
Obsolescence	6-12%
Clerical/Inventory Control	3-6%
Physical Handling	2-5%
Warehousing	2-5%
Insurance	1-3%
Taxes	2-6%
Total	**25-55%**

Source: REM Associates, web article, www.remassoc.com/news/ownership.htm, p.2

Lammare

Are the costs that different in all companies or are the costs just difficult to define? Are close estimates enough to get by? Lamarre states that since it is impossible to assign exact carrying costs on an item-by-item basis, managers of firms should be happy with a rough estimate of carrying costs and not look for a magic number.[28] He further states that managers can raise or lower the carrying cost percentage that they use in order to calculate the ordering quantities that achieve their goals. By using lower carrying costs than actual the firm will give higher service levels but at higher total costs. By using higher percentages the firm will have lower service levels, but at a lower cost.[29]

Lamarre[30] also gave a range of carrying cost from 15 to 43% that included capital, space, and handling costs as well as costs for obsolescence, spoilage, pilferage, damage, and insurance. His costs are shown in Table 6.

Table 6

Carrying costs given by Lamarre

Category	Percent
Cost of Capital	8-22%
Cost of Space	1-3%
Handling Cost	1-3%
Obsolescence	1-3%
Spoilage, Pilferage, Damage	3-10%
Insurance	1-4%
Total	**15-43%**

Source: Robert Lamarre, web article, Determining the Cost of Carrying Inventory, http://pws.prserv.net/cainet.rlamarr/English/magicnue.htm, p.2

Additional Authors

Other authors have stated their own percentages or ranges of percentages in which inventory-carrying cost falls. Schreibfeder listed his range as being 25 to 35%.[31] Tarr writes that inventory-carrying costs are 30% or more per year.[32]

Other estimates of inventory carrying costs were found at 40% by Marino[33], 12% by Bledowski[34], 25% by Schreibfeder[35], 36% by Bolger[36], 20-40% by Tersine[37], 30-40% by Ballou[38], and 30 to 35% from McMahon.[39]

Aggregate Data

If the assumption is made that some author's ranges are more inclusive than others, and if we use the lowest and highest range values of the four cost breakdowns, we would come up with a range of 11%-71%. The spread of these ranges tend to become alarmingly wide. How does a firm know which number to use? Does it make sense to use the old standby of 25%? Some categories were combined to make aggregation possible and the results are shown in Table 7.

The other striking difference between the four cost breakdowns is that values for individual components can vary widely. For example the cost of capital/money can vary as much as 19%. Other costs, such as obsolescence and warehousing differ at 9% and 10.75% respectively. The variances are shown in Table 8.

How can firms make decisions on inventory policy with the range of numbers proposed above? At the lowest percentage these costs would seem at least important to watch and at the highest estimates the inventory costs may even be seen as critical. Is calculating the cost of carrying inventory important to firms? If so, we would expect inventory carrying cost to be covered extensively in inventory and materials management texts.

Table 7

Upper and lower category limits of combined carrying cost ranges

Category	Percent
Cost of Capital/Money	6-25%
Warehousing/Inventory Control	0.25-11%
Handling/Distribution/Transportation	1-5%
Insurance	0.25-4%
Taxes	0.50-6%
Deterioration/Damage/Pilferage	2-10%
Obsolescence	1-10%
Total Range	**11-71%**

Table 8

Variance of individual categories of carrying costs reported by authors

Category	Percent
Cost of Capital/Money	19.00%
Warehousing/Inventory Control	10.75%
Handling/Distribution/Transportation	4.00%
Insurance	3.75%
Taxes	5.50%
Deterioration/Damage/Pilferage	8.00%
Obsolescence	9.00%

Curiously, as important as inventory carrying costs seem to be, many texts on inventory control and materials management have less than a page or two on inventory carrying costs[40,41] Ballou comments in his text that "inventory is an asset that should be carefully managed" yet only two pages of the text deal with inventory carrying costs.[42] In fact some texts have as many pages on pallets as they do on inventory carrying costs.[43]

More recently data was reported in Logistics magazine[44] that showed the inventory carrying costs for 1980, 1985 and 1990 through 1997 in relation to gross domestic product (GDP). The percentages ranged from a low of 22.2% in 1993 to a high of 31.8% in 1980. These numbers represent an aggregate inventory carrying cost for all businesses and are shown in Table 9.

Summary

It is easy to see that the opinions on inventory carrying cost ranges are varied and that the categories are open to speculation and interpretation. The importance of knowing the cost does not seem to be disputed though. Some form of cost needs to be considered in order to make decisions. What these costs may be is the challenge that firms need to face. If firms are to carry inventory there must be some advantage to offset the costs, whatever the rate those costs may be. The next section will discuss different authors views on the advantages that inventories give firms as well as a short discussion of JIT and its relevance to the topic of inventory carrying cost.

Table 9

The cost of the business logistics system in relation to GDP

[$Billion Except GDP]					
Year	Nominal GDP ($Trillion)	Values of All Business Inventory	Inventory Carrying Rate	Inventory Carrying Costs	Transport Costs
1980	2.78	717	31.8%	228	214
1885	4.18	865	26.9%	233	274
1990	5.75	1071	27.2%	291	351
1991	5.92	1060	24.9%	264	355
1992	6.24	1072	22.7%	243	375
1993	6.56	1106	22.2%	245	396
1994	6.95	1163	23.4%	272	420
1995	7.27	1249	24.9%	311	445
1996	7.64	1280	24.4%	312	467
1997	8.08	1325	24.5%	325	504

Source: National Income and Product Accounts - Levels; Survey of Current Business, March 1998. U.S. Statistical Abstract: U.S. Department of Commerce

Remainder of the Report

The remainder of this paper will be based on a literature search of articles on inventory carrying cost that will be broken down into four areas: the advantages to holding inventory (Chapter 2); the disadvantages to holding inventory (Chapter 3); the components that make up inventory carrying cost (Chapter 4); and finally a brief overview of the costing of other assets (Chapter 5). This literature search formed the basis for a survey of carrying cost practices of Iowa Manufacturers. The results of this survey are discussed in Chapter 6. An Appendix containing the survey, the survey answer

code sheet and a spreadsheet of respondents' answers is included. The sources used in this study are identified in the endnotes, included after the Appendix.

CHAPTER 2: WHAT ADVANTAGES DO COMPANIES GAIN BY HAVING INVENTORY?

Types of Inventory

First of all what types of inventories do companies have? Gattorna[45] classifies inventory as raw materials (including components and fuel), work in progress and finished goods. Depending on the type of company (excluding services), the firm will have one or all of these types of inventory.

Greene[46] divides inventory into two types: lot size and anticipation. Lot size inventories include batch deliveries to minimize order costs and to take advantage of price breaks. Also included are inventories held to take advantage of transportation efficiencies or to use full containers. He also include includes inventories produced from achieving manufacturing efficiencies (or smoothed production) in lot size inventories.

Anticipation inventories are defined by Greene as those built up to deal with variable customer demand, promotional campaigns, supply disruptions, like strikes or closings, and seasonal demands that are more economically met with smooth production rather than varying production up and down for demand fluctuations.

Why Not Just In Time?

With the emphasis today on Just in Time (JIT) manufacturing and reduction of inventories,[47,48,49,50] why don't all firms partake of the JIT method? Pease[51], a defender of inventory and a JIT skeptic, believes JIT delivery has costs that many firms don't account for. In his words "if you order your raw materials from a limited number of highly reliable suppliers for the purpose of getting 'JIT Delivery' you should honestly expect to

pay more for that. I've heard that half the trucks in Tokyo are driving around in circles half-empty, wasting time so they can show up at JUST the right minute, not early or late." He further stated, "JIT service is not free, and not necessarily cheap. Someway, somehow, you will pay for it. One traffic jam, one flat tire and your production line goes down."

About his own experiences with inventory, Pease[52] related the importance of having something on hand when customers cannot wait for you to build it to their order. He stated " .....at NSC (his company), we found customers who wanted to buy a product from stock right away, but if we had nothing in stock, they would have to buy elsewhere."

Larson[53] also cautions that JIT savings need to be offset with the higher transport costs. He advises that, "Frequent delivery of small lots will increase freight costs and decrease carrying costs. The increase in freight costs, however, may be greater or less than the corresponding decrease in inventory costs, depending on the relevant characteristics of the items being shipped."

Bernard[54] phrases it even more strongly. He states that receiving more frequently will raise handling costs and that while a decision to reduce carrying costs by receiving materials more frequently has the potential for significant cost reductions, in practice the opposite may take place, especially for companies which receive in unit loads. If the reduction in cost to finance inventory is more than offset by handling and processing costs, actual costs will increase.

Schreffler[55] commented in an article in Distribution, that the savings realized through Kanban aren't necessarily passed on to Japanese suppliers. Most of the costs,

says Schreffler, fall directly on the suppliers' shoulders. Their fear of disrupting the close relationships with suppliers, he theorizes, keeps suppliers from discussing the system's negative impacts.

John Bermudez, director of a Boston research firm, was quoted in Distribution magazine, as saying that "there is some sentiment that JIT has not done all it was supposed to do... JIT drove up [supplier] costs since inventory was being pushed back upon suppliers."[56]

Advantages of Inventory

If suppliers are holding more inventories and in turn increasing the suppliers' costs, might not these costs be passed on to the manufacturer as higher prices? If so, how much is the real savings of carrying lower or no inventories?

Porter, a JIT proponent, still admits that inventory has its uses. She commented in an article in Purchasing, that "as much as one disdains inventory, the ugly truth remains: someone must do the dirty work--someone must carry (and pay for) inventory. Agile manufacturing may be sexy, but economies of scale do occasionally intervene. She also admitted that while JIT has its merits in the cost-savings category that, "few if any firms have figured out how to produce on-demand in a cost-effective manner."[57]

If JIT is the answer for some, and others carry full inventories, what reasons do these firms have for carrying inventory? According to Arrow Electronics, "Historically inventory has been used as a buffer to allow firms to respond to unforeseen increases in demand, to help survive a hiccup by a major supplier or to allow you to build a part you

don't need while you may be waiting for parts for something you need to build now (smooth production)." [58]

Gattorna[59] adds that inventory is held to reduce the cost of purchasing. Ordering goods on a frequent basis involves both high administration and high delivery costs, as well as missed opportunities for bulk discounts and the benefits of reduced handling costs. He also adds that inventory can be used as a buffer for the variability in both supply and demand. Economies of production are also achieved by producing more than is needed at the time at a lower unit cost and holding them for later sale.

Another advantage cited in the Journal of Futures Markets by Wright and Williams[60]was termed the convenience yield. This is the peace of mind or surety of having inventory close at hand when needed. The Journal also cited increased chances for sales and repeat business as an advantage of having inventory.

Smith[61] adds that inventories can help achieve transportation economies, help maintain a source of supply and support customer service policies. He also adds that inventories can be used to meet changing market conditions (e.g., seasonality, demand fluctuations, competition), to overcome time and space differentials between producers and customers, and to accomplish least total cost physical distribution commensurate with a desired level of customer service.

Magad and Amos[62] give five reasons for firms to carry inventory

1. Improve customer service
2. Maximize ROI
3. Increase production efficiency
4. Minimize inventory investment (purchase price, order costs)
5. Improve management (easier to manage fewer shipments, receipts)

Gattorna also shows that advantages of inventory can be in the form of cost avoidance. Stock-outs can cost the firm in the form of lost business, lost production time, lost labor time, as well as the possible interruption of complex manufacturing processes. Other costs of stock-outs can include inbound parts expediting, rescheduling, costs of placing an emergency order, idle capital, extra set-ups, and the cost of boosting production after material arrives[63] Additional costs on the customer end consist of the costs with expediting a back-order, the cost of a lost sale if a customer purchases elsewhere, and the costs of a lost customer who may permanently seek another source of supply.

Moinzadeh and Ingene[64] cite another cost of stock-outs as being a loss of goodwill from customers whose orders are not met.

Examples of the cost of stock-outs can be seen in two examples in the auto industry. In 1996 a strike at two brake plants for GM[65] caused 24 other GM plants to sit idle. This consisted of 175,200 workers sitting idle as well as 26 plants. Not only was GM affected but also other plants that provide parts came to a standstill, including Caterpillar who built engines for GM, Ryder who transported vehicles and Bethlehem Steel who provided raw materials. Another example was the Ford plant shutdown in 1989, when two separate plants were shut down for one week due to parts shortages.[66] A comment by Bowman[67] in Distribution magazine states that, "the cost of inventory is not as great as the loss when it turns out you don't have it."

Mather[68] cites similar reasons for holding inventories but breaks them into five categories: Lot size, Fluctuation, Anticipation, Transportation and Obsolescence. His category of lot size includes any goods bought in batches that exceed our immediate

needs. Fluctuation inventories are held to deal with sales and production rates that are not always smooth. Anticipation inventories occur because production or buying must occur earlier than the need times. Examples of this would be plant shutdowns or sales promotions. His fourth category is transportation inventories. These are goods that are moved between factories, between distributors or between factories and distributors. His last category is obsolescence. These are basically goods that you bought or produced too much of. He claims these could be as a result of over-planning. Mather[69] states that almost all inventories are needed or created when flow rates are erratic.

