INVENTORY PRACTICES OF FLOUR MILLING FIRMS

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ABSTRACT

The logistical function of inventory management has greatly changed greatly over the last few decades. Historically, inventories have been used to manage production and were considered a necessary component of doing business. However, with recent developments such as Just-In-Time (JIT) and Electronic Data Interchange (EDI), this perception is changing. In addition, issues such as transportation modal choice, plant location, and transit characteristics impact inventory management. In this study, a set of four mail surveys were sent to flour milling firms in the United States to measure how firms were reacting to these trends and issues.

Results indicated some confusion in the industry regarding EDI. There was strong agreement from respondents that EDI will continue to grow in importance but its benefits are not well understood. There also appeared to be differences in the industry regarding preferred supplier programs, with some firms indicating close relationships with all of their customers while other firms reported no close relationships with customers. In addition, there were some interesting comparisons between rail and truck transportation relating to inventory management. Transit characteristics were examined to look at rail and truck efficiencies. Finally, reported inventory carrying costs appeared to be extremely low in the industry. Accurately measuring carrying costs is important due to the large financial investment inventories represent.

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CHAPTER 1. INTRODUCTION

The logistical function of inventory management has greatly changed over the last few decades (Loar, 1992). In the 1950s, firms typically utilized excess inventories to manage material and production flows. This was due to the relatively low cost of money during that era. It was cheaper for firms to maintain large buffer stocks to guard against uncertainties and defective products than it was to actively manage inventories. However, by the mid-1970s, interest rates had risen to a point where it became necessary to implement closer controls because of the large financial investment inventories represented. In addition, information technology had progressed enough so that data were increasingly available and affordable. Better data reduced variance and uncertainty, minimizing a major justification for large inventory investment (Loar, 1992).

As the cost of money rose and remained relatively high, firms became increasingly concerned about asset productivity (Loar, 1992). A direct consequence of the increased cost of money was higher inventory carrying costs. Carrying costs are those that "...result from storing, or holding, goods for a period of time..." (Ballou, 1992). The three major groups of assets are fixed assets, labor, and inventory. Since inventory is the easiest to change, there has been increased management emphasis.

While too much inventory is an obvious problem, not enough causes other serious problems. Stockouts can be extremely costly, not only because of reorder and other administrative costs, but also due to lost sales and customer dissatisfaction. The challenge for managers is to coordinate the overall logistical system so the optimal amount of inventories are maintained.

Firms that practice effective inventory management can gain significant advantages over competitors that do not actively manage inventories. The costs of excessively large inventories drain needed capital from other areas of a business. Ballou estimates that inventories cost 20 to 40 percent of their average value per year. In addition, inventories account for 16 percent of U.S. gross national product (Ballou, 1992).

Poorly managed inventories also can mask quality deficiencies which result in lower customer service and create an atmosphere that allows management to avoid integrating the supply channel. However, some holding of inventory may offset uncertain demand, allow instantaneous service, reduce transportation costs, and insulate the system from unplanned shocks (Ballou, 1992).

The function of inventory management is being affected by three important trends in logistics. Probably the biggest trend in business during the last decade has been the focus on quality initiatives. These include Total Quality Management (TQM), process re-engineering, ISO 9000 quality programs, and close buyer/seller relationships. The underlying purpose of all these initiatives is to improve customer service while reducing costs. An important inventory concept associated with the quality trend is Just-In-Time (JIT) processes. The goal of JIT is to eliminate waste and inefficiency (Robeson and Copacino, 1994). Not surprisingly, the elimination, or at least minimizing of inventories is one of the first things targeted when JIT is implemented in a firm.

A second trend affecting logistics and inventory management is the evolution of information technology. This is related to quality initiatives in that improved information is a necessity when implementing new programs such as JIT. Improvements in information technology allow firms to integrate internal functions and communicate better with external suppliers and customers. The result of these improvements is "to trade information for inventory" (Robeson and Copacino, 1994).

Finally, in recent years there has been a significant trend toward increased supply chain management. Firms are attempting to manage information throughout the supply chain to reduce uncertainty and decrease cycle times (Miller and Dooley, 1995). Partnerships, or close buyer/seller relationships, are becoming more common as managers realize the benefits of working closely with other firms are greater than those of traditional adversarial relationships (Boyson, Mierzwa, Salton, and Thornton, 1995).

In addition, there are two divergent philosophies about how inventory should be managed. These philosophies are the quantity-based method and scheduling method. Each one is appropriate for certain types of products and processes. The quantity-based method replenishes inventories based on specific needs, while the scheduling method replenishes inventories based on forecasted needs. The quantity-based method often is used with relatively low value, high volume items, while the scheduling method is appropriate for high value, custom made items. With the trends and new ideas affecting inventory management, firms should be looking to combinations of the two approaches to maximize their strengths.

While the trends and philosophies previously described are important to all industries, their effect on particular sectors remains unclear. One particular sector is the agriculture processing industry. This industry is the focus of the remainder of this study.

The agriculture processing industry, specifically the wheat milling segment, must deal with certain characteristics that make their industry unique. One of these characteristics is the seasonality of inputs, such as wheat. Since all wheat is harvested within a relatively short period of time, storage of raw materials is necessary somewhere within the supply chain.

Similarly, due to the inherent uncertainty of the wheat crop regarding quality and quantity, significant price fluctuations often occur. As a result, buying strategies are sometimes developed to purchase wheat at its lowest possible price throughout the year and store it until needed for production requirements. When this type of approach is used, it becomes necessary to realize the tradeoffs between purchase price and carrying cost of wheat.

Another industry characteristic is the impact caused by changing political agendas and foreign trade agreements. This can significantly change the demand for wheat and flour, resulting in uncertainty for millers. Finally, location can impact how a flour mill does business. An origin mill, or one close to raw materials, differs greatly from a destination mill, or one close to final customers. Origin mills have an advantage in that they are not dedicated to one particular region or market. However, they are at a disadvantage when it comes to transportation costs and service due to longer shipping distances. These advantages and disadvantages must be weighed when deciding where to locate a new mill (Wilson, 1995).

Objective

The objective of this research was to determine how current logistics trends were affecting inventory policies within the flour milling industry. Specifically, the results of this research benchmark current inventory management practices and important trends within flour milling and was accomplished through a literature review, expert interviews, and a survey of firms.

Information is provided that allows managers to assess their inventory performance against other firms within the flour milling industry. Their opinions on current trends regarding inventory management, usage of tools such as electronic data interchange (EDI), inventory policies within the industry, and an analysis of carrying costs within the industry all are included. Analysis of the data was done based on industry standards and included usage of tools such as economic order quantities (EOQ), inventory carrying cost levels, and effects of preferred supplier programs.

Justification

The main justification for this research is to develop a method that can be used to improve inventory management policies. With the recent and rapid evolution of quality programs, firms are undoubtedly at different stages in their progression of these programs. Firms may be using inventory systems which are not consistent with firms quality initiatives. With increased competition both domestic and worldwide, firms must be aware of every aspect within their business and be looking for ways to improve them. This research would be valuable to firms in the industry because it would allow them to compare their performance and development with similar firms in the milling industry. In addition, it would provide progressive firms with the opportunity to achieve a competitive advantage over rival firms with respect to inventory management by implementing tools and practices not being used by other firms in the industry.

Report Organization

The report is divided into four remaining chapters. A literature review which summarizes current philosophies of inventory management, along with impacts of technology and metrics used to measure the effectiveness of inventory policies is described in Chapter Two. The survey instrument is described in ChapterThree. In Chapter Four, empirical results of the survey are presented, and conclusions and study summary are presented in Chapter Five. For a summary of characteristics of the wheat milling industry, refer to UGPTI Staff Paper No. 129 (Barber and Titus, 1996).

CHAPTER 2. LITERATURE REVIEW

In this chapter, inventory management methods currently in practice are reviewed including quantity-based and scheduling methods. In addition, new trends and tools that are being incorporated into traditional approaches, including JIT and information systems, are considered. Storage considerations with respect to inventory management are briefly discussed. Finally, measures that are used to evaluate the effectiveness of inventory management methods are examined.

Current Inventory Philosophies

Inventory management policies for the inbound flow of raw materials are designed around two basic philosophies. These are the quantity-based or reactive method, also referred to as the pull method, and the scheduling or push method. While these represent polar opposites, many firms utilize combinations of the two approaches. Each method has individual strengths and weaknesses and is appropriate for managing different types of materials or products. A brief comparison of the two methods follows in Table 2.1.