Magee[70] agrees on the many of the advantages of inventories. First, inventory allows the firm to uncouple successive operations in the making of a product and getting it to the consumer. Inventory also makes it unnecessary to gear production directly to consumption. Quantity discounts can also be obtained by ordering more than you need and holding the balance. He also notes that inventory can be used for seasonal demands, smoothing of production, protect from fluctuations in demand and supply, and to build seasonal stocks for products whose sales may be high at one point in the year and low the rest of the year, boats for example, and for goods where the demand is uniform but the supply is seasonal as in some agricultural products.

Arnold[71] gives the following functions of inventory, which mirror many of those previously cited. First, inventory is built up for peak selling seasons, promotional campaigns, strikes, and vacation shutdowns. Second, having inventories on-hand can help level production. Inventory can also cover fluctuations in supply and demand. Quantity discounts can also be obtained by forward buying. Shipping, clerical and setup costs can

be reduced by buying in large lots. Lastly, he states that inventory can be used as a hedge against rising prices.

The View of Inventory as Evil

Simons comments in Forbes[72] that, "internet investors are brainwashed into thinking of inventory as an evil relic of the old economy, yet if its well managed it can be a huge plus. It enables volume buying, discounts that can boost margins, and it can be used for security for bank credit lines that are more efficient means of financing than tapping the stock or bond market."

His last point is illustrated by a comparison of two furniture retailers: old style Heileig-Meyers and new dot.com Living.com[73]. Both stores declared bankruptcy two days apart in August of 2000. Living.com went Chapter 7, effectively ending their business life, while Heilig-Myers filed for Chapter 11. The same day Heilig filed for bankruptcy they obtained a $215 million dollar credit line, primarily on the strength of their $360 million in inventory. Living.com lacked the collateral to obtain loans and selling stock for either was out of the question, so Living.com became another dot.com casualty. Simons[74] adds that "inventory isn't a magic elixir, but tangible assets can enable retailers to recover from business fumbles."

Summary

It appears there are many reasons that firms carry inventories. The most common seem to be to achieve quantity purchasing discounts, to respond to unforeseen increase in demand or decreases in supply, to smooth production flow, to avoid stock-outs and

increase sales possibilities. They are also used to achieve transportation economies, and even for convenience. Whether the savings from these aspects offsets the cost of holding is hard to determine and may be dependent upon the practices of a particular firm.

CHAPTER 3: WHY INVENTORIES ARE VIEWED AS BAD

Magnitude of Inventory

The Colorography Group[75] points to the rise of inventories as a trouble sign for the future. Figures stated in an article on their web site show that the amount of unsold inventory, measured in absolute dollars, has nearly quadrupled since 1970.

They further state that the cost of carrying and warehousing inventory has leaped by double digits during that same time period, despite declines in transportation costs. They estimate that if current trends continue, inventory and warehousing expenses could consume as much as 71% of a company's distribution budget by 2010.

A 1998 article in Transportation and Distribution[76] confirms the increase in the amount of inventory held by companies. Their numbers showed $950 billion of inventory in 1994, compared to $200 billion in 1970, with warehousing costs rising 17.6% in the same time period.

Reasons Not to Carry Inventory

Magad and Amos[77] give the following reasons against carrying inventories: increased carrying costs, less easy to respond to change, more management time needed to coordinate large inventories, reduced ROI, inventory takes up valuable space (possibly could be included as part of carrying costs), obsolescence (again a part of carrying costs), and hidden production problems.

Porter[78], a firm believer in reduced inventories, stated in an article in Purchasing, "Everybody know that inventory is bad. It ties up corporate cash and often it must be financed. Inventory must be insured. It has tax implications. It can become obsolete. It

must be warehoused, and it costs to manage and move inventory from stockroom to end-user." She also states that, "there are instances when inventory might be considered a plus, but even then the positives can be fleeting and risky."

If inventories are seen by some as necessary for firms to function efficiently, why do others view inventory as unnecessary or unproductive? If inventories are seen as bad, why are they rising?

Problems with Inventory Control

One problem cited by Magee[79] is that managers of each business function tend to think of inventories in isolation from each other's operations. Sales wants high inventories of finished goods for customer service, production wants high inventories of raw materials for long manufacturing runs to give lower per unit costs and steady employment. This in turn creates higher inventories of finished goods. Finance wants low inventories of all kinds to free up cash for use elsewhere. This conflict of goals usually leads to inventories that are higher than they need to be.

Miller[80] agrees, stating that one obstacle to lowering inventories is the traditional evaluation of purchasing managers and agents on the lowest per item cost and not the least total system cost. The striving for lowest unit cost usually leads to volume purchases that are held in inventory.

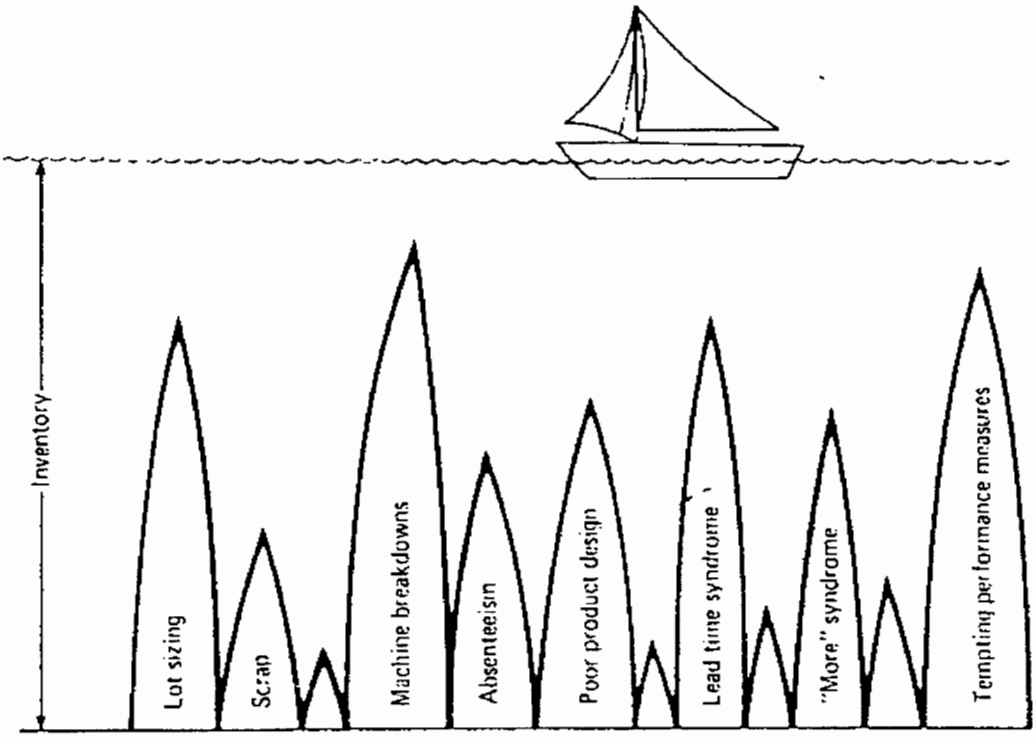
McMahon[81] attributes part of the problem to people being blinded to the cost of carrying inventory by volume purchasing and shipping savings of 3% to 4%. Special deals for volume purchases contribute to these larger inventories and in turn raise carrying costs.

Inventory as Evil

Others take an even harsher view of inventory. Mather[82] states that the ideal inventory for a plant or distributor is close to zero. He further states that, "almost all inventory can be categorized as a large adhesive bandage covering up the problems of business. This is exactly the opinion the Japanese have of it, that it is evil."

As a representation of what problem inventories can hide, Mather[83] refers to the lake analogy that states that inventory is like a lake with rocks at the bottom. The rocks represent our failures to create a smooth flow, because of problems such as lot sizing, absenteeism, scrap, machine breakdowns, lead-time syndrome, poor performance measures, poor product design, etc. As long as the lake is full, representing high inventories, the rocks are covered and the boat sails peacefully along. The cost, though, is huge inventories and inventory amplification as the rocks get bigger or smaller (see Figure 1).

An article in MnTAP Source[84] mirrors this analogy. It states that inventory is like money kept in a coffee can instead of a bank; no value is gained, as it's stored. The most likely effect of the inventory will be to hide problems and result in waste. Examples of problems that may be covered by inventory include; lengthy setups, poor quality, machine breakdowns, bad designs, unreliable suppliers, and inefficient layout.



Source: Hal Mather, How to Manage Inventories, 1984, p.142

Figure 1

Mather Lake Analogy

Costs of Carrying Inventory

Mahoney[85], a proponent of the hidden costs of inventory, includes the following as disadvantages to carrying inventory: longer lead times because of longer product runs; reduced responsiveness to changes in the market; non-detection of underlying problems in the system; overlooked quality problems; and reduced incentive to improve processes.

Greene[86] in his Production and Inventory Control Handbook refers to inventories as "non-productive assets which earn no return and which are subject to loss, pilferage,

obsolescence and taxes. Inventories exist solely to cover discontinuities in the supply demand relationship."

Advantages to Low Inventories

Alles, Amershi, Datar and Sarkar[87] posited that lower inventories force workers to think in non-routine and creative ways, and hence influence process reliability, quality and costs. They also believe that lower inventories will improve workers ability to identify and isolate the underlying causes of defective production by being able to provide instant feedback on manufacturing problems. Their research, they claim, shows that lower inventories drove quality up by forcing workers to work smarter and rethink the production process.

Summary

Inarguably there are costs to carrying inventory. These costs include the normal carrying costs such as pilferage, obsolescence, capital costs, warehousing, etc. Also included are more intangible costs such as hidden production and supplier problems, increased management time in the oversight of inventories, and reduced responsiveness to change in market conditions. That businesses need to be aware of these costs is probably easy to agree on. It may be harder to ascertain what this cost is in dollars per unit of inventory.

CHAPTER 4: COMPONENTS IN INVENTORY CARRYING COSTS ACCORDING TO THE LITERATURE

Background

The components of inventory cost are difficult to pin down with many researchers and companies adding or removing costs from those set down by Alford and Bangs in 1944.[88] The goal of this section is to form a comprehensive list of all costs that could be contained in carrying cost and then to try to define the costs contained in each component.

Alford and Bangs cost breakdowns give categories to begin with. Alford and Bangs[89] had eight categories in their analysis of inventory carrying cost; these were: storage, insurance, taxes, transportation, handling and distribution, depreciation, interest, and obsolescence.

Lambert and LaLonde[90] break inventory carrying costs into four categories that include capital costs, inventory service costs, storage space costs, and risk costs. The capital costs include both the investment in inventory and the investment in physical assets such as material handling equipment. The inventory service costs include insurance and taxes. The storage space costs include any cost attributed to plant warehouses, public warehouses, rented warehouses or company-owned warehouses (warehouses that are separate from the plant). The final category of risk costs included obsolescence, damage, pilferage and relocation costs. Relocation costs were defined as the cost associated with the transshipment of inventory from one stocking location to another.

Shell[91] breaks inventory carrying costs into 11 categories. These are warehouse rental (implicit or explicit), clerical costs of counting, insurance, security, taxes,

obsolescence, damage, theft, reduced item life, spoilage, and value of funds. These costs are mirrored by Jordan[92], whose costs include: cost of capital invested, deterioration, obsolescence, pilferage, insurance, taxes, storage, handling costs, security, space, and record-keeping.

An article by Business Solutions[93] contained the elements of capital costs, warehouse space, warehouse maintenance, spoilage, damage, transportation, and service fees (insurance, taxes and counts). The article also added some non-traditional costs to its carrying cost calculations. These included the cost of personal accidents from materials handling, and the cost of property and equipment damage from materials handling.

Bledowski [94]suggests the addition of inflation and deflation as a component of carrying costs. She asserts that if the value of inventory inflates as it is held, then this will in essence depress the carrying cost and the opposite would be true for deflation.

Fazel[95] breaks costs into the following: cost of physical storage, opportunity cost of the working capital tied up in purchased goods, taxes and insurance paid on inventory items, spoilage, and obsolescence.

An article from Shipco Wireless[96] breaks inventory-carrying costs into 3 parts: financing, warehousing and holding. Financing costs include interest that could be earned on the money invested in inventory. The warehousing costs include insurance, power (utilities), property taxes, warehouse supplies, and physical inventory counts. Holding costs include obsolescence, deterioration (spoilage), shrinkage, and scrap.

Higgins[97] adds another non-traditional cost to the list. This is the cost to prevent stock deterioration. It may be thought that deterioration prevention is included in warehouse and utility costs, but Higgins argument is that these costs will not be the same

for all firms. These costs would have to be calculated for each firm, since products differ in the amount of protection needed. Thomas[98] also adds this item to inventory costing as the cost of special packaging to prevent deterioration in storage. The cost of added equipment for refrigeration and humidity control may need to be counted if added to protect new stock items or added for additional protection of old stock.

It can be easily seen that some costs are common with all of the cited sources. Capital costs, storage costs, insurance, taxes and obsolescence are all familiar and obvious. Others like warehouse supplies, cost of accidents and damage to equipment are more intuitive. Many researchers may leave these costs out of their list because the costs may be negligible. Since our goal is to create a comprehensive list of all costs that could be included, we will include all of the mentioned costs in some form in the following discussion. Each item on the list will be analyzed in turn to establish its relevancy and methods of costing. We will use Lamberts'[99] four categories of capital costs, storage space costs, inventory service costs, and risk costs as a framework in order to group similar items together for simplicity.

The list will be as follows:

<u>Capital Costs</u>
Interest rate
Opportunity cost
Inflation
Depreciation

<u>Inventory Service Costs</u>
Taxes
Insurance

Risk Costs

Scrap

Spoilage

Damage

Obsolescence

Pilferage

Shrinkage (Deterioration)

Equipment and property accidents associated with inventory

Storage Space Costs

Warehouse space (includes)

- Material handling equipment
- Security
- Utilities
- Inventory control
- Warehouse maintenance
- Warehouse supplies

Transportation

Deterioration prevention costs

Capital Costs

Interest and Opportunity Cost

The cost of capital invested in inventories consists of two parts: first is the interest rate that would be paid to finance the inventory and second the opportunity cost or the return that could be received if the money used for inventory was invested elsewhere. Some authors use the cost of capital as one term and do not break it down into these separate parts.

Again, looking back to Alford and Bangs[100] 1944 estimate of inventory carrying cost it can be seen that the category of interest as the only capital cost category. This figure was given at 6% at that time. For the purposes of this paper, it will be assumed that this was a finance charge on the value of the inventory.

Other authors have given reference points for their cost of capital. Schreibfeder[101] uses the title of opportunity cost for all capital costs and states that the firm should use the rate that it would get if the money were invested in a more traditional investment. He suggests using the rate of treasury bills, or if the firm is financing its inventory, the interest rate that the firm is paying the bank.

Capital costs can be estimated in many ways. Lambert and Quinn[102] suggest that looking at what the money would be used for if not invested in inventory. If firms were going to pay off debt, use that rate. To buy plant and equipment, use the rate that it would cost to borrow for this.

REM Associates[103] gives a range for the cost of capital of 6%-12%. They comment that, "inventory is an asset, and should be treated as such. If an investment is made in inventory, the company should reap a return on the investment. If cash is tied up

in inventory, then it cannot be used for other investments, or the repayment of debt. If you had less inventory, what would you do with the available capital? Is the inventory investment working as well as a portfolio of the same value?" Again, they are looking at the use of the capital if money were freed up from inventory and using the rate for whatever use the firm would put it to as the capital cost.

Lamarre[104] refers to the cost of capital as the return on investment of the next most attractive opportunity, which cannot be taken advantage of because the funds are tied up in inventory. The problem is, he asserts, is that the "next most attractive opportunity" can reap a different return every day. This, Lamarre states, can make estimating the cost of capital difficult to pinpoint. That is why Lamarre's cost of capital ranges from 8 to 22% in his inventory carrying cost model.

Kostika[105] has a similar cost estimate for the capital cost. He asserts that when an organization carries inventory, it is tying up borrowed money to finance the inventory when funds could be used to generate an alternative return. The return of this alternative is the capital cost of investing in the inventory.

In other writings by Lambert and LaLonde[106] the suggestion is to use hurdle rates if capital rationing exists, and, if not, to use rates competitive with marketable securities and/or other liquid assets of the firm

James Mao is quoted by Lambert and LaLonde[107] on the use of hurdle rates for capital costs when capital rationing is present. Mao states that if we "consider a firm which pays 10% for funds that it acquires and that because of capital rationing, is currently turning down marginal investments promising annual returns of 15%. For this company the hurdle rate in investment decisions is 15%, although the cost of capital is

only 10%. Lambert and LaLonde assert that if a firm is using capital rationing, then the hurdle rate is the cost of capital for inventory carrying cost. Magee, Copacino and Rosenfield[108] also have seen firms use hurdle rates for the capital cost of inventory. These rates were reported to range from 10% to 30%.

In organizations that are not experiencing capital rationing, Lambert and LaLonde[109] suggest that "holding inventory requires capital that could be used in other corporate investments, and by having funds invested in inventory a company forgoes the rate of return that could be obtained on such investments. Therefore the company's opportunity cost of capital should be applied to the investment in inventory."

Walter[110] advises caution in the setting of hurdle rates, pointing out that according to Lambert and Mentzer, hurdle rates are often set "by management fiat." He also pointed out that setting a high hurdle rate is also one of the basic flaws in evaluating capital expenditures identified by Middlaugh and Cowen.

Piasecki[111] suggests that if firms borrow money to pay for their inventory, the interest rate would be the capital cost. If firms don't borrow, they should use the interest rate of loans on other capital items, since the money from the inventory could have been used to pay off these debts.

Bledowski[112] suggests that the rate of 90-day commercial paper be used for the cost of interest, because it is most representative of the cost of access to capital for a typical medium-sized company. Traffic Management's[113] study of carrying costs also measured capital costs of carrying inventory by using the commercial paper rate. Walter[114] seems to agree by stating that, "it may be realistic to match inventory, a short-term asset, with the costs of short-term financing."

Higgins[115] espouses an even different view from others. He states that the total cost to retain stock is only in the 5 to 10% range. He considers the cost of acquisition a sunk cost and only feels the need to use the cost of capital when acquiring new inventory, not when holding, so Higgins' cost of capital would effectively be zero.

Inflation (Change of Valuation)

What happens to inventories when we experience inflation? According to Porter,[116] "the value of inventory can appreciate if prices rise, but the reverse is also true." Horowitz[117] phrased it even more strongly by saying that inflation should be incorporated into the inventory decision system. A Bank of Canada[118] conference proceeding also commented that, "firms will benefit from inflation through inventory gains."

Burnett[119] reiterates this for firms using LIFO (Last In First Out). These firms, in an inflationary environment, will understate inventory as well as other assets. This lower cost of goods will result in a lower carrying cost. Firms using LIFO may then have to adjust carrying costs in an inflationary environment.

How much gain is unclear and would relate to the length of time a unit spends in inventory and the prevailing rate of inflation and deflation. Since most periods of valuation change involve rising prices, deflation will be considered a negligible factor for inventory carrying cost in this paper. Inflation also will not be a significant factor, except for cases of very high value inventory items that are held in inventory for long periods of time. Since most inventories do not fall into this category, inflation effects on inventory carrying costs were also considered negligible in this paper.

Depreciation

Fawcett, McLeish and Ogden define depreciation[120] in their book, Logistics Management, as "the reduction in an asset's value." Coyle and Bardi[121] talk about depreciation in a text as "when goods are held in inventory, there is a chance that they can depreciate in value because of changes in style or technology." This seems to be a very close to a description of obsolescence also.

The earliest mention of depreciation as an inventory carrying cost goes back to Alford and Bangs, who reported that cost as 5%. This charge was exclusive of obsolescence, which was given as a further 10% cost by Alford and Bangs.

Current articles and texts have little to say on depreciation as an inventory cost and may include depreciation as part of obsolescence.

Risk Costs

Scrap

Scrap is defined by Tersine[122] as "material that cannot be used in its present condition, it may be reworked to be usable or discarded if no salvage value is evident." Most texts mention scrap as part of manufacturing costs and possibly as inventory costs, but no percentages are usually given.

Scrap is also mentioned in Coyle and Bardi's[123] text but mainly as a by-product of the manufacturing process. They refer more specifically to the disposition of scrap on a timely basis to free up storage space and the disposal of hazardous material as a costly process to be managed, but do not mention scrap as an inventory cost.

A survey by Management Accounting[124] of 1000 plant managers found that the biggest cause of inventory losses and gains were misreported production counts and unreported scrap. The article pointed out that many plant managers could identify processes likely to incur scrap and encouraged the use of standardized costs to help maintain inventory accuracy.

Spoilage/Deterioration

Spoilage and Deterioration are not only a cost when they occur, but the cost of preventing spoilage and deterioration may also be included here. Thomas[125] points to prevention measures that must be taken in order to protect vulnerable inventories such as moisture proof barriers to prevent rust-receptive goods. He also mentions goods such as ice cream, liquid oxygen and dry cell batteries, all of which can deteriorate or spoil over

time. He estimates this cost at about 1% for most goods and higher for other goods such as produce or eggs.

Gautham[126] estimates spoilage costs (along with pilferage) at 2% and Lamarre included spoilage in with pilferage and damage at a 10% cost. Obviously spoilage will be a highly variable cost depending on the product held in inventory. An inventory of pea gravel and bricks will not spoil at the same rate as an inventory of apples and cabbages. One rate will simply not work for every item.

Damage

Lambert[127] suggests that damage costs should be included only for the portion of damage that is variable with the amount of inventory held. He argues that damage during shipping should not be considered a holding cost, but a throughput cost, since it will continue regardless of inventory levels. He also points out that damage that occurs at a public warehouse is usually charged to the warehouse operator if it is above a specific amount, so these also are not part of carrying costs.

Davis[128] notes that damage is identified as the net amount after claims. This refers to the amount not covered by insurance. Lamarre has estimated damage[129] with spoilage and pilferage thrown in as 10%. Thomas[130] had damage along with deterioration as 1%.

Damage to inventory can be variable, depending on its packaging, susceptibility to damage and how it is stored. An example would be an inventory of sand and coal versus windowpanes and laptop computers. The consequences of a truckload of either of these being dumped or having a water leak that floods the area where stored are completely different.

Obsolescence

Conner defines obsolescence[131] as existing when "inventory in any form cannot be used in the production process or sold to realize its cost." He further listed three causes: excessive purchases of raw materials, significant technological changes, and inadequate locator systems. By locators systems he meant that inventory had somehow become lost as a result of error or improper identification.

Lambert and LaLonde[132] give the cost of obsolescence as the difference of original cost and salvage value. They also refer to relocation costs of inventory that are expended to move product between locations to avoid obsolescence. They did note that they thought these costs were "negligible" and "in most cases…not relevant for carrying costs."[133]

Krajewski and Ritzman give another definition of obsolescence[134]. They define obsolescence as "when inventory cannot be used or sold at full value, owing to model changes, engineering modifications, or unexpectedly low demand."

Bowersox[135] refers to obsolescence, as the deterioration not covered by insurance that takes place while a product is in storage. He also expands this to include a form of marketing loss that can occur when a product becomes obsolete with respect to model or accepted customer usage. He also points out that obsolescence should be limited to only the direct loss related to the storage.

Tersine[136] offers a simpler definition. He states that, "obsolescence is the risk that an item will lose value as a result of shifts in style or consumer preference."

Simpler yet, Welch, a retired ITT executive, was quoted in Mathers [137] book as saying that "the only reason you have obsolete inventory is you made or bought too much the last time."

Bolger[138] warns that some obsolescence may not be the fault of the product involved but in how the product is marketed and sold. He points out that slow moving inventories may add more to costs than they should because they are not shown, advertised or marketed.

Obsolescence is defined in many ways, but is it a significant portion of the cost of carrying inventories? Alford and Bangs, cited earlier, gave the value as 10% of the item value for the cost of obsolescence. Mather[139] estimates the cost of obsolescence at 2%. Other authors and consultants cited in earlier sections of this paper have estimated ranges for obsolescence at higher and lower amounts. REM associates estimates obsolescence at 6-12%, Lamarre at 1-3%, Gautham at 1% (including deterioration), and Thomas at 5%. This gives a business a very broad range of numbers to choose from.

Some authors even refer to obsolescence as negligible. Mossman and Morton[140] refer in their 1965 book to obsolescence (along with deterioration) as "usually very small in comparison to the overall costs, ... In many cases, these costs are assumed to be negligible." This varies widely from the initial estimate from Alford and Bangs[141] estimate from 1925 as 10% of total cost, or 40% of total carrying costs.

Walter[142] cites that obsolescence may be more a function of marketing and promotion than of carrying inventory, and that only the magnitude of the value will increase (or decrease) with the amount of inventory, but it is not caused by the practice of maintaining an inventory.

Pilferage

Pilferage will refer to theft by employees, customers and vendors. Many authors refer incorrectly to theft as "shrinkage"[143,144,145]. (Shrinkage is explained more fully below.) Although theft (pilferage) can be a component of shrinkage (defined as unexplained loss), it is not the only component. Thomas[146] explains that the extent of loss due to pilferage depends on the industry concerned. He also notes that the supermarket industry usually budgets around 1 to 2 percent for theft, but this refers to items of direct appeal to the general public, and under particularly tempting circumstances. There should be little, if any theft in most industrial concerns, with some exceptions, so pilferage should not be a concern for calculating inventory-carrying costs.

Walter[147] found the costs of pilferage (theft) in his study of farm machinery dealers to be low or less than (0.2%). He also pointed out that even though it may be difficult to accurately gauge pilferage costs as a percentage, based on isolated incidents of theft, ignoring pilferage, as a component of carrying costs would be a mistake.

Most information from mass merchandisers, chain stores, and supermarkets support the two percent estimate of pilferage. [148,149,150] These same sources estimate that 50% of the theft is attributable to staff, with the remaining being stolen by customers. Since many manufacturers do not have customers on the premises regularly, this would probably bring the cost of theft down to the 1% mark attributed to employees. The nature of the goods in the manufacturing setting, being less attractive or marketable for thieves, may bring this percentage under 1% and more near the negligible range, mirroring Thomas' earlier information.

Lambert[151], conversely, believes that pilferage (referred to as shrinkage) costs may be more closely related to security measures than inventory. He believes that even though these costs may vary in proportion to the number of warehouse locations, all or some of these costs should be allocated to warehousing (throughput) costs and not carrying costs.

Shrinkage

Tersine[152] defines shrinkage as " the decrease in inventory quantities over time from loss or theft." Deterioration, which can also be contained in shrinkage, is defined by Tersine[153] as a "change in properties due to age or environmental degradation."