Table 2.1. Comparison of Quantity Based and Scheduling Inventory Management Methods.

Item	*Quantity Approach (Pull)*	*Scheduling (Push)*
Characteristics	1. Reactive or pull method	1. Schedule used to determine requirements
	2. Inventory is used as a buffer against uncertainty	2. Materials may arrive JIT or from inventories
	3. Priority is to maximize output	3. Priority is to coordinate flow of materials
	4. Demand may be lumpy or irregular	4. Demand is reasonably known
Usage	1. Usually used for relatively low value items	1. Usually used for high value, custom made items
	2. Can be used with minimal information	2. Requires some information processing
Weaknesses	1. Requires higher levels of inventory than scheduling methods	1. Not as simple to implement and operate as quantity methods
	2. There is little coordination among business functions	2. Requires more precise management control

Adapted from Ballou, 1992.

Quantity-based methods

The quantity-based method was first developed when information processing was a labor-intensive manual task. This method utilizes a pull or reactive approach where replenishment orders are introduced when inventory levels fall below a predetermined amount (Closs, 1989). This concept is derived from inventory being “pulled” through the production process. Forecasted demand is used to determine the reorder point and target inventory levels. A significant characteristic of this method is the priority to maximize output using economies of scale. Historically, inventory has been considered a necessary component of the production process because it creates a buffer when demand is volatile and provides a buffer between production stages, or steps, to help maintain production when machine breakdowns occur.

Products that are seasonal in demand or not available for subsequent selling periods are good candidates for this type of inventory management approach. Examples include Christmas toys, daily newspapers, and perishable foods. Unfortunately, demand is usually difficult to predict with certainty and results in either too much or not enough inventory. The Economic Order Quantity (EOQ) formula is often used to determine the amount of a single order. The EOQ formula is based on the concept of tradeoffs between production setup costs and inventory carrying costs (Ballou, 1992).

The pull method is often used with relatively low value items. In addition, it can be employed with minimal amounts of information. One weakness sometimes associated with the pull approach is the greater amounts of inventory it requires to function effectively. However, when JIT is implemented in a pull system, inventories are often minimized at the expense of greater information. Finally, there is often little coordination among business functions when the pull method is used in a non-JIT environment.

Scheduling Methods

An alternative to quantity-based inventory management methods is scheduling, which relies on the use of schedules to plan purchasing and production. Requirements may be obtained from inventories, similar to quantity-based methods, or arrive when needed in the production process (Ballou, 1992). This is accomplished utilizing a technique known as Materials Requirements Planning (MRP).

Requirements scheduling has been used for decades, but MRP was formalized in the mid-1970s. Since it is a push system, or one in which materials are “pushed” through the production process, MRP is usually used to schedule high value custom-made items with fairly predictable demand (Ballou, 1992). An example is the demand for expensive parts that are needed in the final assembly of an end product. Demand for these parts is derived from the demand of the end product. The goal is to eliminate inventories of these parts because of the high carrying cost associated with them. However, since derived demand is inherently lumpy or irregular, it is often necessary to maintain a minimum safety stock to protect against this uncertainty. Another important consideration in using MRP is lead time variability. Lead times with high variability result in materials arriving either before or after they are needed in the production process. This creates unnecessary holding costs or late penalty charges (Ballou, 1992).

The idea of MRP II sprung from the original concept of MRP in the last decade. MRP II, often referred to as second generation MRP, actually stands for manufacturing resource planning. This is important because MRP II extends the boundaries of MRP to include a broad scope of functions within a firm. It not only manages material requirements, but also other resources that are allocated to production. Additional areas affected by MRP II include "purchasing, capacity planning and master scheduling, as well as inventory and production planning" (Kessler, 1991).

Although MRP II is an impressive tool when used properly, there are some considerations that must be addressed for it to function effectively. First, the functions within a firm must be integrated. They must agree on what is being produced and in what quantities. Often, organizational boundaries are crossed when these decisions are being made. Second, stringent data requirements are needed for MRP II to function properly. Errors in data can be magnified greatly by the process. Finally, it is extremely important that feedback from the process is monitored regularly. Information that is shared among functions can help to reduce errors, especially with lead times (Kessler, 1991).

International Business Machines Corporation (IBM), a strong proponent of MRP II, believes that it will continue to evolve into a more complex process. They feel it is part of a trend of computer integrated manufacturing (CIM). CIM utilizes computer technology to interconnect manufacturing processes throughout an organization, even on a world-wide scale. This trend is justified by three considerations (Kessler, 1991):

1. The emergence of new information technology. This includes faster, more integrated computer systems and improved software.
2. A philosophy that business functions must integrate with each other rather than manage themselves separately and adversely impact one another.
3. Increasing competitive pressures throughout the world that emphasize increased quality.

While it may prove to be a major investment for a firm, MRP II can reap impressive benefits. Some firms have been able "to reduce inventory levels by 65% - or more - using MRP II" (Kessler, 1991).

Sometimes too much is expected when an MRP II system is implemented. There may be a misconception that the system is able to completely manage business functions without much input from human managers. In some instances, companies feel they have been short-changed by going through the time and expense of implementing an MRP II system (Mozeson, 1991).

One item that is very important to the operation of an MRP II system is inventory accounting. Problems occur when physical inventories differ from the amount that is stated in the system. The MRP II system gets blamed for discrepancies when it is usually a human error that caused the problem. Every transaction that occurs with regard to material movements must be recorded in the system to keep it accurate. Someone should be responsible for each activity within the system to ensure its reliability and accuracy (Mozeson, 1991).

Unfortunately, people may lose sight of the real purpose of the system. It should be treated as a tool and not a cure-all for an organization's problems. One advantage of a good system is its ability to manage large amounts of information. For example, the system may be able to schedule thousands of stock-keeping-units (SKUs), but it may not be necessary or efficient. There may be better ways to design the process and it is important to realize that the system is only as good as the people operating it. An MRP II system can often provide enhancements in many areas, including inventory management, that with good management can assist in improving the business processes (Mozeson, 1991).

Combined Methods

Many firms use a combination approach of quantity-based and scheduling, utilizing the strengths of each method. Items that are fairly homogeneous may be produced using the quantity-based method while other items which are more unique and costly may require an MRP type method. In some cases, when JIT is implemented, a hybrid method will result which incorporates strengths of both methods in the same process (Bowman, 1991).

Another method has recently been developed by Cornell Professors Joseph Thomas and John McClain, and Auburn University Assistant Professor Charles Sox. The goal of their method is to maximize customer service while minimizing inventory expense. Their philosophy is “stock your high-demand products, but give them low production priority. Do not stock products for which demand is unpredictable, but give these non-stock items high production priority” (Perkins, 1994). This method has been used successfully by some electronics, cosmetics, and sandpaper companies. Some of the characteristics and benefits of this method are as follows:

1. The method eases customer service stresses caused by full JIT methods, by maintaining adequate inventory of high-demand items and giving non-stock items production priority.
2. It reduces excessive inventories by only stocking high demand items with predictable demand.
3. Factories that are operating at near capacity can prioritize better, without having to upgrade to new, more flexible, equipment.

While this method does have benefits, it is not without drawbacks. It must rely on customers' willingness to wait some period of time for their order. This is acceptable for most firms because it is common for orders to be filled by a certain time period. Regardless, Thomas, McClain, and Sox believe that maintaining some inventory is necessary to provide good customer service. What their method strives to do is meet today's tougher competitive standards without incurring unbearable costs (Perkins, 1994).

Influences of JIT and Kanban

JIT is a philosophy of continually striving to eliminate waste while improving quality. The goal of JIT is to make sure the right item arrives at the right place at the right time. It became popular in the 1980s with improvements in information technology and greater organizational integration and coordination. JIT relies on close buyer-seller relationships rather than adversarial relationships that historically have been prominent. These relationships are important because good communication and information exchange are necessary to operate a JIT system. The results of a JIT system are greater efficiencies, process improvements, and ultimately higher customer service (Robeson, 1992). According to Bowman (1991), the JIT philosophy is based on eight factors (Table 2.2). Bowman emphasizes that these factors relate to all types of products and do not require a computer to implement. The only distinguishing factor is that anyone who wants to implement JIT must be committed to improving their processes.