Many authors used shrinkage as a term for theft.[154,155,156,157] Brandman[158] argues that this notion of shrinkage is used incorrectly. He maintains that shrinkage is used many times as a term for unexplained losses, sometimes including theft, but that pilferage costs are there to cover theft and that shrinkage should include other unexplained losses.

Equipment and Property Accidents Associated with Inventory

This topic is not addressed in many texts but could be found in an article titled "The Real Cost of Inventory: It's Not What You Think." [159] There are accidents that occur to personnel, equipment and property as a result of carrying inventory that could increase as you carry more and more and aisles and spaces become more and more crowded. These costs could increase with volume held and may result as more than throughput operations. The logic of the inclusion of the cost of accidents to a possible set of total costs is arguably there.

Inventory Service Costs

Taxes

Taxes are most commonly assessed on the value of goods at the day of assessment.[160] Because of this many companies try to avoid paying taxes on their inventory by having a year-end sale to limit the amount of inventory on-hand at year-end.[161]

Taxes have ranged from 0 to 19% of the value of total year-end inventory depending on the state tax laws. States like Indiana, that have had very high inventory tax rates in the past,[162] put companies at a disadvantage by increasing this component of their carrying costs.

Walter[163] states in his article on inventory carrying cost methodology that "Taxes on inventory may vary by the methods and valuations established by the state or municipality imposing the tax. These variations further support the suggestion that inventory service costs for each situation be evaluated individually for differences due to industry practice and political boundaries."

Lambert[164] suggests in an article in Distribution that actual dollars spent during the last year for taxes can be calculated as a percentage of that year's inventory value and used as a guide for the percentage of costs to provide an estimate of future carrying costs.

Estimates for taxes in carrying costs were cited earlier in this work by Alford and Bangs at 0.50% and by REM Associates as 2-6%. Since the variability of taxes depends on the location of the firm's site, taxes may need to be considered by each firm individually to establish a correct percentage.

Insurance

Ballou[165] talks of insurance as being "used to protect against losses from fire, storm or theft." Thomas[166] estimated the cost of insurance at 1 1/2% as a typical figure. Alford and Bangs[167] cited insurance as costing 0.25%, Lamarre[168] chose a range of 1-4% and REM Associates[169] cites the cost at a range of 1-3%.

When a firm uses insurance costs as part of inventory carrying costs it is important that the firm only charges the remainder of uncovered losses from theft, fire or whatever else the insurance protects the firm from, to the inventory cost and not the loss covered by the insurance.

Storage Space Costs

Warehouse Space

Ballou[170] defines space costs as charges made for the use of the cubic footage inside the storage building. When rented, it is usually charged at Dollars/CWT/Month. For owned space, heat, light and fixed costs are allocated over the space used.

For some companies the warehousing cost may be one of the most difficult to assess. Gordon[171] quotes Delaney, in an article in Distribution, that "it is clear that we in business logistics do not know very much about warehousing costs." He also commented about a project that he worked on with Delaney to calculate warehousing costs that proved difficult. He said that " if Delaney, one of the industry's best researchers, had a hard time putting together his warehousing [costs], it makes one wonder whether shippers find it equally difficult to pinpoint their warehousing costs."

Conversely, Walter[172] states in an article on the carrying cost calculation of farm implement dealers that "probably the most concrete and comprehensible of the four cost categories is the cost of physical facilities used to house the inventory."

Gordon[173] quotes an executive from a private warehousing firm in his Distribution article, who comments on the lack of knowledge that some of his customers have on their warehousing costs. The executive who is approached regularly by firms who want to see his costs states that "if they want to look at our costs, they need to know what a reasonable overhead is. One guy came in and said our overhead should be 4% or 5%." The executive estimated that between 20% and 30% of the prospective customers that he sees don't know what they spend on warehousing. He goes on to say, "It's kind of

frustrating to be competing with a company-owned facility when they don't know what their costs are."

A study by the Warehouse Education and Research Center of Oxford, Ohio[174] asking 30 logistics and warehouse executives, found that more than half of the respondents had not conducted studies to analyze the merits of public versus private warehousing. In fact, of the half that does, only a cursory examination is done comparing third-party rates to the operating costs for a private facility. To illustrate their point the researchers pointed to one respondent who reported that the expected return on a 7-8 million dollar facility would only be 5%.

Speh[175], a professor of logistics at Miami University of Ohio, was quoted as saying "that companies limiting their analysis to comparing operating costs fail to address a key issue...asset utilization. ...It is important that a company identify whether the cost difference (public vs. private) is significant enough to justify investment in the facility.

Another problem with warehousing costs is the question of what costs to include. LaLonde and Lambert[176] state that only out-of-pocket costs that are related to the amount of inventory held should be included in storage costs. They further define that any warehousing costs that can be eliminated or added if a warehouse facility is deleted or added are related to throughput and must be included in the warehousing cost category and not included in carrying costs.

Kostika[177] claims that on-site storage space is fixed and that a reduction in 20% of inventory while using the same space will not reduce the fixed cost. Thomas, however, would disagree pointing out that if a store is 80 or 90% full it is easier to keep neat and

orderly and runs smoother. If it is filled to capacity and beyond, order becomes chaos resulting in lower efficiency, mistakes and damage.

So what is the estimate of these costs as a component of carrying costs? Alford and Bangs[178] estimated the cost at .25% with a 2.5% cost of handling and distribution. Thomas[179] estimates the cost of storing inventory at 1 to 3%. REM Associates[180] estimated the costs at 2-5% but if the clerical cost estimates they provide are added in this balloons to 5-11%. Lamarre[181] also arrives at the 1-3% figure for storage costs and a 1-3% cost for handling.

Transportation

Alford and Bangs[182] used a cost of 0.50% for transportation in their carrying cost. Lambert and LaLonde[183] also refer to relocation costs in their carrying costs, but do not consider inbound and outbound transportation as part of carrying cost, unless it is to move inventory to another location. If this movement of goods is because of a trade-off in warehousing and relocation costs, making it cheaper to move it to another storage location than to keep it where it is, then those charges should not be included as carrying charges.

Deterioration Prevention Costs

Although prevention of deterioration or deterioration itself is mentioned in some texts and articles, Thomas[184] is the only one to put a number to it. He estimates the cost at 1%. It may be intuitive that if special considerations are made to house inventory, for example, refrigeration, humidity control, cathodization (rust protection through electrical

grounding), etc., then those costs should be considered part of the cost of holding that particular inventory.

Prevention costs need to be determined on a firm-by-firm basis, since some products need more protection (fruits, vegetables, computer chips) and some need less (sand, gravel, coal).

Summary

Firms may include some or all of these costs in their inventory carrying cost calculation. It may be a matter of resource availability of how many they track and include in their costing formula. Capital costs are by far the most commonly cited cost, but also one of the most widely varied from author to author. Obsolescence, warehouse space and shrinkage are also topics found in many articles, although the percentages vary less widely most of the time. The costs of insurance and taxes, while both intuitive for inclusion are usually mentioned as components but not discussed in depth. It may be for two reasons that this is so: these costs vary from state to state so no firm cost can be given; and these costs are dry subject for reading and there is little a firm can do to change these costs. Other components of carrying costs such as scrap, spoilage, damage, and others are mentioned very infrequently in the literature.

CHAPTER 5: COSTING OF OTHER ASSETS

Background

Do companies charge a capital cost to other projects in the firm or is inventory the only asset charged this way? According to a survey by Timme[185] less than 5% of supply chain managers answered yes when asked if they are assessed a capital charge on inventory, warehouses, fleets, plants, etc. This seems odd when capital or interest cost seems a major part of the carrying cost calculation for a majority of researchers.

Baumol[186] suggest that other assets, mainly cash and securities, also have an opportunity cost when held. He proposes that interest on the average cash held and brokerage (transaction fee) charges on cash conversions or withdrawals should be taken into account. The opportunity cost and brokerage fees act as inputs into an EOQ type model for cash. As brokerage or cash conversion fees rise, more cash will be held, as these fees drop, so will cash balances. He further states that if there were not a need for cash balances, all earnings would be invested in other more profitable assets. Since this is not the case, the cash and securities should have an opportunity cost as well.

Miller and Orr[187] agree somewhat with Baumol that there is an opportunity cost to holding cash. Although their model differs from Baumol, the opportunity cost issue remains.

According to the Department of Treasury website[188] costs incurred when using assets is critical to their effective management. Asset costs should be used to set operational budgets and targets for management control, to monitor asset and program performance, to evaluate capital projects, and set a basis to establish prices. The site continues to add that, "The costing of assets should take place in concert with the costing

of other components of service delivery... Corporate costing systems (need) to be able to capture the costs of assets on a whole-of-life basis. This may require the ability to attribute portions of indirect and corporate overhead costs to individual assets."

The cost of assets like plant and equipment are depreciated over time. The Treasury website[189] explains depreciation of assets in this way: "Most physical assets-other than land-deteriorate with time and use. Depreciation recognizes this as a cost, even though it may not immediately incur a cash expense. In accounting terms, the use of an asset results in a progressive loss of 'service potential' and has to be recorded as a cost."

The site further describes these costs as life cycle costs and includes three components: capital costs, recurrent costs (operating costs), and salvage and disposal costs. Depreciation, it comments, should include all of these costs as well as an estimate of the expected life. The site also mentions that opportunity costs should also be included when relevant.

Summary

There is some opinion in literature both past and present that some opportunity cost should be attributed to all assets, even cash. Although there are very few articles regarding this topic, it is important to remember that if cash is not invested in profit producing enterprises then an opportunity to earn those returns is foregone; therefore there is an opportunity cost. Other assets such as plant, equipment, and supplies as well as inventory should be charged an opportunity or carrying cost if cash is invested in them.

CHAPTER 6: SURVEY METHODOLOGY AND RESULTS

Survey Background and Results

In order to evaluate if Manufacturers actually use inventory carrying cost, what value they find it to be and what items they include in inventory carrying cost, a survey was produced to garner that information by asking a series of questions applicable to their business.

The questionnaire consisted of nine questions. (See survey, Appendix A.) The questionnaire was sent to 1113 Iowa manufacturers from the Omni database consisting of over 6000 Iowa Manufacturers. Iowa manufacturers were used in hopes that a survey from an Iowa university would gain a better response. It also was hoped that the results of the survey would be more applicable to Iowa firms and therefore consistent with Iowa State's outreach efforts.

Iowa State University requires that all surveys and survey letters using human subjects be reviewed by the Human Subjects Committee. No problems were identified by the Human Subjects Committee with regards to this survey.

The number of surveys sent was limited by budgetary and analysis constraints. The 35 SIC code, which contains metal and machinery manufacturers, was chosen because of its inclusion of many agricultural implement manufacturers and like businesses . This SIC code contained 1120 possible names of which 7 were duplicate addresses, leaving a total of 1113 surveys sent. Of these 1113 surveys, 68 contained undeliverable addresses or were not applicable and reduced the net total surveys to 1045. Of the remainder, 160 responses were received, giving a response rate of 15.31%. (See Table 10)

Table 10

Response rate

Baseline	1120
Less: duplicate addresses	(7)
Less: USPS returned undeliverable	(53)
Less: deliverable but not applicable	(15)
Net Requests	1045
Responses	160
Response Rate	**15.31%**

The results will be discussed in the same order as the survey questions. Data sheets can be seen as Appendix B (Survey Code Sheet) and Appendix C (Response Spreadsheet).

The first question on the survey asked manufacturers to rank four inventory objectives from most-to-least important (1-4). The objectives were high customer service levels, minimize total cost, minimize carrying cost and reduce inventory levels. Respondent answers are shown in Tables 11 and 12. The tables are read as number or percentage of respondents who ranked each objective accordingly. For example, in Table 11, 108 respondents ranked high customer service level as their top objective and 31 people ranked minimizing carrying cost as their number two objective. In Table 12, this

is read as 70% of respondents choosing high customer service levels as their primary goal and 22% of people ranking minimizing carrying cost as their second most important objective. Not all columns will have the same number of respondents. Some respondents only answered their primary objective (14 respondents) and one respondent answered only their number one and number four objectives. Five respondents did not answer in a way that could be counted. This means there are a different number of total respondents for some categories.

Table 11

Number of respondents answering each objective for each rank

Objective	Rank			
	1	2	3	4
High customer service levels	108	20	14	10
Minimize total cost	28	69	35	10
Minimize carrying cost	8	31	63	40
Reduce inventory levels	11	19	27	81
Total respondents	155	139	139	141

Table 12

Percentage of respondents answering each objective for each rank

Objective	Rank			
	1	2	3	4
High customer service levels	70%	14%	10%	7%
Minimize total cost	18%	50%	25%	7%
Minimize carrying cost	5%	22%	45%	28%
Reduce inventory levels	7%	14%	19%	57%
	100%	100%	100%	100%

Have all of these vendors already reduced their inventory to the correct point or maybe believe they do not have too much? Question two of the survey asks, "Which of the following does your company perceive as its current inventory situation?" Respondents could answer one of three possibilities: higher than should be for our industry, in the average range for our industry, or lower than average for our industry.

Half (48%) of respondents felt their inventory is in the average range for their industry. More of the remaining respondents thought that their inventories were too high than thought it was too low. In fact, of that remaining group, 58% thought their inventory was too high. Also, 30% of the overall group thought that their inventory was too high. Table 13 shows the results of Question 2.

Table 13

Rating of inventory levels by respondents for their firm

Response	Number of respondents	Percent of respondents
Higher than should be for our industry	46	30%
In the average range for our industry	76	48%
Lower than average for our industry	35	22%

If inventory is seen as running high by almost a third of respondents, and high customer service levels and minimizing total costs also being seen as important objectives for manufacturers, it could be expected that many of these companies would use inventory carrying cost to monitor cost levels and set inventory levels for customer service goals.

Question three of the survey set out to answer this by first asking "Does your company use inventory carrying costs to make inventory purchase and holding decisions?"

A large number of respondents (82%) indicated that they do not use inventory carrying cost for their purchasing and holding decisions. This does correlate somewhat with the fact that most of the respondents chose inventory reduction as their least most important goal. The responses are shown in Table 14.

Table 14

Use of carrying cost by respondents for inventory decisions

Response	Number of respondents	Percent of respondents
Yes	29	18%
No	131	82%

The second part of question 3 asked, "If you answered Yes (you do use inventory carrying cost), what is the source of the ICC used?" The choices were as follows: calculated in-house, published standard for a particular industry, rule of thumb or other.

A large percentage, (69%), of manufacturers calculate carrying cost in-house. Seemingly this shows that, for the firms who do use carrying cost for decisions, it is important enough for them to customize their cost to their operation. All other respondents (31%) used a rule of thumb, probably the 25% as quoted from Alford and Bangs. The responses are shown in Table 15.

To determine what costs were being included in carrying costs for these manufacturers, question four contained a series of carrying costs in four categories: capital costs, storage space costs, inventory service costs and risk costs. Respondents were asked to indicate whether they included these costs in their in-house calculation. Even the respondents who used rule of thumb gave answers in this section, possibly indicating that they are using a *customized* rule of thumb and are in essence calculating something in-house.

Table 15

Method of carrying cost calculation used by respondents

Response	Number of respondents	Percent of respondents
Calculated in-house	20	69%
Published standard	0	0%
Rule of thumb	9	31%
Other	0	0%

The first section was on capital costs. This section asked respondents that calculated carrying costs in-house, to indicate what factors they include in capital costs. The choices were interest rates, commercial paper, inflation (or deflation), depreciation, and opportunity cost. If interest rate was indicated, respondents were asked what they used to calculate interest rate. If opportunity cost was used, respondents were asked to indicate how they determine it. Most respondents (79%) indicated that they use interest rates as part of their carrying cost. Of those that use interest rates in their carrying costs, 59% use bank rates to calculate this. The remainder of the section dealt with other costs that could be included in the capital cost portion of carrying costs. Commercial paper, inflation (or deflation), depreciation and opportunity cost were used by very few firms as components in their capital cost calculation. The results can be seen in Tables 16 and 17 and 18.

Table 16

Use of interest rates in carrying cost calculation

Response	Number of respondents	Percent of respondents
Yes	23	79%
No	6	21%

Table 17

Calculation of interest rate by respondents

Response	Number of respondents	Percent of respondents
Use bank rate	13	59%
Prime rate	3	14%
T-Bills	0	0%
Arbitrary	5	23%
Other	1	5%

A majority of the respondents assess some form of capital cost on their inventory. Very few of these assess an opportunity cost beyond the interest rate. As expected, only a handful included depreciation and inflation/deflation in their calculations or rules of thumb.

Table 18

Other capital costs included in inventory carrying costs by respondents

	Response			
Cost Category	**Yes**	**%**	**No**	**%**
Commercial paper	0	0%	29	100%
Inflation (or deflation)	3	10%	26	90%
Depreciation	2	7%	27	93%
Opportunity cost	3	10%	26	90%

The second section dealt with storage space costs. Respondents were asked if warehouse space cost was used for inventory carrying cost and if so, which did they use to calculate it: rent, prorated cost, or other cost. Respondents were also asked to indicate whether they used other costs in their storage costs such as material handling costs, security, utilities, labor costs and maintenance.

Most respondents (79%) indicated that they do use warehouse costs in their carrying cost calculation. Of the respondents who do use warehouse costs, many (61%) use a prorated cost. Results are shown in Tables 19 and 20. The rest of the section dealt with other components of storage costs that could be included in inventory carrying costs. The most commonly included costs were material handling costs, utilities, handling and storage, and inventory control.

Material handling equipment costs of owned equipment was included by 52% of the respondents. Utilities for storage space were only included by 45% of the respondents. This was expected to be much higher. The results are shown in Table 21

Table 19

Respondents who include warehouse space cost in inventory carrying cost

Response	Number of respondents	Percent of respondents
Yes	23	79%
No	6	21%

Table 20

Costs used to calculate storage costs by respondents

Response	Number of respondents	Percent of respondents
Rent	6	26%
Prorated Cost	14	61%
Other	3	13%

Table 21

Other warehouse costs included by respondents

Cost Category	Response			
	Yes	%	No	%
Material handling equipment (owned)	15	52%	14	48%
Material handling equipment (leased or rented)	4	14%	25	86%
Security	1	3%	28	97%
Utilities for storage space	13	45%	16	55%
Inventory control	14	48%	15	52%
Labor assigned to other activities (i.e. handling and storage)	14	48%	15	52%
Warehouse maintenance	4	14%	25	86%
Warehouse supplies	10	34%	19	66%
Transportation (to and from warehouse)	6	21%	23	79%
Cost to prevent deterioration	2	7%	27	93%

The third section of question four dealt with inventory service costs, including insurance on inventory, insurance on warehouse equipment, taxes on inventory, and warehouse property taxes. Most respondents (55%) included inventory insurance in their carrying costs and many (45%) included property taxes. Some respondents (28%) included taxes on inventory in their carrying cost. Since there is not a tax on inventory in Iowa, this begs several questions. Were the respondents including out-of-state taxes in their calculations? Did respondents misunderstand the question? Were respondents attributing some other tax to inventory?

One interesting finding is the percentage of respondents who include insurance on warehouse equipment. Although 52% of the respondents were including the cost of warehouse equipment in their calculation, only 24% include the insurance on these in their costs. Possibly they are self-insuring some of this equipment or do not have separate policies for equipment, but include it with the building and contents, so no separate costs are included. The insurance category results are shown in Table 22.

Table 22

Inventory service costs included by respondents

Cost Category	Response			
	Yes	%	No	%
Insurance on inventory	16	55%	13	45%
Insurance on warehouse eq.	7	24%	22	76%
Taxes on inventory	8	28%	21	72%
Warehouse property taxes	13	45%	16	55%

The last section of question four dealt with risk costs of inventory. These included scrap, spoilage, pilferage, obsolescence, damaged inventory, shrinkage (other unexplainable losses), safety equipment, and accidents associated with inventory. The costs most commonly included by respondents were obsolescence (48%), scrap (41%), and damaged inventory (31%). Many respondents included scrap. This may seem unusual, unless the participants in the survey are taken into account. The survey was sent

to SIC codes that included many metal manufacturers, so scrap would be a natural by-product of their processes. This may also explains the low percentage (21%) of respondents who include spoilage in their costs. Metal manufacturers would tend to have less spoilage than, for example, produce vendors or grocers.

Also, two respondents did include equipment and property accidents associated with inventory in their costs. Shrinkage and pilferage, however, were lower than expected at 14% and 10%. This may not be low, however, for manufacturing and metal-related manufacturing. The results are shown in Table 23.

Table 23

Inventory risk costs included by respondents

Cost Category	Response			
	Yes	%	No	%
Scrap	12	41%	17	59%
Spoilage	6	21%	23	79%
Pilferage	3	10%	26	90%
Obsolescence	14	48%	15	52%
Damaged inventory	9	31%	20	69%
Shrinkage (other losses)	4	14%	25	86%
Safety equipment	1	3%	28	97%
Accidents associated with inventory	2	7%	27	93%

Table 24

Measure of carrying costs used by respondents

Response	Number of respondents	Percent of respondents
Percentage of cost	24	83%
Dollar amount per unit	5	17%

Question six asked respondents to indicate their percentage of cost or amount per unit. The prices per unit were reported by three of the five respondents who used this measure. Of the three, two were in dollars per pound and the last in dollars per unit. The per-unit cost was $0.19 per unit and the two per pound were $0.35 per pound and $1.00 per pound.

There were 24 respondents who used percentage of cost for carrying costs. Twenty-two of these respondents reported the carrying cost percentage that they were using. The average (16%) and the median (14%) are well below the 25% set down by Alford and Bangs and also below the percentages given by many others in texts and journals. The ranges used by the respondents are quite wide and the percentages used quite varied. That would probably be expected more across many varied industries, but is more surprising in firms from like industries. Table 25 shows the data ranges and averages and Figure 2 shows a graph of the distribution of the different percentages.

Table 25

Carrying cost survey data

Data	Percent
Average percentage	16%
Range of percentage	1% to 60%
Median percentage	14%

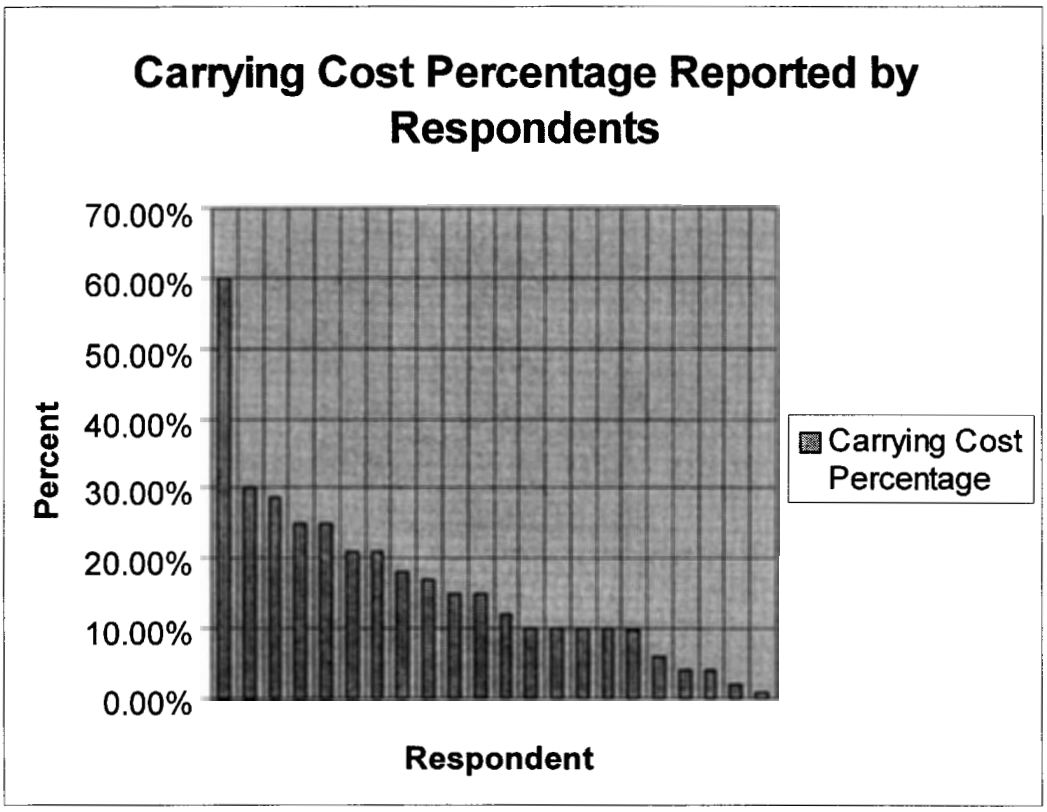


Figure 2

Question seven asked the respondents who used percentages, if they used percentage of cost, retail price, replacement cost or other. Most respondents (73%) used purchase cost as their basis of costing. Very few (8%) used retail price, which makes sense in a manufacturing setting. The results are shown in Table 26.

Question eight asked if the manufacturer had a separate capital or opportunity cost for other assets (i.e. plant, equipment, real estate, etc.). Most respondents (89%) do not use a capital or opportunity cost for other assets. The remainder (11%) did use some form of costing for other assets. Only two of these respondents gave figures for this asset cost. One response was 12% and the other was 90%. 12% seemed a reasonable capital rate, but the 90% is so far out that it must be a mistake or the question was misunderstood. It is odd that many do not use a capital or opportunity cost for other assets, unless you consider that most firms may use depreciation or some other method of costing for larger assets. The results are shown in Table 27.

Table 26

Percentage of cost used by respondents

Response	Number of respondents	Percent of respondents
Purchase cost	19	73%
Replacement cost	3	12%
Retail price	2	8%
Other	2	8%

Table 27

Capital or opportunity cost used by respondents for other assets

Response	Number of respondents	Percent of respondents
Yes	3	11%
No	25	89%

The final question in the survey asked if the firms use the revenue generated from having inventory to offset the cost of carrying inventory. Although the majority of firms do not offset the cost of carrying inventory with revenue generated by inventory (61%), the number of firms that claim to do this seems surprisingly high at 39%. Perhaps these firms believe that the additional sales that they generate from having inventory on-hand offsets the additional costs associated with carrying those inventories. The results are shown in Table 28.

Table 28

Respondents who offset carrying cost with revenue generated by inventory

Response	Number of respondents	Percent of respondents
Yes	11	39%
No	17	61%

Summary and Conclusions

According to the results of the survey, most respondents have high customer service levels as their primary objective and are least concerned with reducing inventories. Most do not use inventory-carrying costs to make decisions regarding the purchase and holding of inventory. Of those that do use inventory-carrying cost, the majority calculate it in house or use a rule of thumb. The most commonly included costs are an interest rate, based on a bank rate, warehouse space costs, either rented or prorated, material handling equipment costs, utilities, inventory control costs, labor assigned to inventory activities, insurance on inventory, warehouse property taxes, scrap, and obsolescence. Opportunity cost, pilferage, shrinkage, and spoilage, although common categories in most texts and articles, are little used in this manufacturing group.