Table 2.2. Fundamentals of JIT

Factor	***Description***
1. Products should be designed for economical production.	The design of new products should strive to reduce unnecessary complexity. Simpler products are cheaper and easier to produce.
2. Plant layouts should facilitate "flow" manufacturing.	New plant layouts should focus on reducing or eliminating material movements. This results in significant lead time savings.
3. Create employee driven quality programs.	Programs that involve employees allow them to contribute their knowledge about the manufacturing process to eliminate waste.
4. Improve data accuracy	This is extremely important because inaccurate data will cause the system to fail.
5. Reduce paperwork	Processes documented on paper are obsolete and should be available on-line.
6. Reduce scrap	Scrapped parts consume labor, material, and capacity. Scrap is when a part must be thrown out or possibly recycled, but it is not fit for use in production. It is important to remember that the cost of a scrapped part is more than the value of a good part because of the resulting costs. These include reordering, remanufacturing, and reduced customer service.
7. Reduce inventories	Excessive inventories not only carry unnecessary costs, but also cover-up quality problems. Developing good relationships with suppliers is crucial to accomplishing this task.
8. Strive for continuous improvement in all areas of the firm	Goals should be set and when they are attained should be improved on more.

Adapted from Bowman, 1991.

Since JIT is inherently a pull system, it can work quite well with quantity-based methods. A firm must become committed to reducing its reliance on inventories and be more focused on improving processes.

There has been much debate on how effective JIT and MRP are together. Confusion occurs because MRP is a push system while JIT is a pull system. However, this is not as important as it may initially appear. It is important to remember that MRP is a method for planning a manufacturing firm's resources while JIT is a philosophy about achieving manufacturing excellence by reducing waste and improving quality (Bermudez, 1991). Table 2.3 offers a comparison of JIT scheduling versus supply-to-inventory scheduling.

Table 2.3. Comparison of JIT and Supply-to-Inventory Scheduling.

Factors	***JIT Scheduling***	***Supply-to-Inventory Scheduling***
Inventories	Considered inefficient and efforts are made to eliminate them. Includes work-in-process inventory.	Considered a necessary requirement. Protects against uncertainties and quality problems.
Lot sizes and purchase quantities	Meet only immediate needs. A minimum amount determined by the EOQ formula is desired.	Quantities are determined by the EOQ formula or by economies of scale.
Setups	They are insignificant due to the rapid changeover required of a JIT system. Quick setups allow greater manufacturing flexibilty.	They are not a priority since the goal is to maximize output.
Vendors or Suppliers	A close relationship must be maintained and sharing of information must occur. The entire supply chain should be treated as one entity.	Often, adversarial relationships exist and finding a supplier with the lowest cost is the goal.
Quality	Defects are not tolerated.	Some defects may exist so quality costs are not exceedingly high.

Adapted from Ballou, 1992.

The role of inventory is a major difference between the two approaches. JIT considers inventory inefficient while supply-to-inventory scheduling relies on it as a necessary component. For JIT to accomplish reductions in inventories, the production process must be flexible. In addition, close relationships must be maintained throughout the supply chain to ensure smooth operation. Finally, quality is emphasized as defects greatly impact the close tolerances within the process that are required for JIT to succeed.

Supply-to-inventory scheduling greatly differs in its approach. The goal is to maximize output, so flexibility and quality is usually not emphasized. Also, adversarial relationships often exist with suppliers in an attempt to minimize costs.

Methods that utilize MRP or MRP II have been used effectively in conjunction with JIT. In many cases, firms that implement JIT are already advanced in their use of MRP II, in fact it may be necessary. Bowman (1991) described how Hewlett Packard changed their method to a pull system in 1983 and subsequently produced a video to teach viewers about the benefits that this method produces. However, what the tape really depicts is that the benefits are not the result of the pull system, but rather the reduction of lot sizes. It is emphasized “that if you manufactured in lot sizes of 1 in a 'flow' environment, you probably couldn't tell whether you were 'pushing' or 'pulling', nor would it matter” (Bowman, 1991). The kanban system was originated in Japan by Toyota as a just-in-time scheduling method. Although it draws many similarities with JIT, kanban is a more simplistic tool to implement and use. “Kanban is a simple, mechanistic tool for tightly linking a material use point with its source” (Schonberger, 1993). Kanban uses a set of cards to instruct various components of the supply chain when to order and deliver the correct materials. The benefits of kanban are reduced lead times, low setup costs, and small order quantities which result in lower inventories (Ballou, 1992).

The Role of Information Systems

The flow of information has become a vital component to the operation of an effective inventory management system. In recent years, new information technology has made initiatives such as JIT and MRP II possible. These new technologies provide a means to more accurately track the flow of materials, "substituting information for inventory" (Robeson and Copacino, 1994). The reason is "the cost of information has been declining relative to other expenses such as land, labor, and capital" (Robeson and Copacino, 1994). A good information system allows firms to maintain lower levels of inventory .

Barcoding

Barcoding has become popular due to its accuracy and speed. It entails the use of a scanner operated by a worker and universal product code (UPC) symbols on products. Trends have shown that nearly 80 percent of companies are now using barcoding for almost all products that move through their system (Robeson and Copacino, 1994).

Electronic Data Interchange

An important component of information systems is electronic data interchange (EDI). Electronic data interchange is a format that links organizations and computer systems. The "purpose of EDI is to eliminate duplicate data entry and to improve the speed and accuracy of the information flow by linking computer applications between companies" (Robeson and Copacino, 1994). A key characteristic of EDI is that it is intended to be a computer-to-computer link that does not require human interpretation, thereby reducing data entry errors and time caused by multiple entry (Robeson and Copacino, 1994). Another characteristic of EDI is that it requires some type of computer system to operate it.

EDI is used for two primary purposes: to improve customer service and to improve the efficiency of the logistical system (Robeson and Copacino, 1994). Examples of EDI usage include the processing of freight bills, purchase order processing, and to enhance Just-In-Time (JIT) systems. In addition, inventory reduction is often possible with the use of EDI (Robeson and Copacino, 1994).

Computer Software Used in Information Systems

Computer software is a key component in any information system. Many types of software exist for virtually all business functions. Areas that have grown rapidly in recent years are MRP and computer integrated manufacturing (CIM) software. This market segment is predicted to generate revenue of over $2 billion in 1995 (Industrial Engineering, 1991). While most MRP II systems are essentially similar, software has to be tailored to each individual firm. Types of hardware, size of the system, and functionality determine what type of software package is needed. As more firms continue to implement MRP II and better information systems, the demand for better software packages will grow.

Four factors will influence information system software development in the future (Industrial Engineering, 1991). First is the continued integration of business functions throughout an organization and the supply chain. The growing importance of JIT is the second factor influencing software development. The third factor is hardware compatibility. Finally, shifts in hardware usage from mainframes to mini and microcomputers as smaller machines become more powerful will influence software development of information systems. While computers will continue to become an even more important component of inventory management, the costs of these systems should drop and the capabilities improve (Industrial Engineering, 1991).

A new type of software is finite-capacity-scheduling (FCS) which is used to enhance MRP systems with regard to scheduling. Many managers do not understand how to fix scheduling problems, but FCS software helps production planners solve problems by coordinating resources such as manpower, machinery, and materials. While MRP tells a manager what is needed, it assumes there is infinite capacity and does not recognize constraints. Finite-capacity-scheduling software is a planning tool that is designed to handle some of these problems. Many companies have noticed significant cost savings after they have implemented FCS software. For example, Crescent Manufacturing Company, a firm in Ohio that produces 600 different products, already operated in a JIT system but they scheduled manually. Benefits of adding an FCS package included “reducing lead time from 60 to 30 days, reducing inventory by 30 percent, and cutting setup time by at least 20 percent” (Stevens, 1994). Other benefits firms noticed with FCS were improved customer service and increased production capacity (Stevens, 1994).

Storage Concerns

Obviously, the types of materials needed for production and finished output has a major effect on storage requirements for a firm. There are four basic reasons for maintaining storage space (Ballou, 1992).

The first reason for maintaining storage space is to reduce transportation and production costs. The added expense of maintaining extra storage space and the associated inventory may be offset by improved transportation and production efficiency. Coordination of supply and demand is the second reason for maintaining storage space. Products with highly seasonal demand and production require warehousing to store either raw materials or finished goods. The added cost may be offset by allowing firms to purchase commodities at cheaper prices throughout the year. A third reason is to assist in the production process, since some products may require aging before they are ready for sale. Finally, the fourth reason is to assist in the marketing process. Warehousing finished goods may improve customer service by reducing delivery times and variability of lead times (Ballou, 1992).

While maintaining some storage space may be an important aspect of a firm's business processes, too much results in inefficiency and unnecessary costs. Problems associated with too much storage capacity with regard to inventory management may include duplication of inventories and high in-transit inventories (Ballou, 1992).

Evaluating Inventory Management Effectiveness

The role of logistics has grown considerably over the last decade in both importance and scope. As this has occurred, performance measurements of the logistical system have changed as well (Caplice and Sheffi, 1995). Inventory management is one component of the logistical system. As such, it should be evaluated within the scope of the system rather than an isolated department or function (Caplice and Sheffi, 1995).

The primary goal for a measurement system is to guide managers into better decision making (Caplice and Sheffi, 1995). “A measurement system, therefore, should be more than a disparate assortment of individual metrics; it must be cohesive, comprehensive, and complementary” (Caplice and Sheffi, 1995). One major problem associated with many measurement systems is that there are too many performance measures. Some are obsolete, while others are not consistent with the objectives of the system. Also, while new measures are added to the system, obsolete ones are rarely removed (Caplice and Sheffi, 1995).

The entire logistical system should be evaluated within the context of six criteria (Caplice and Sheffi, 1995). Table 2.4 summarizes these criteria.

Table 2.4. Summary of Evaluation Criteria for Logistical Systems.

Criterion	***Description***
Comprehensive	The measurement system captures all relevant constituencies and stakeholders for the process.
Causally Oriented	The measurement system tracks those activities and indicators that influence future, as well as current, performance.
Vertically Integrated	The measurement system translates the overall firm strategy to all decision makers within the organization and is connected to the proper reward system.
Horizontally Integrated	The measurement system includes all pertinent activities, functions, and departments along the process.
Internally Comparable	The measurement system recognizes and allows for trade-offs between the different dimensions of performance.
Useful	The measurement system is readily understandable by the decision makers and provides a guide for action to be taken.

Adapted from Caplice and Sheffi, 1995.

For these six criteria to work effectively, they should be used collectively to transform a measurement system. In fact, the entire approach to logistics management often needs to be changed as well (Caplice and Sheffi, 1995). Traditionally logistics, including inventory management, has been viewed as an expense center. However, three realizations in recent years have changed that idea. These three realizations are "logistics output is not standard, logistics adds significant value to customers down the supply chain (not just costs), and logistics service level is a critical component of customer satisfaction" (Caplice and Sheffi, 1995).

The overall implication for inventory management, when part of a logistics system described above, is that it should be managed in conjunction with other logistical components. Managers must realize that their management practices must change, rather than just measurement techniques (Caplice and Sheffi, 1995).

The most common way that firms currently evaluate their inventory management policy is by comparing the monetary costs of the system against the service levels that are required to do business. To accomplish this effectively, managers must often look at the system as a whole rather than focusing on individual items. Four methods are commonly used to measure the aggregate inventory policy (Ballou, 1992). These are the turnover ratio, ABC product classification, inventory-to-demand relationships, and total investment limit.

Turnover Ratio

The turnover ratio, or inventory turns, may be the most common method to measure the aggregate inventory policy. This is due to the simplicity of the formula and readily available data used to calculate the ratio. It measures the ratio of annual sales at cost by average inventory investment,

$$Turnover\ Ratio = \frac{Annual\ Sales\ at\ Inventory\ Cost}{Average\ Inventory\ Investment} \tag{2.1}$$

The turnover ratio is valuable because it is possible to control inventory investment by specifying a ratio and varying inventory with sales levels. Since turnover ratios can be applied to specific product classes as well as the entire inventory, comparisons can be drawn for each product class. Unfortunately, due to its simplicity, problems occur when sales rise because inventory levels should rise at a lower rate due to economies of scale (Ballou, 1992). It also does not work particularly well with seasonal items due to variation in demand throughout the year.

ABC Product Classification

ABC analysis is a valuable tool because it allows managers to stratify products into groups. Undoubtedly, a firm that carries many different products will experience different sales levels for each product. This disproportionate effect is often referred to as the 80-20 principle. The premise behind this principle is that roughly 20 percent of the products will generate 80 percent of sales. Products are divided into three classes based on sales volume. High moving products are classified as A items, B items are medium, and slow moving products are C items. Utilizing this scheme, different inventory methods can be assigned to each group, thus reducing overall inventory investment. A items are stocked due to their high turnover, while C items may be produced to order (Ballou, 1992).

One weakness of ABC classification is that there is not a definite method to assign products to appropriate categories. Similarly, there is no objective way to determine the correct number of categories to use. Another weakness of ABC classification is C items are often discontinued. Although a product may be a slow mover and therefore classified as a C item, it may have a high profit margin. Also, carrying C items may be necessary to maintain existing customers and attract new ones. Finally, C items may complement A items.

Inventory-to-Demand Relationships

The inventory-to-demand relationship is a method to determine how much inventory should be in the system as demand changes. One way to accomplish this is to use the square-root rule,

$$I_T = I_i\sqrt{n} \tag{3.2}$$

This formula calculates the optimal amount of inventory to stock, I_T, from the amount of inventory, I_i, at each of n locations. It assumes that each location carries the same amount of inventory (Evers and Beier, 1993).

Total Investment Limit

This method places a monetary limit on the amount of inventory that can be carried by a firm. When the average inventory value for all items exceeds the limit, order quantities are reduced to decrease the inventory levels and meet the monetary limit. Firms also may use promotional tools such as sales to reduce finished goods inventory (Ballou, 1992).

Inventory Carrying Costs

Inventory carrying costs are those costs incurred from storing or holding a product and are roughly proportional to the average quantity of product on hand (Ballou, 1992). Inventory carrying costs should represent only those that vary with quantity of inventory and can be split into four groups: space costs, capital costs, inventory service costs, and inventory risk costs (Ballou, 1992). Of these four costs, capital costs represent the largest proportion, possibly upward of 80 percent (Table 2.5).

Capital costs should reflect a firm's opportunity cost of capital, or the rate of return that could be achieved by using the money in another venture (Lambert and Stock, 1993). The hurdle rate, or the minimum rate of return on new investments, should be used for firms that are experiencing capital rationing (Lambert and Stock, 1993). Even low-risk projects may be expected to achieve an after-tax return of 10 percent. Since all inventory carrying cost components must be stated in before-tax numbers along with other costs such as transportation and warehousing costs, capital costs may be close to 20 percent, assuming a 50 percent tax rate (Lambert and Stock, 1993).

Assuming capital costs are approximately 80 percent of inventory carrying costs, the total cost is around 25 percent.

A more conservative approach to calculating capital costs is to use the prime interest rate or the interest rate at which a firm can borrow money (Ballou, 1992). Using this method, the capital cost should still be close to 10 percent. This translates into a total inventory carrying cost of at least 12 percent.

Table 2.5. Inventory Carrying Cost Elements.

Element	*Relative Percentage*
Interest and opportunity costs	82.00%
Obsolescence and physical depreciation	14.00
Storage and handling	3.25
Property taxes	0.50
Insurance	0.25
Total	***100.00%***