As expected most firms used a percentage of cost for their carrying cost, but a significant enough number was using dollars per unit to make mention of it.
The range of percentages used was surprising to find within firms in a similar industry, as well as averaging below the well-known 25% figure.

Also of interest, was the number of firms offsetting inventory-carrying cost with revenue generated from holding inventory. More research into how this is accomplished would be of interest.

If what the literature says were true, the expectation would be that most firms should be trying to reduce inventories and lower carrying costs. The survey information seems to run contrary to this with a majority of the firms placing high customer service levels as their number one priority and reducing inventories less important. Are these

businesses all wrong or is the sample group one that supports customer service as most important, even at the expense of higher carrying costs?

Perhaps this explains somewhat why many of these firms are looking at customer service more closely than inventory costs. To them customer service is measurable by an unhappy customer or unfulfilled order, but inventory carrying cost can be a cumbersome and confusing calculation that even the experts can't agree on.

Since most respondents emphasize customer service over inventory costs, it could be expected that many of these firms would have higher than average inventories in order to meet customers' demands. Most expressed the opinion that their inventories were average or below average. A little less than a third did express that they thought their inventories were higher than average for the industry. This is not surprising given the emphasis on customer service. It does seem to correlate well with the earlier inventory reduction study from Distribution magazine, presented earlier in this paper, that showed almost half of the of the respondents reducing their inventory by less than 15%. [190]

Quite shocking was the abundance of respondents (82%) who do not use inventory-carrying cost to make decisions on inventory purchases and holding.
Why would so many firms ignore something that textbooks, business articles, consultants and experts all say is a major cost to control? One reason could be that although much is written on the carrying cost of inventory, much of it is conflicting or varies widely. There are few benchmarks to use and calculating it for each firm on an ongoing basis can be arduous.

Lambert and LaLonde commented in an article in the International Journal of Physical Distribution, that, " a number of authors have estimated inventory carrying cost

in the range of 12% to 35%, but there is no generally accepted methodology for determining inventory carrying costs or for that matter even a framework for developing such costs."[191]

Lambert and LaLonde stated in another article that "(it) appears that the traditional industry benchmarks for ICC are not accurate. It is more prudent for companies to actually calculate the figure that applies to their specific set of circumstances."[192]

Again this points to the task of calculating and revising a carrying cost for a business. This may be difficult or even impossible for small firms. Many of the firms in the study had 100 employees or less, which would classify the firms as small under most research definitions. This frustration and lack of accurate benchmarks may lead small firms to discount the value of using carrying costs and just stock to a level that "seems to work." Although this may lead to excess inventories and associated costs, given the emphasis on customer service found in the study, this would not be surprising.

Murphy, Daley and Knememyer[193] posed the same question in an article in Transportation Journal. They said

> Smaller businesses regularly make a variety of logistics related decisions including purchasing, customer service, warehousing, inventory management, order management, transportation, and so on. While larger organizations make these same decisions, are larger firms logistics procedures, processes, and activities necessarily applicable or even meaningful to small firms?

They also commented that large firms had one or more professionally trained people focusing on logistics where small firms don't have that luxury. They also pointed out that, "The vast majority of logistics literature is based on and geared to large companies

logistics." A further review by Murphy, et al., of scholarly literature form the years 1989 to 1999 revealed very few articles specifically focusing on small company logistics.

LaLonde[194] also was quoted in the same article as describing the general status of small companies logistics as abysmal and suggested that many small businesses have yet to embrace logistics on either a strategic or operational level. This may show a weakness in the writings of logistics in the area of inventory carrying costs. Is it possible that logistics professionals are touting the costs of carrying inventory and their importance without giving a sound framework for its calculation or overemphasizing the cost of carrying inventory so that many firms ignore the calculation and use other sets of rules to balance their stocks?

Kosta comments that, "although carrying inventory is important in generating sales, it is not always clear what the cost of inventory really is… there is no clear way to measure how much inventory really costs and how much should be carried."[195]

The survey responses by those who do calculate their carrying cost seem to support Lambert and LaLonde's assertion of calculating your cost to fit your business. Sixty-eight percent of respondents were calculating their costs in-house and 32% were using rules of thumb, most of these loosely based on their own costs. None were using industry standards, which again lends credence to Lambert and LaLonde's statements of inaccuracy in those standards.

The survey also brings to light some possible shortcomings in the carrying cost literature as it relates to these manufacturers. Although many of the traditional costs such as interest rate, warehouse cost, obsolescence, etc. are used by many of the respondents, the issues of scrap and materials handling equipment costs tend to be overlooked in many

texts and articles, while the costs of pilferage and shrinkage tend to be overstated. Most likely it is the nature of the respondents that lends itself to these differences and a more thorough survey across different business categories could shed more light on the costs that are generally used.

In this research on components of inventory carrying cost, inconsistencies were found in the terms of pilferage and shrinkage. Although these are (or should be) two separate costs, many authors treat shrinkage as theft. Shrinkage, when viewed with pilferage, should be seen as other unexplained losses, such as order errors, evaporation, leaks, etc. that are not a result of theft.

Another finding was the number of respondents (19%) who used dollars per unit as their method of calculating carrying costs. Cavinto commented in Distribution[196] that because, ".... Companies generate revenue and pay expenses in dollars, that inventory carrying cost should be expressed in dollars to better see the carrying cost as an expense coming from the company cash register." The firms that are counting their inventory costs in this fashion would probably agree. One reason that a significant portion of the respondents counted their inventory carrying cost in this fashion may again be the nature of the business. Manufacturing and metal manufacturing in particular may lend itself to counting pieces in pounds, tons, sheets or other unit measures that may be best expressed for holding purposes as dollars per pound or unit.

The percentages given by participants in the survey ranged almost as far as the estimates of carrying cost found in the literature, ranging from 1 to 60%. The average at 16%, however, was much lower than the 25% given by Alford and Bangs and the higher

estimates given by others cited earlier in this paper. Interestingly, the average is very close to Walter's finding of around 14% in Iowa farm equipment dealers.

The importance of carrying cost is not being disputed, but the magnitude of the cost may be in question. The findings of this paper, although limited in scope by geography and industry, may point to a shortcoming in the calculation of costs for textbook purposes. Perhaps more attention needs to be given to the subject of carrying costs and further developing the frameworks for calculation. It may also be noted that more emphasis needs to be put on the custom calculation of carrying costs for individual firms to take into account the unique characteristics of the firm.

The lack of firms charging a capital cost for other assets (11%), while not surprising, still points to a possible weakness in business theory. Why would firms charge an asset (inventory) a capital charge for investment and not charge other assets (plant, equipment, real estate) for their use of capital. The percentages would probably vary since the length of investment is different for each, but the use of capital is still occurring.

Finally, many respondents (41%) indicated that they use the revenue generated from having inventory available to offset the cost of carrying inventory. If true, this is very forward thinking. These firms are probably not reducing their calculated inventory carrying cost by the generated revenue, but are attributing some cash increased sales or cash flow value to having inventory on hand when customers ask for it.

There is obviously an advantage to having things in stock. Most texts do not mention a way to calculate the value of having inventory available, but are more than up to the challenge of giving the cost of having that inventory on hand. If there is no value to

having the inventory on hand, why do firms carry any? An anecdote from a book by Dadamo[197] illustrates some of the frustration of manufacturing departments.

> In all my years of experience in management and as a consultant, I have found more blame (whether justified or not) being heaped upon the Heads of Manufacturing than any other department manager. Sammy Sales can be forgiven for continually missing forecasts; Andy Accounting will get away with delayed reporting; and Eddie Engineering may never meet a budget or completion date; but it is Max Manufacturing who will be called on the carpet over the company's perceived inventory problems because inventory is his responsibility. Because the manufacturing inventory is so visible, both in financial reports and in components, parts and products, it gets spotlighted; however, the degree of the problem is often blown out of perspective.

Further study on this topic would be helpful in establishing some value to offset carrying cost owing to the availability of having inventory on-hand when customers want it.

APPENDICES

Appendix A
Survey Instrument

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

College of Business
Department of Logistics, Operations, and Management Information Systems
300 Carver Hall
Ames, Iowa 50011
515-294-8632
FAX 515-294-2534
cwalter@iastate.edu

May 22, 2001

Dear Iowa Manufacturer:

We are conducting a research study on the inventory carrying costs used by manufacturers in Iowa. Your firm was selected at random from a database of Iowa manufacturers. The enclosed survey will only take a few minutes to complete. Please pass it on to the individual in your firm most likely to have the inventory carrying cost information requested. Return the survey in the business reply envelope provided, or by faxing it to 515-294-2534. You may obtain an e-mail version of the survey by inquiring at clharms@iastate.edu with the subject line **ICC Survey**.

We assure you that absolute confidentiality of your firm's responses will be maintained, as our interest lays only in the aggregate statistical results of the survey. Since only a limited number of manufacturers are being asked to participate, your response will greatly aid the completion of this project and the validity of the results.

Thank you for your consideration. If you have any questions regarding this survey, please contact either of us at the numbers listed. We look forward to receiving your completed copy.

Sincerely,

Cory L. Harms
Graduate Student
515-294-2591
clharms@iastate.edu

Clyde K. Walter
Associate Professor
of Transportation and Logistics

Iowa State University

Inventory Carrying Cost Survey

General Instructions. Please answer the following questions as they apply to your company.

All responses to this questionnaire will be **strictly confidential**. (Only averages and ranges will be included in the published findings.) As with all Iowa State University research projects, your participation is voluntary.

Surveys can be returned by mail in the envelope provided, by fax at 515-294-2534 or by e-mail. For an e-mail copy of the survey, please send a request to clharms@iastate.edu with the subject line **ICC Survey**.

If you have any questions, contact one of the following researchers:

Cory L. Harms (515-294-2591) or clharms@iastate.edu
Clyde K. Walter (515-294-8632) or cwalter@iastate.edu

College of Business
Department of Logistics, Operations,
and Management Information Systems
Iowa State University
300 Carver Hall
Ames, Iowa 50011-2063

1. What are your firm's objectives regarding inventory?

Please rank the following four objectives in order of importance, with **1** being most important and **4** being the least important.

____ High customer service levels ____ Minimize total cost

____ Minimize carrying cost ____ Reduce inventory levels

2. Which of the following does your company perceive as its current inventory situation?

□ Higher than should be for our industry

□ In the average range for our industry

□ Lower than average for our industry

3. Does your company use inventory carrying costs (I.C.C.) to make inventory purchase and holding decisions?

□ Yes □ No If **No**, proceed to Item 10.

If **Yes**, what is the source of the I.C.C. used?

□ Calculated in-house □ Rule of thumb

□ Published standard for particular industry Other: _____

Answer the following question only if you calculate your inventory carrying costs. Otherwise, please skip to question 5.

4. If your inventory carrying cost is calculated in-house, which of the following items do you include? Mark all that apply.

Capital Costs

- ☐ Interest rate: If so, which of these do you use?
  - ☐ Bank loan rate
  - ☐ Prime rate
  - ☐ T-bills
  - ☐ Commercial paper
  - ☐ Arbitrary
  - ☐ Other: please explain: _____
- ☐ Inflation (or Deflation)
- ☐ Depreciation
- ☐ Opportunity cost. If so, how is it determined? _____

Storage Space Costs

- ☐ Warehouse space cost: Which of the following do you use?
  - ☐ Rent
  - ☐ Prorated cost
  - ☐ Other: _____
- ☐ Material handling equipment (owned)
- ☐ Material handling equipment (rented or leased)
- ☐ Security
- ☐ Utilities for storage space
- ☐ Inventory control (e.g., counts, software, etc.)
- ☐ Labor assigned to other inventory activities (e.g., handling and storage)
- ☐ Warehouse maintenance (e.g., cleaning, repair)
- ☐ Warehouse supplies (e.g., boxes, office materials)
- ☐ Transportation (to or from warehouse)
- ☐ Costs to prevent stock deterioration (refrigeration, humidity control)

Inventory Service Costs

- ☐ Insurance on inventory
- ☐ Insurance on warehouse equipment
- ☐ Taxes on inventory
- ☐ Warehouse property taxes

Risk Costs

- ☐ Scrap
- ☐ Spoilage
- ☐ Pilferage
- ☐ Obsolescence
- ☐ Damaged inventory
- ☐ Shrinkage (other unexplainable losses)
- ☐ Safety equipment needed for inventory handling
- ☐ Equipment and property accidents associated with inventory

(Over, please)

5. Do you use a percentage or dollar amount for your inventory carrying cost?

- ☐ Percentage of cost
- ☐ Dollar amount per unit (e.g., per carton, pallet, gallon, pound, cubic foot or yard, etc.)

6. Please indicate the most recent actual inventory carrying cost and whether it is a percentage of cost or an amount per unit and the units used.

_____% or $_____ per _____
unit(s)

7. If you use a percentage, is it a percentage of purchase cost, retail price, replacement cost or other value?

- ☐ Purchase cost ☐ ☐ Retail price
- ☐ Replacement cost ☐ ☐ Other: _____

8. Do you have a separate capital or opportunity cost for other assets (i.e., cash and securities, plant and equipment, real estate)?