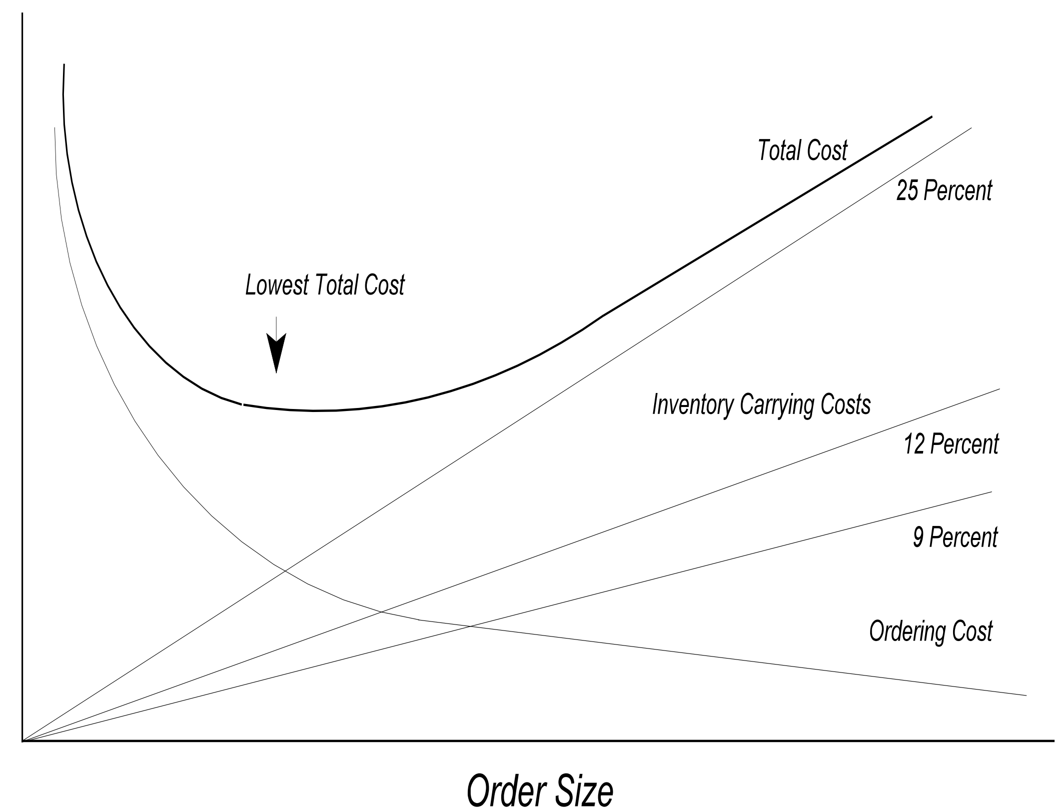
Adapted from Ballou, 1992.

To minimize the total logistical cost in an organization, tradeoffs must occur between activities. Attempting to reduce the cost of each activity in the organization may actually increase the total cost of logistics (Lambert and Stock, 1993). Size of order quantities (EOQ) and inventory carrying cost is one such tradeoff. A firm's ordering costs include "the cost of transmitting and processing the inventory transfer; the cost of handling the product if it is in stock, or the cost of setting up production to produce it, and the handling cost if the product is not in stock; the cost of receiving at the field location; and the cost of associated documentation" (Lambert and Stock, 1993).

When estimated carrying costs are extremely low, the economic order quantity is relatively large because it costs less to order and store large amounts of product than it does to order smaller amounts more frequently. However, if the actual inventory carrying cost is actually larger than the estimate, total costs are not minimized (Figure 2.1).

Figure 2.1. Trade-Offs Between Order Cost and Inventory Carrying Cost.

Adapted from: Lambert, Douglas M. and James R. Stock. Strategic Logistics Management. 3rd ed. Boston, Massachusetts: Richard D. Irwin, Inc., 1993., 409.



Other Methods

Firms may use other methods to measure performance based on inventory levels. One of these is investment in inventory as a percentage of all assets. Similar to the total investment limit, this method is used to determine how many resources a firm has committed to maintaining inventories.

According to the literature, the area of inventory management offers managers an opportunity to introduce new ideas and technology in an attempt to reduce costs and improve production processes. In this chapter, current inventory management methods in practice were reviewed, including trends and tools that are being incorporated into traditional methods. Storage considerations with respect to inventory management also were discussed. Finally, traditional measures that are used to evaluate the effectiveness of inventory management methods were examined. In the following chapter, a survey is introduced that incorporates the trends and philosophies discussed in this chapter.

CHAPTER 3. RESEARCH METHODS

In this chapter there are two main sections, data collection and data analysis. The data collection section is further broken down into a discussion of survey group selection, survey design, survey pretesting, and mailings. A summary of response rates to the survey is also included in this section (Table 3.1).

Data Collection

To gain a better understanding of how firms in the flour milling industry are conducting their inventory management policies, data were collected with four mail surveys (Appendix A). Each survey was sent to the appropriate manager at each U.S. mill to gather current information and determine their opinions about future prospects. Once the data were collected, analysis was done and comparisons drawn about the mills to determine the optimal inventory policy for the flour milling industry. The surveys and analysis will be discussed in the following sections of this chapter.

Survey Group Selection

Surveys were mailed to a census of wheat flour milling plants in the United States. Currently, there are 208 flour mills in the country. Addresses for these firms were obtained from the Milling and Baking News 1996 Annual Directory. Firms operating multiple mills were sent one survey for each plant. This was done to determine if there was any variation among mills operated by the same company.

Survey Design

The survey was a mail questionnaire consisting of 36 questions. These questions were divided among four main topic areas covering the overall theme of inventory management in the flour milling industry. Initially, each of these topic areas were incorporated into one large survey.

However, after review by industry experts, the survey was divided into four smaller questionnaires. This was done to allow the appropriate individuals to answer questions in their area of expertise, and also to minimize the time any one person had to look at the survey. The four surveys were logistics/transportation, president/CEO, marketing, and plant. All four surveys were of a combination of open-ended and closed-ended questions.

The logistics/transportation survey was the largest, totaling 15 questions, was designed to be answered by the logistics expert in the firm. The first part of the survey was devoted to questions about metrics, or measurements, used to evaluate inventory policies. Included were questions regarding carrying cost, turnover ratios, and return on investment. The purpose of this section was to determine the historical progression of the inventory management system.

Two questions in the logistics/transportation survey examined inventory policies with respect to bulk and bagged products, and account size. Respondents were asked to indicate relative importance for large or small buyers of six inventory policies to determine driving forces in the industry regarding inventory policies.

The next section of the logistic/transportation survey looked at the inventory management system for outbound materials, including if flour is produced for inventory or directly to order and where the produced flour is stored. The final section was four questions concerning electronic data interchange (EDI). Specifically, questions were asked concerning EDI and computerized scheduling systems. The main goal of this section was to gain insight about how widespread the use EDI and other technologies were, and their compatibility with each other.

The president/CEO survey consisted of seven questions, with five of the questions offering participants the opportunity to provide their opinions concerning present inventory policies and how they will be impacted in the future. These questions were presented in a scaled format and included a range of five choices for each particular question. The main purpose of this section was to determine how managers feel about the role of inventories in their business and changes they think may occur in the future. Specifically, questions were asked about inventory management progression in the industry, the role of information, and close buyer/seller relationships. The final two questions concerned how and where firms are managing their inventory issues.

The marketing survey consisted of eight questions concerning flour products, customers, and EDI. Two questions compared the number of flour related products or stock keeping units (SKU's) that firms produce in 1996 compared to five years ago. Also, questions were asked about involvement in preferred supplier programs. The final three questions in the marketing survey concerned EDI and its impact on inventories in the industry.

The plant survey asked questions concerning each plant in an organization. Included were questions about number of employees, mill capacity, age of the mill, and the distance primary markets were from the mill. Also included was a question asking how the firm managed inventory functions. The purpose of this section was to be able to differentiate mills into groups and determine if there were correlations among these groups.

The last page of each survey provided space for respondents to include other comments they had regarding the survey. A cover letter was included with the surveys to briefly outline objectives of the study. In addition, postage paid return envelopes were enclosed.

Pretest

A pretest was conducted with two industry experts to evaluate readability and content of the surveys. Roger Dunning, General Manager of the North Dakota Mill, pretested the entire set of questions and made suggestions regarding the appropriate managers to direct particular questions. Bob Gale, a former transportation manager familiar in the flour milling industry, provided feedback on the content and wording of questions. Questions were dropped, added, or modified after reviewing their comments. Their input also was used to break down the entire set of questions into the four surveys.

Sampling Method

Initially, mailings were sent to every flour milling firm and plant in the United States according to the Milling and Baking News 1996 Annual Directory.

Mailings

All surveys were mailed during the week of Jan. 8, 1996. A total of 218 sets were sent, broken down into three groups. The first group consisted of 10 sets of surveys sent to the corporate headquarters of major milling firms in the United States. Each set of surveys sent to these companies consisted of a CEO/president, marketing, and logistics/transportation survey. The second group consisted of 91sets of surveys which were sent to each individual milling company in the country. All firms in this group operate only one plant and were sent copies of all four surveys. Finally, the third group of 117 plants were sent copies of the plant survey. Each member of this group is a plant operated by a multiple plant firm. A total of 101 logistics/transportation, marketing, and president/CEO surveys were sent. In addition, 208 plant surveys were mailed.

Eight of the plant surveys were returned as undeliverable. The response rate for all four surveys from the first mailing was 18 percent (Table 3.1). While the response rate for the plant survey was relatively good (25 percent), response rates for the other three surveys was only 13 percent. In addition, only one of the 10 largest firms in the industry responded to all four surveys. Therefore, results of the study reflect small to medium sized firms in the flour milling industry.

Table 3.1. Summary of Survey Response Rates.

Survey	*Number Sent*	*First Mailing*	*Second Mailing*	*Total Received*	*Percent Response*
Plant	208	59	6	65	31.3
CEO/President	101	15	6	21	20.8
Marketing	101	15	6	21	20.8
Logistics/ Transportation	101	14	6	20	19.8
TOTAL	511	103	24	127	24.9

In an attempt to improve the response rate, 21 randomly selected firms were contacted by phone five weeks after the first mailing was conducted. Of these, five indicated they were not interested in responding to the surveys. The remaining 16 firms were mailed a second set of surveys the week of Feb. 19, 1996.

To test for non-response bias, paired *t*-tests were conducted. This was accomplished by splitting the sample of respondents into two groups based on when their surveys were received. Respondents from the first mailing were put into one group and respondents from the second mailing were put into a second group. A paired *t*-test compared differences in the means for 61 questions from the entire survey for these two groups. Only one question had a difference statistically different from 0 at the 95 percent confidence interval. This indicates non-response bias in our sample.

Data Analysis

Data were entered in the Microsoft Excel spreadsheet program. As surveys were returned, they were entered into the spreadsheet by survey type. Once the data were ready to be analyzed, the spreadsheet was sorted by survey type to develop a list of responses for each survey. The data was analyzed using the statistical software package SAS. Statistics computed included means, frequencies, and paired *t*-statistics. Paired *t*-tests were used to compare if the means of two groups of observations are equal. This is a valuable technique when comparing responses to see if responses are the same between groups.

In addition, the Aitchison-Silvey model was used for selected questions to rank responses. This model utilizes a logistic regression and works well ranking responses from questions that use a numeric scale. A brief description of the Aitchison-Silvey model is presented in Appendix B. The following chapter describes in detail empirical results from the surveys.

CHAPTER 4. EMPIRICAL RESULTS

In this chapter, results of the survey are presented and the chapter is divided into sections by survey type. Included is a discussion of the overall results, in addition to analysis by firm characteristics and location factors.

Overall Survey Results

Four mail surveys were used to measure the inventory policies of flour mills in the United States (See Appendix A for copies of the survey). These surveys were directed toward the president/CEO, marketing manager, logistics/transportation manager of each firm, as well as every plant manager. Only one of the first three surveys were mailed to each firm but a plant manager survey was mailed to each plant in every organization. Firm responses were representative of mainly small to medium sized organizations in the industry. Results are not reflective of the largest firms in the industry who may be managing inventories quite differently than smaller organizations.

President/CEO Survey

The president/CEO survey consisted of seven questions which measured opinions regarding current trends and policies affecting inventory management. Five of the questions used a five point scale to measure the relative importance of the question being asked. In each circumstance, the value “1” portrayed unimportance or disagreement by the respondent. The number “5” represented strong importance or agreement by the respondent. A mean value was generated for each of these questions (Table 4.1).

There is strong agreement by respondents that EDI will continue to become a more important aspect of the flour milling industry (Table 4.1). This is an interesting result considering most larger firms were not represented in this survey. Surprisingly, many respondents do not think improved information will allow them to reduce inventories. However, there was a wide range of responses to this question. A possible explanation for these contradictory results is firms are at different stages with regard to managing information. For example, firms with greater information management capabilities may have experienced reduction in inventories. Conversely, firms with less capability to manage information are less familiar with the correlation between information and inventory reduction.

Table 4.1. Responses for President/CEO Survey to Industry Trends, 1996.

Question	*Mean*	*1*	*2*	*3*	*4*	*5**
			Percent Responses			
Do you feel EDI (Electronic Data Interchange) will continue to evolve and become a greater influence than it is now in your business?	4.10	0.0	4.8	19.0	38.1	38.1
Is inventory control critical to remaining competitive in the flour milling industry?	3.43	4.8	19.0	33.3	14.3	28.6
Do you feel inventory management practices of the industry have progressed to reflect current management philosophies?	3.14	0.0	14.3	57.1	28.6	0.0
Do you think improved information will allow you to reduce inventories?	2.95	19.0	14.3	23.8	38.1	4.8
Do you think the trend towards closer relationships with suppliers and customers will result in reduced levels of inventory for you firm in the future?	2.71	23.8	14.3	33.3	23.8	4.8

* 1 = Strongly disagree, 2 = Somewhat disagree, 3 = No opinion, 4 = Somewhat agree,
5 = Strongly agree

The importance of inventory control to maintaining competitiveness in the flour milling industry produced mixed results (Table 4.1). Nearly 30 percent felt it was very important to remaining competitive while the rest were evenly distributed throughout the range of responses. This result may be due to differing types of competition throughout the industry. Some firms may be forced to maintain relatively high levels of inventory because of longer product lines or service level requirements. These firms are probably less concerned with inventory management because of their business requirements. There was little opinion whether current practices have progressed to reflect contemporary management philosophies. Interestingly, the trend towards closer relationships resulting in lower inventory levels produced mixed results. This may be explained by the wide variation in percent of close relationships that firms are developing with their customers.

In addition, the president/CEO survey showed that approximately 60 percent of the respondents manage inbound and outbound inventories in the same department. Finally, this survey revealed that firms organize inventory management many ways (Table 4.2). According to the survey, most firms manage inventory issues through the accounting department. More than 50 percent indicated using the accounting department. The second most popular option was the transportation department, also accounting for more than 50 percent. Nearly 30 percent indicated having a formal logistics department to manage inventory issues, with approximately 10 percent utilizing third party providers. Other methods mentioned included plant management staff, sales forecasters, and grain departments. It should be noted that some firms indicated using more than one department. This may be due to differing departmental responsibilities depending on inventory type. In addition, more than 35 percent of firms indicated managing inbound and outbound inventories in different departments. Also, every firm responding to the survey reported managing their inventory issues in some manner.

Table 4.2. Inventory Management Responsibilities.

Department	*Percentage*
Accounting department	57.1
Transportation department	52.4
Formal logistics department	28.6
Third party providers	9.5
Other (Grain department, forecasters, other managers)	28.6

Note: Some firms indicated more than one department had responsibility for inventory issues, thus the total percentage is greater than 100 percent.

Marketing Survey

The marketing survey consisted of eight questions directed toward obtaining information about the inventory management system for outbound materials. The first two questions determined how many flour related products firms are producing in 1996 compared to five years ago. A flour product in this case is defined as one that has its own stock keeping unit (SKU). These products are differentiated by industrial and retail use. In addition, they are further separated into bagged and bulked products for each classification.

The current trend reflects more products being held compared to five years ago (Table 4.3). The number of bagged products appear to be increasing the most, especially in the industrial use area. Overall, firms participating in the survey are producing an average of more than 6 percent more products in 1996 compared to 1991.

Table 4.3. Overall Number of Products Produced by Flour Mills, 1991 and 1996.

	Number of Products		*Difference*	*Percent*
	1991	*1996*		*Change*
Bagged Products				
Retail	10.3	11.2	0.9	8.0%
Industrial	29.1	30.8	1.7	5.5%
Bulk Products				
Retail	1.4	1.1	-0.3	-27.3%
Industrial	5.7	6.4	0.7	10.9%
Total	46.5	49.5	3	6.1%

It should be noted that there are a greater numbers of bagged products than bulk products (Table 4.3). Therefore, while the area of bulk-retail products has the greatest percentage change, the actual change in number of products in this area is relatively small compared to other areas.

Questions three through five were concerned with flour customers. More than 60 percent of respondents said they are participating in preferred supplier programs. Similarly, the percentage of customers, by volume, that firms are developing close relationships is relatively high, approximately 65 percent. In this case, volume indicates the percentage of product shipped from the mill. For example, one customer may represent 50 percent of total product volume for a particular mill (Table 4.4).

Table 4.4. Distribution of Preferred Supplier Relationships in the Flour Milling Industry.