☐ Yes ☐ No

If **Yes**, please report this rate: _____% or $_____ per _____
unit(s)

9. If you use an inventory carrying cost, do you offset this cost with the revenue generated from having inventory available?

☐ Yes ☐ No

10. Thank You for participating in this study. Would you be willing to provide additional information or be interviewed?

☐ Yes ☐ No

Summary of results. If you would like to receive a summary of the results, attach a business card or complete the section below (please print).

Name _____

Phone _____

Company _____

Fax _____

Address _____

E-mail _____

_____

_____

Appendix B
Inventory Carrying Cost Survey Code Sheet

General Instructions. Please answer the following questions as they apply to your company.

All responses to this questionnaire will be **strictly confidential**. (Only averages and ranges will be included in the published findings.) As with all Iowa State University research projects, your participation is voluntary.

Surveys can be returned by mail in the envelope provided, by fax at 515-294-2534 or by e-mail. For an e-mail copy of the survey, please send a request to clharms@iastate.edu with the subject line **ICC Survey**.

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College of Business
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Iowa State University
300 Carver Hall
Ames, Iowa 50011-2063

1. What are your firm's objectives regarding inventory?

Please rank the following four objectives in order of importance, with **1** being most important and **4** being the least important.

____ High customer service levels(1a) ____ Minimize total cost (1b)

____ Minimize carrying cost (1c) ____ Reduce inventory levels (1d)

2. Which of the following does your company perceive as its current inventory situation?

□ (A) Higher than should be for our industry (2)

□ (B) In the average range for our industry (2)

□ (C) Lower than average for our industry (2)

3. Does your company use inventory carrying costs (I.C.C.) to make inventory purchase and holding decisions?

□ Yes (Y) □ No (N) If **No**, proceed to Item 10. (3a)

If **Yes**, what is the source of the I.C.C. used? (3b)

□ (A)Calculated in-house □ (C)Rule of thumb

□ (B)Published standard for particular industry □ (D) Other: _____

Answer the following question only if you calculate your inventory carrying costs. Otherwise, please skip to question 5.

4. If your inventory carrying cost is calculated in-house, which of the following items do you include? Mark all that apply.

Capital Costs

- □ Interest rate: If so, which of these do you use? (4a) (Y/N)
  - □ (A)Bank loan rate (4b)
  - □ (B) Prime rate (4b)
  - □ (C) T-bills (4b)
  - □ (D) Arbitrary (4b)
  - □ (E) Other: please explain: _____ _____ (4b)
- □ Commercial paper (4c) (Y/N)
- □ Inflation (or Deflation) (4d) (Y/N)
- □ Depreciation (4e) (Y/N)
- □ Opportunity cost. (4f), If so, how is it determined? _____

Storage Space Costs

- □ Warehouse space cost: Which of the following do you use? (4g) (Y/N)
  - □ (A)Rent (4h) (Y/N)
  - □ (B) Prorated cost (4h) (Y/N)
  - □ (C) Other: _____ (4h) (Y/N)
- □ Material handling equipment (owned) (4i) (Y/N)
- □ Material handling eq. (rented or leased) (4j) (Y/N)
- □ Security (4k) (Y/N)
- □ Utilities for storage space (4l) (Y/N)
- □ Inventory control (4m) (Y/N)
- □ Labor assigned to other inventory activities (e.g., handling and storage) (4n) (Y/N)
- □ Warehouse maintenance (4o) (Y/N)
- □ Warehouse supplies (4p) (Y/N)
- □ Transportation (to or from warehouse) (4q) (Y/N)
- □ Costs to prevent stock deterioration (refrigeration, humidity control, etc.) (4r) (Y/N)

Inventory Service Costs

- □ Insurance on inventory (4s) (Y/N)
- □ Insurance on warehouse eq. (4t) (Y/N)
- □ Taxes on inventory (4u) (Y/N)
- □ Warehouse property taxes (4v) (Y/N)

Risk Costs

- □ Scrap (4w) (Y/N)
- □ Spoilage (4x) (Y/N)
- □ Pilferage (4y) (Y/N)
- □ Obsolescence (4z) (Y/N)
- □ Damaged inventory (4aa) (Y/N)
- □ Shrinkage (other unexplainable loss) (4bb) (Y/N)
- □ Safety equipment needed for inventory handling (4cc) (Y/N)
- □ Equipment and property accidents associated with inventory (4dd) (Y/N)

(Over, please)

5. Do you use a percentage or dollar amount for your inventory carrying cost?

□ (A) Percentage of cost (5)

□ (B) Dollar amount per unit (e.g., per carton, pallet, gallon, pound, cubic foot or yard, etc.) (5)

6. Please indicate the most recent actual inventory carrying cost and whether it is a percentage of cost or an amount per unit and the units used.

_____% (6) or $_____ per _____ (6)
unit(s)

7. If you use a percentage, is it a percentage of purchase cost, retail price, replacement cost or other value?

□ (A) Purchase cost (7)

□ (B) Replacement cost (7)

□ (C) Retail price (7)

□ (D) Other: _____ (7)

8. Do you have a separate capital or opportunity cost for other assets (i.e., cash and securities, plant and equipment, real estate)?

□ Yes (Y) □ No (N) (8a)

If **Yes**, please report this rate: _____% or $_____ per _____ (8b)
unit(s)

9. If you use an inventory carrying cost, do you offset this cost with the revenue generated from having inventory available?

□ Yes (Y) □ No (N) (9)

10. **Thank You** for participating in this study. Would you be willing to provide additional information or be interviewed?

□ Yes (Y) □ No (N) (10)

Summary of results. If you would like to receive a summary of the results, attach a business card or complete the section below (please print).

Name _____

Company_____

Address _____ Phone _____

_____ Fax _____

_____ E-mail _____

Appendix C

Response Spreadsheet

Survey #															Question Number										
	1a	1b	1c	1d	2	3a	3b	4a	4b	4c	4d	4e	4f		4g	4h	4i	4j	4k	4l	4m	4n	4o	4p	4q
001	1	2	4	3	B	Y	A	Y	D	N	N	N	N		N	99	N	N	N	Y	Y	Y	N	N	N
002	1	3	4	2	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
003	1	2	3	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
004	3	2	1	4	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
005	1	2	4	3	A	Y	A	Y	E	N	N	N	N		Y	B	Y	N	N	Y	Y	Y	N	Y	Y
006	2	1	3	4	C	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
007	4	2	3	1	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
008	1	3	4	2	C	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
009	1	2	3	4	C	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
010	1	3	4	2	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
011	1	2	3	4	B	Y	A	Y	A	N	N	N	N		Y	B	N	N	N	N	Y	N	N	N	N
012	1	2	3	4	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
013	1	2	3	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
014	1	99	99	99	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
015	1	3	2	4	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
016	1	2	4	3	B	Y	C	Y	D	N	Y	N	N		Y	B	Y	N	N	N	Y	N	N	N	N
017	1	2	3	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
018	1	2	3	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
019	1	2	3	4	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
020	3	1	4	2	C	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
021	1	3	2	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
022	1	99	99	99	99	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
023	1	3	4	2	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
024	1	2	3	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
025	1	2	3	4	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
026	1	2	3	4	C	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
027	1	2	3	4	A	Y	C	Y	A	N	N	N	Y		Y	99	Y	N	N	Y	Y	Y	N	N	Y
028	1	99	99	99	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
029	1	99	99	99	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
030	1	3	2	4	C	Y	A	Y	A	N	N	Y	N		Y	B	Y	Y	Y	Y	Y	Y	Y	Y	N
031	1	3	2	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
032	1	2	3	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
033	4	3	2	1	C	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
034	1	2	4	3	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
035	1	2	4	3	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
036	1	4	2	3	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
037	4	1	3	2	A	Y	A	Y	A	N	N	N	N		Y	C	Y	N	N	Y	Y	Y	N	Y	N
038	1	2	4	3	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
039	1	2	4	3	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
040	4	3	2	1	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
041	1	3	2	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
042	1	2	4	3	A	Y	A	Y	A	N	Y	N	N		Y	B	N	N	N	N	N	Y	N	Y	N
043	1	2	4	3	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
044	1	2	3	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
045	1	2	3	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
046	99	99	99	99	C	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
047	2	1	3	4	C	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
048	3	1	4	2	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
049	1	2	3	4	B	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
050	2	1	3	4	A	N	99	99	99	99	99	99	99		99	99	99	99	99	99	99	99	99	99	99
051	1	1	1	1	B	Y	A	Y	A	N	N	N	N		Y	B	Y	N	N	Y	Y	Y	Y	Y	N
052	1	1	1	1	C	Y	C	Y	D	N	N	N	N		Y	B	Y	N	N	N	Y	Y	N	N	N

Surv	4r	4s	4t	4u	4v	4w	4x	4y	4z	4aa	4bb	4cc	4dd	5	6	7	8	8a	9	10
001	N	N	N	N	Y	Y	N	N	Y	N	Y	N	N	A	18.00%	B	99		Y	N
002	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
003	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
004	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
005	N	N	N	N	Y	Y	N	N	N	N	N	N	N	B	10.00%	D	Y		Y	N
006	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
007	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
008	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
009	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
010	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
011	Y	Y	N	N	Y	Y	Y	N	Y	Y	N	N	N	A	21.00%	B	N		N	N
012	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
013	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
014	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
015	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
016	N	N	N	N	N	N	N	N	Y	N	N	N	N	A	1.00%	C	N		Y	N
017	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
018	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
019	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
020	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
021	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
022	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
023	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
024	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
025	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
026	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
027	N	Y	N	N	Y	Y	N	N	Y	N	N	N	N	A	2.00%	C	N		N	N
028	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
029	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
030	Y	Y	Y	Y	Y	Y	N	N	N	Y	N	Y	N	B	.19/UNIT	99	N		N	N
031	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
032	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
033	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
034	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
035	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
036	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
037	N	Y	Y	N	Y	N	N	N	N	N	N	N	N	A	28.77%	B	N		99	Y
038	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
039	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
040	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
041	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
042	N	N	N	N	N	N	N	N	N	N	N	N	N	A	10.00%	A	N		N	Y
043	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
044	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
045	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
046	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
047	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
048	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
049	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
050	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
051	N	Y	Y	N	Y	N	N	N	Y	N	N	N	Y	A	4.00%	A	N		N	N
052	N	N	N	N	Y	Y	N	N	N	Y	N	N	N	A	na	A	N		Y	N

Survey #														Question Number										
	1a	1b	1c	1d	2	3a	3b	4a	4b	4c	4d	4e	4f	4g	4h	4i	4j	4k	4l	4m	4n	4o	4p	4q
053	3	2	4	1	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
054	1	99	99	4	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
055	1	2	3	4	A	Y	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
056	1	99	99	99	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
057	1	2	3	4	A	Y	C	Y	A	N	N	N	N	Y	A	N	N	N	N	N	Y	N	N	Y
058	1	4	2	3	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
059	1	2	3	4	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
060	1	3	4	2	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
061	1	2	3	4	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
062	2	1	3	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
063	1	3	2	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
064	99	99	1	99	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
065	2	1	3	4	A	Y	A	Y	99	N	N	N	N	Y	B	N	N	N	Y	N	N	N	N	N
066	1	3	2	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
067	1	2	3	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
068	3	1	2	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
069	1	3	2	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
070	1	3	2	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
071	1	2	4	3	B	Y	A	Y	B	N	N	N	N	Y	A	Y	Y	N	Y	N	N	N	N	N
072	1	2	3	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
073	4	1	2	3	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
074	1	3	4	2	A	Y	C	Y	A	N	N	N	N	Y	B	N	N	N	Y	Y	Y	Y	Y	Y
075	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
076	1	3	2	4	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
077	1	2	4	3	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
078	1	2	4	3	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
079	2	1	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
080	1	2	4	3	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
081	1	3	2	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
082	99	1	99	99	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
083	3	1	2	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
084	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
085	99	99	99	1	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
086	2	4	3	1	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
087	2	1	3	4	B	Y	A	Y	B	N	N	N	N	Y	A	Y	N	N	Y	N	N	N	N	N
088	1	3	2	4	B	Y	A	Y	D	N	N	N	N	Y	B	N	N	N	N	N	N	N	N	N
089	1	2	4	3	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
090	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
091	99	99	99	1	B	Y	A	Y	A	N	N	N	N	Y	A	Y	N	N	Y	Y	Y	N	N	N
092	1	2	3	4	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
093	1	4	3	2	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
094	1	2	3	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
095	1	2	4	3	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
096	1	4	3	2	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
097	3	1	2	4	A	Y	A	Y	D	N	N	Y	N	N	99	N	N	N	N	Y	N	N	Y	N
098	3	1	2	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
099	2	3	1	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
100	1	3	4	2	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
101	2	1	3	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
102	1	3	2	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
103	99	99	99	99	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
104	1	99	99	99	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
105	3	2	1	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
106	1	3	4	2	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
107	4	1	3	2	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
108	1	99	99	99	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
109	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99