	Participant in Preferred Supplier Programs	*Non-Participant in Preferred Supplier Programs*
Percent of Milling Firms	65.0	35.0
Number of Customers (Industry mean)	57.2	7.0
Volume Developing Close Relationships (Industry mean percent)	43.9	20.7

There was a wide range of responses to the preferred supplier question. A few firms said they are developing close relationships with 100 percent of their customers while others indicated not developing close relationships with any of their customers. In addition, the number of buyers, or customers, that firms have for their flour vary greatly. The mean was about 79 customers, but responses ranged from zero to more than 400 customers.

One characteristic of preferred supplier programs is a decrease in the number of customers (Miller and Dooley, 1995). Firms concentrate on developing close relationships with a few firms to improve service and reduce costs.

Results from Table 4.4 indicate confusion within the industry about preferred supplier relationships. Surprisingly, the number of customers is much greater from firms indicating they are involved in close relationships. This is completely opposite of what is expected. In addition, firms responding that they are not in preferred supplier programs indicated an industry mean of more than 20 percent product volume being in close relationships. It is difficult to explain this contradiction. Undoubtedly, confusion exists within the industry about the nature of preferred supplier relationships. Examples of flour milling customers involved in preferred supplier programs include Campbells, Bordens, General Mills, and Pillsbury. Obviously, due to the size of the companies involved, preferred supplier programs are an important aspect in the flour milling industry. It is imperative that flour mills understand the nature of preferred supplier relationships and position themselves to participate in these types of programs.

Question six in the marketing survey queried how milling firms, along with their customers and suppliers, utilize EDI data. About 40 percent of responding mills indicated they are using EDI already, and others indicated they will be implementing it in the near future.

Six features of EDI were listed, each with a ranking on a “1” to “5” scale. This ranking corresponded to the percentage of suppliers and customers using each feature. A ranking of “1” indicated more than 75 percent of milling firms are using a particular feature whereas a ranking of “5” indicated the feature is not being used. The Aitchison-Silvey statistical model was used to rank each feature with regard to the percentage of suppliers and customers that utilize each feature (Table 4.5). Rankings indicate both firms that are currently using EDI and those that are not using EDI. As a result, the ‘Not in use’ column reflects firms that are not using EDI at all, as well as firms using EDI but not that particular feature.

Table 4.5. Overall Ranking of EDI Features, 1996.

		Percent of Firms Using Feature				
Ranking	*Feature*	*> 75*	*51 to 75*	*26 to 50*	*< 25*	*Not in use*
1	Purchase Orders	0.0	0.0	4.8	28.5	66.7
2	Invoices	0.0	0.0	14.3	9.6	76.1
3	Production Schedules	0.0	0.0	4.8	9.6	85.6
3	Freight Bills	0.0	9.6	0.0	4.8	85.6
5	Quick Response Initiatives	0.0	0.0	4.8	4.8	90.4
6	Forecasts	0.0	0.0	0.0	9.6	90.4

Purchase orders and invoices are the most popular features of EDI that firms are currently using (Table 4.5). However, purchase orders still are being used by only about 30 percent of firms.

Other features such as quick response initiatives and forecasts are used by less than 10 percent of firms. Undoubtedly other features will become more popular as EDI becomes more widespread in the industry.

Interestingly, 20 of 21 firms reported little or no reduction in inventories after implementing EDI. In addition, the number of stockouts were not reduced using EDI. These results indicate EDI is not being used to its potential within the flour milling industry. This may indicate a training void with respect to EDI. Firms may not be aware of features that exist and their opportunities. Possibly when other EDI features such as forecasting and scheduling become more popular, impacts on inventories will become more noticeable.

Logistics/Transportation Survey

The logistics/transportation survey was the largest of the four surveys, consisting of 15 questions. The first question asked what tools are being used to measure the effectiveness of the inventory policy. A “1” to “6” scale was used. A response of “1” indicated that measure was not being used. Responses of “2” through “6” indicated yearly, quarterly, monthly, weekly, or daily use, respectively. These data were also ranked with the Aitchison-Silvey model. Rankings are in order of usage. For example, a ranking of “1” for inventory records indicates that tool is used most often (Table 4.6).

Table 4.6. Overall Ranking of Inventory Measurement Tools.

Ranking	*Measurement Tool*	*Percent Responses*					
		Not in use	*Yearly*	*Quarterly*	*Monthly*	*Weekly*	*Daily*
1	Inventory Records for Each Item Stocked	0.0	5.0	5.0	15.0	30.0	45.0
2	Carrying Costs	20.0	15.0	20.0	35.0	0.0	10.0
3	Return on Investment	15.0	15.0	30.0	30.0	5.0	5.0
4	Statistical Process Control (SPC)	50.0	0.0	5.0	10.0	10.0	25.0
5	Inventory Service Levels	40.0	5.0	0.0	20.0	20.0	15.0
6	Inventory Turnover Ratio	25.0	25.0	5.0	35.0	0.0	10.0
7	Stockout Costs	65.0	10.0	5.0	15.0	5.0	0.0
8	ABC Classification	70.0	0.0	5.0	10.0	15.0	0.0
9	EOQ Amounts	80.0	5.0	5.0	5.0	5.0	5.0

Inventory records is the most used inventory measurement tool (Table 4.6). In fact, this is the only tool that was reported being used by every firm. The results for statistical process control (SPC) were interesting in that a large group of firms reported not using it, while others reported using it on a regular basis. The final three tools in the table, stockout costs, ABC classification, and EOQ amounts, are not being used on a widespread basis in the flour milling industry.

A comparison was done between firms that are using inventory records on a daily basis and those firms that are not to determine if there is any differences in inventory measurement tool usage and EDI usage. This was done because measuring inventory records are necessary to use many of the other tools on the list. There was virtually no difference in the rankings from Table 4.6 between firms using inventory records on a regular basis and firms using them less often. However, firms indicating daily usage of inventory records are using other tools more often. In addition, EDI usage for firms indicating daily usage was 56 percent compared to the overall percentage of EDI usage of 40 percent. This is an expected result since EDI usage requires regular product information.

The percentage of firms reported measuring inventory carrying costs was slightly more than 50 percent. These carrying costs ranged from 1 to 25 percent, with an average of about 9 percent. There was a wide variation in inventory turnover ratios, ranging from 2 to 48 times per year, with a mean of 11.3 times per year. This compares favorably to the median turnover rate of 10.6 in 1995 published in the Inventory Reduction Report (1996) for flour and other grain mill products. In addition, return on investments varied greatly, from approximately 4 percent to more than 20 percent, with a mean of 15 percent. Overall, 50 percent of respondents indicated calculating return on investments (Table 4.7).

Question six examined when particular items were incorporated into a firm's inventory management system. Five items were listed: scheduling (MRP), EDI, economic order quantities (EOQ), JIT, and computerized inventory management systems. These items corresponded to a range of five numbers. A response of "1" indicated that item is not in use. Responses of "2" to "5" indicated a range of more than 10 years to under two years ago when the item was incorporated into the system. Table 4.8 summarizes the results of this question, including rankings based on when items were introduced into inventory management systems.

Table 4.7. Frequency Distributions for Various Inventory Characteristics in the Flour Milling Industry.

Reported Carrying Cost (Percent)	*Frequency (Percentage)*	*Cumulative Frequency*
0 - 5	27.2	27.2
6 - 10	54.6	81.8
11 - 15	9.1	90.9
Over 16	9.1	100.0
Total	100.0	
Mean	9.2	
Percent Reporting	55.0	
Annual Turnover Ratio	*Frequency (Percentage)*	*Cumulative Frequency*
1-10	69.2	69.2
11-20	15.4	84.6
21-30	7.7	92.3
Over 31	7.7	100.0
Total	100.0	
Mean	11.3	
Percent Reporting	65.0	
Return on Investment (Percent)	*Frequency (Percentage)*	*Cumulative Frequency*
0 - 5	10.0	10.0
6 - 10	20.0	30.0
10 - 15	30.0	60.0
Over 16	40.0	100.0
Total	100.0	
Mean	15.0	
Percent Reporting	50.0	

Table 4.8. Summary of Items Incorporated into Inventory Management Systems.