Surv																					
	4r	4s	4t	4u	4v	4w	4x	4y	4z	4aa	4bb	4cc	4dd	5	6	7	8	8a	9	10
053	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
054	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
055	N	N	N	N	N	N	N	N	N	N	N	N	N	A	10.00%	A	N		N	N
056	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
057	N	Y	N	N	N	N	N	N	Y	N	N	N	N	A	4.00%	A	N		N	Y
058	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
059	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
060	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
061	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
062	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
063	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
064	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	N		N	Y
065	N	N	N	N	N	N	Y	N	N	N	N	N	N	A	NA	99	N		Y	N
066	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
067	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
068	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
069	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
070	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
071	N	Y	N	N	N	Y	N	N	N	N	N	N	N	A	21.00%	A	N		N	N
072	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
073	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
074	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	N	A	15.00%	A	Y	12%	Y	N
075	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
076	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
077	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
078	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
079	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
080	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
081	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
082	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
083	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
084	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
085	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
086	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
087	N	Y	Y	Y	N	N	N	N	Y	N	Y	N	N	A	15.00%	A	N		Y	N
088	N	N	N	Y	N	N	N	N	N	Y	N	N	Y	A	10.00%	A	N		Y	N
089	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
090	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
091	N	Y	Y	N	Y	Y	N	N	Y	N	N	N	N	A	9.63%	A	N		N	N
092	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
093	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
094	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
095	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
096	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
097	N	Y	Y	Y	Y	N	N	Y	Y	Y	N	N	N	A	60.00%	A	N		N	N
098	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
099	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
100	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
101	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
102	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
103	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
104	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
105	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
106	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
107	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
108	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
109	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N

Survey #														Question Number										
	1a	1b	1c	1d	2	3a	3b	4a	4b	4c	4d	4e	4f	4g	4h	4i	4j	4k	4l	4m	4n	4o	4p	4q
110	1	3	2	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
111	1	2	4	3	B	Y	A	N	99	N	Y	N	N	Y	A	Y	N	N	Y	N	N	Y	Y	Y
112	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
113	1	3	4	2	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
114	2	3	4	1	B	Y	A	Y	A	N	N	N	N	Y	B	N	N	N	N	N	N	N	N	N
115	1	99	99	99	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
116	1	2	4	3	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
117	99	99	99	99	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
118	2	3	4	1	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
119	1	99	99	99	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
120	1	2	4	3	C	Y	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
121	4	2	3	1	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
122	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
123	1	2	4	3	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
124	1	2	3	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
125	4	2	1	3	B	Y	C	N	99	N	N	N	Y	N	99	Y	N	N	N	N	Y	N	Y	N
126	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
127	1	2	3	4	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
128	1	3	2	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
129	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
130	2	1	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
131	2	1	3	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
132	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
133	1	4	3	2	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
134	1	2	4	3	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
135	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
136	1	3	2	4	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
137	4	1	2	3	C	Y	C	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
138	1	3	2	4	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
139	1	2	4	3	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
140	1	2	3	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
141	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
142	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
143	1	2	4	3	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
144	1	2	3	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
145	1	2	3	4	A	Y	A	N	N	N	N	N	N	Y	C	N	N	N	N	N	N	N	N	N
146	2	3	1	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
147	4	1	3	2	A	Y	A	Y	A	N	N	N	Y	Y	B	Y	Y	N	N	Y	Y	N	N	N
148	1	3	2	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
149	2	1	3	4	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
150	1	4	3	2	99	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
151	3	1	4	2	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
152	2	4	3	1	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
153	3	1	2	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
154	2	1	4	3	99	Y	A	Y	A	N	N	N	N	Y	B	Y	N	N	Y	N	N	N	N	Y
155	99	1	99	99	C	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
156	1	3	2	4	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
157	1	4	2	3	A	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99
158	2	1	4	3	A	Y	A	Y	B	N	N	N	N	Y	B	Y	Y	N	N	Y	Y	N	Y	Y
159	2	3	1	4	C	Y	A	Y	A	N	N	N	N	Y	A	N	N	N	N	N	N	N	N	N
160	99	99	1	99	B	N	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99

Surv																					
	4r	4s	4t	4u	4v	4w	4x	4y	4z	4aa	4bb	4cc	4dd	5	6	7	8	8a	9	10
110	99	99	99	99	99	99	99	99	99	99	99	99	99			99	99		99	N
111	N	Y	Y	Y	Y	Y	N	Y	N	Y	N	N	N	B	NA	A	N		N	Y
112	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
113	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
114	N	Y	N	N	N	N	N	N	N	N	N	N	N	B	1.00/#	A	N		Y	N
115	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
116	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
117	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
118	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
119	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
120	N	N	N	N	N	N	N	N	N	N	N	N	N	A	25.00%	A	N		N	Y
121	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
122	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
123	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
124	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
125	N	N	N	Y	N	N	Y	N	N	Y	N	N	N	B	$/UNIT	99	N		Y	N
126	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
127	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
128	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
129	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
130	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
131	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
132	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
133	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
134	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
135	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
136	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
137	N	N	N	N	N	N	N	N	N	N	N	N	N	B	35/#	A	Y	90%	N	Y
138	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
139	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
140	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
141	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
142	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
143	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
144	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
145	N	Y	N	Y	N	N	N	N	Y	N	N	N	N	A	6.00%	D	N		N	N
146	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
147	N	Y	N	N	N	Y	N	N	Y	Y	Y	N	N	A	30.00%	A	N		N	Y
148	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
149	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
150	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
151	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
152	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
153	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
154	N	N	N	Y	N	N	Y	N	Y	N	N	N	N	A	17.00%	A	N		N	N
155	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	Y
156	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
157	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N
158	N	N	N	N	Y	Y	Y	N	Y	N	N	N	N	A	25.00%	A	N		Y	Y
159	N	Y	N	N	N	N	N	N	Y	N	N	N	N	A	12.00%	A	N		N	Y
160	99	99	99	99	99	99	99	99	99	99	99	99	99	99		99	99		99	N

Appendix D
Question Analysis

Question 1 Valid Responses

Ranking of firms objectives regarding inventory

	1	1	2	2	3	3	4	4
High customer service levels	108	69.7%	20	14.4%	14	10.1%	10	7.1%
Minimize total cost	28	18.1%	69	49.6%	35	25.2%	10	7.1%
Minimize carrying cost	8	5.2%	31	22.3%	63	45.3%	40	28.4%
Reduce inventory levels	11	7.1%	19	13.7%	27	19.4%	81	57.4%
Total	155	100%	139	100%	139	100%	141	100%

139 answered completely
1 answered 1 and 4
15 answered 1 only
2 answered all 1's and were not counted
3 answered in an incorrect manner and were not counted
160

108 (69.7%) of respondents chose high customer service levels as their primary goal. Of that group 63 out of 108 (58.3%) rated minimizing total cost as their next most important goal. 28 out of 108 (25.9%) rated minimizing carrying cost as their next most important objective. 10 (10%) did not answer a next most important objective. 7 (7%) chose reduction of inventory sas their next most important objective

Of the 108 respondents who chose high customer service levels as their primary objective 60(55.5%) chose reducing inventory levels as their least important objective

28 (18.1%) of respondents chose Minimizing total cost as their primary objective. Of that group 13 (46.4%) chose high customer service levels as their next most important objective. 7 (25%) chose minimizing carrying and 6 (21.4%) chose inventory reduction as their next most important objective

Of the 22 respondents who chose minimizing total cost as their primary inventory objective, 15 (53.6%) chose reducing inventory as their least important objective. 4 (18%) chose high customer service levels and 3 (14%) minimizing carrying cost as their least important objectives. 1 (4%) did not answer least important.

8 respondents (5.2%) chose minimizing carrying cost as their primary objective.

2 respondents indicated all 4 goals were of primary importance.

5.2% of repondents chose minimizing carrying cost as their primary inventory objective

7.1% chose reducing inventory levels as their primary objective

57.4% of respondents chose reducing inventory as their least important objective regarding inventory

28.4% of respondents chose minimizing carrying cost as their least important inventory objective

Question 2

Which of the following does your company perceive as its current inventory situation?

Higher than should be for our industry	A	46	29%	157 answered correctly
In the average range for our industry	B	76	48%	3 did not answer
Lower than average for our industry	C	35	22%	
		157	100%	160

Question 3a

Does your company use inventory carrying costs (I.C.C.) to make inventory purchase and holding decision

Yes	29	18.1%	160 answered correctly
No	131	81.9%	
	160	100%	

Question 3b

If Yes, what is the source of the I.C.C. used? 29 responded correctly

Calculated in-house	20	69%
Published standard for particular industry	0	0%
Rule of thumb	9	31%
Other	0	0%
	29	100%

Question 4
If your inventory carrying cost is calculated in-house, which of the following items do you include?

	Include			
	Yes	23	79%	29 responded correctly
Interest Rate	No	6	21%	
		29	100%	

How is intetest rate calculated?

Bank Rate	13	59%	22 responded
Prime rate	3	14%	1 gave no answer
T-Bills	0	0%	
Arbitrary	5	23%	
Other	1	5%	
	22	100%	

Commercial Paper	**Include**			29 answered correclty
	Yes	0	0%	
	No	29	100%	
		29	100%	
Inflation (or Deflation)	**Include**			
	Yes	3	10%	29 answered correclty
	No	26	90%	
		29	100%	
Depreciation	**Include**			
	Yes	2	7%	29 answered correclty
	No	27	93%	
		29	100%	
Opportunity Cost	**Include**			29 answered correclty
	Yes	3	10%	
	No	26	90%	
		29	100%	

Warehouse space cost	**Include**					29 answered correclty
	Yes	23	79%			
	No	6	21%			
		29	100%			
	Which of the following do you use?					22 answered correctly 1 did not answer
	Rent			67	80%	
	Prorated cost			14	17%	
	Other			3	4%	
				84	100%	
Material handling equipment (owned)	**Include**					29 answered correclty
	Yes	15	52%			
	No	14	48%			
		29	100%			
Material handling equipment (rented or leased)	**Include**					29 answered correclty
	Yes	4	14%			
	No	25	86%			
		29	100%			
Security	**Include**					29 answered correclty
	Yes	1	3%			
	No	28	97%			
		29	100%			
Utilities for storage space	**Include**					29 answered correclty
	Yes	13	45%			
	No	16	55%			
		29	100%			
						29 answered correclty
Inventory control	**Include**					
	Yes	14	48%			
	No	15	52%			
		29	100%			
Labor assigned to other inventory activities (e.g., handling and storage)						
	Include					29 answered correclty
	Yes	14	48%			
	No	15	52%			
		29	100%			
Warehouse maintenance	**Include**					29 answered correclty
	Yes	4	14%			
	No	25	86%			
		29	100%			
Warehouse supplies	**Include**					29 answered correclty
	Yes	10	34%			
	No	19	66%			
		29	100%			

Transportation (to and from warehouse)	**Include**				29 answered correclty
	Yes		6	21%	
	No		23	79%	
			29	100%	
Cost to prevent deterioration	**Include**				29 answered correclty
	Yes	2	7%		
	No	27	93%		
		29	100%		
Insurance on inventory	**Include**				29 answered correclty
	Yes	16	55%		
	No	13	45%		
		29	100%		
Insurance on warehouse equipment	**Include**				29 answered correclty
	Yes		7	24%	
	No		22	76%	
			29	100%	
Taxes on inventory	**Include**				29 answered correclty
	Yes		8	28%	
	No		21	72%	
			29	100%	
Warehouse property taxes	**Include**				29 answered correclty
	Yes		13	45%	
	No		16	55%	
			29	100%	
Scrap	**Include**				29 answered correclty
	Yes		12	41%	
	No		17	59%	
			29	100%	
Spoilage	**Include**				29 answered correclty
	Yes		6	21%	
	No		23	79%	
			29	100%	
Pilferage	**Include**				29 answered correclty
	Yes		3	10%	
	No		26	90%	
			29	100%	
Obsolescence	**Include**				29 answered correclty
	Yes		14	48%	
	No		15	52%	
			29	100%	
Damaged inventory	**Include**				29 answered correclty
	Yes		9	31%	
	No		20	69%	
			29	100%	
Shrinkage (other unexplainable losses)	**Include**				29 answered correclty
	Yes		4	14%	
	No		25	86%	
			29	100%	

Safety equipment needed for inventory handling

Include		29 answered correclty
Yes	1	3%
No	28	97%
	29	100%

Equipment and property accidents associated with inventory

29 answered correclty

Include		
Yes	2	7%
No	27	93%
	29	100%

Question 5
Do you use a percentage or dollar amount for your inventory carrying cost? 29 answered correclty

Percentage of cost	24	83%
Dollar amount per unit	5	17%
	29	100%

Question 6
Please indicate the most recent actual inventory carrying cost

Average of Percentage	16.11%	23 answered correctly
Range of Percentages	1%-60%	2 did not answer
Median	13.50%	
Dollar amount per unit	2 answered per pound	4 answered correctly
	2 answered per unit	1 did not answer

Question 7
If you use a percentage, is it a percentage of purchase cost, retail price, replacement cost or other va

Purchase cost	19	73.1%	26 answered correctly
Replacement cost	3	11.5%	3 did not answer
Retail price	2	7.7%	
Other	2	7.7%	
	26	100%	

Question 8
Do you have a separate capital or opportunity cost for other assets (i.e., cash and securities, plant and equipment, real estate)?

Yes	3	11%	28 answered correctly
No	25	89%	1 did not answer
	28	100%	
If **Yes**, please report this rate:		12% respondent 74	2 answered correctly
		90% respondent 145	1 did not answer

Question 9
If you use an inventory carrying cost, do you offset this cost with the revenue generated from having inv available?

Yes	11	39%	28 answered correctly
No	17	61%	1 did not answer
	28	100%	

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