Ranking	*Item*	*Percent Responses*				
		Not in use	*More than 10 years*	*5 to 10 years*	*2 to 5 years*	*Under 2 years*
1	Computerized Inventory Management Systems	38.9	22.2	11.1	11.1	16.7
2	Electronic Data Interchange (EDI)	50.0	0.0	0.0	22.2	27.8
3	Just-In-Time (JIT)	55.6	16.7	0.0	16.7	11.1
4	Scheduling (MRP)	55.6	5.6	5.6	16.7	16.7
5	EOQ to determine production amounts	76.5	0.0	0.0	23.5	0.0

The use of computers to manage inventories was given the highest ranking (Table 4.8). This ranking means that computerized inventory management systems is the most used item in inventory management systems within the flour milling industry. Also, this ranking gives preference to those items which have been in use the longest time. EDI has been implemented by 50 percent of firms within the last five years, but is not being used by the other 50 percent. Other items listed in the table are currently being used by only a small percentage of firms in the industry.

Looking at the column corresponding to items implemented in the last two years, there has been a lot of activity, especially toward EDI (Table 4.8). However, there has been no activity with respect to EOQ. This is not surprising since EOQ is a relatively old tool and we would expect newer tools such as EDI, JIT, and MRP to supplement and replace EOQ.

Questions seven and eight looked at the importance of several inventory policies relative to account size. Question seven looked at this issue from a bulk product perspective (Table 4.9), while question eight looked at it from a bagged product perspective (Table 4.10). A “1” to “5” scale was used to differentiate whether a particular policy was more important for large or small accounts. A value of "1" represented greater importance for large buyers while a "5" represented greater importance for small buyers. A value of "3" denotes equal importance to both. These questions were also ranked using the Aitchison-Silvey model.

Table 4.9. Inventory Policy Effects on Account Size for Bulk Products.

Ranking	*Item*	*More important for large buyers*				*More important for small buyers*
		Percent Responses				
1	Inventory policies are determined by customer requirements (JIT, EDI, etc.)	11.1	0.0	88.9	0.0	0.0
2	Inventory policies are determined by shipment methods (truck, rail, etc.)	5.6	11.1	83.3	0.0	0.0
3	Inventory policies are determined by production runs	5.6	16.7	66.7	11.1	0.0
4	Inventory policies are determined by product volume (ABC classification)	11.1	5.6	66.7	11.1	5.6
5	Inventory policies are determined by market prices for wheat	0.0	0.0	100.0	0.0	0.0
6	Inventory policies are determined by product value	0.0	0.0	83.3	11.1	5.6

Table 4.10. Inventory Policy Effects on Account Size for Bagged Products.

Ranking	*Item*	*1*	*2*	*3*	*4*	*5**
				Percent Responses		
1	Inventory policies are determined by customer requirements (JIT, EDI, etc.)	5.6	11.1	77.8	0.0	5.6
2	Inventory policies are determined by market prices for wheat	0.0	5.6	94.4	0.0	0.0
3	Inventory policies are determined by product volume (ABC classification)	5.6	11.1	72.2	11.1	0.0
4	Inventory policies are determined by shipment methods (truck, rail, etc.)	0.0	11.1	83.3	5.6	0.0
5	Inventory policies are determined by product value	0.0	0.0	100.0	0.0	0.0
6	Inventory policies are determined by production runs	0.0	0.0	72.2	27.8	0.0

* 1 = More important for large customers, 3 = Equally important, 5 = More important for small customers

Comparing Tables 4.9 and 4.10 reveal similarities and differences between inventory policies for bagged and bulk products. Overall, the vast majority of responses to these questions did not view inventory effects differently due to customer or account size. However, there were a few notable observations from these results.

Customer requirements are more important for large customers of both bulk and bagged products (Tables 4.9 and 4.10). This is not surprising due to the importance of large customers and accounts to firms in the industry. In addition, large customers often specify what their requirements are to their suppliers. Inventory policies being determined by production runs was the one policy that had the largest difference between bagged and bulk products. This policy had a ranking of two for bulk products, being more important for large accounts. However, from a bagged product perspective, it had the lowest ranking of six, favoring smaller accounts. Reasons for this may include longer production run times associated with bulk products.

Paired *t*-tests[1] were conducted to determine if there were significant differences in responses to each question for bagged and bulk products (Table 4.11). The only question with a significant difference at the 95 percent confidence level was inventory policies determined by production runs. According to test results, the mean for bagged products was 0.4 greater than the mean for bulk products for this particular question. This means that small buyers are a greater influence than large buyers when inventory policies are determined by production runs for bagged products. Setup costs may be an explanation for this result. Setup costs are incurred whenever a different product is manufactured and the manufacturing process must be reconfigured. In this case, smaller production runs associated with small buyers result in higher setup costs than large production runs for large buyers. Maintaining inventory is one way to offset high setup costs. Another explanation may be customer requirements. Small customers who purchase bagged products may be buying in small amounts, placing more responsibility for maintaining inventory on the milling plant.

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[1]See the *SAS/STAT User's Guide: Volume 2, GLM-VARCOMP*, Version 6, 4th Ed., Cary, NC: SAS Institute, 1990, for more information about the procedure.

Table 4.11. Paired *T*-Test Results for Bagged and Bulk Product Inventory Policies.

Item	*Bulk - Bagged Mean*	*T-test value*
Inventory policies are determined by customer requirements (JIT, EDI, etc.)	- 0.40	-2.6285 *
Inventory policies are determined by shipment methods (truck, rail, etc.)	0.05	0.2708
Inventory policies are determined by production runs	- 0.10	-0.4620
Inventory policies are determined by product volume (ABC classification)	0.20	1.7097
Inventory policies are determined by market prices for wheat	- 0.15	-1.0000
Inventory policies are determined by product value	0	-

Note: A * indicates a significant difference in responses at the 95 percent confidence level.

Shipment methods were cited as being more important for large accounts in both cases. Other policies shown in the table revealed little differences between both account size and product characteristics.

The majority of flour production is directly to customer order (Table 4.12). A small proportion of bulk flour (nearly 9 percent) is produced for other requirements such as further processing while no bagged flour is produced for this type of usage. While these numbers reflect industry means, it should be noted that approximately 10 percent of firms reported producing flour for additional processing. From the results, the majority of firms are producing directly to order for both bulk and bagged products. However, more firms are producing to inventory for bagged products than bulk products. This is not surprising since there are greater numbers of bagged products than bulk products (Table 4.3).

Table 4.12. Bulk and Bagged Produced Flour Characteristics.

Produced For	*Bulk Products*	*Percent of Firms Producing Bulk*	*Bagged Products*	*Percent of Firms Producing Bagged*
		(Percentages)		
Inventory	7.8	20.0	30.3	60.0
Directly to Order	83.4	70.0	69.7	70.0
Other (Additional processing)	8.8	10.0	0.0	0.0
Total	100.0%		100.0%	

Plant Survey

The plant survey was used to differentiate firms by size and location. This allowed responses from the other three surveys to be separated by either size or location criteria. Location criteria for each mill consisted of either origin or destination. Results based on size and location factors are further discussed in the next two sections of the chapter.

One question asked in the plant survey attempted to determine an overall trend within the industry with respect to total inventory. The question asked if their plant carries more inventory now than five years ago. Interestingly, this question produced mixed responses. The percentage of respondents who said they do not carry more inventory now compared to five years ago was more than 50 percent. However, 42 percent said yes and close to 8 percent said they do not know.

The plant survey also determined how firms measure outbound transit times. Three categories were asked, including distance in miles, transit time in days, and transportation mode. Nearly 70 percent of the firms indicated they are measuring outbound transit times (Table 4.13).

Table 4.13. Summary of Outbound Transit Characteristics.

Mode	*Percent Responses*	*Mean Transit Time (days)*	*Mean Distance (miles)*	*Percent of Firms Carrying More Inventory*
Truck	62.2	0.8	266.3	54.5
Rail	37.8	9.3	792.0	42.9
Container	0.0	---	---	---

Firms which utilize trucks for their outbound products are reporting greater inventory levels over the past five years than those firms using rail transportation (Table 4.13). This may be due to reasons including greater numbers of products being produced by firms using truck transportation.

Many respondents to the plant survey provided additional comments. A few plants emphasized they are JIT capable, providing excellent customer service based on delivery arrival times. This allows mill customers to carry lower inventory amounts, pushing inventory back in the supply chain. Related to this, there is wide variation in the distance to markets that plants serve. Some plants serve a very local market, while others are nationwide. Obviously, location of primary markets has a large impact on delivery times and variability.

Responses to the plant survey based on criteria such as plant size, facility age, distance from primary markets, and modal factors also were evaluated to determine differences. Paired *t*-tests were conducted to determine whether any of these factors lead plants to carry more inventory in 1996 as opposed to five years ago (Table 4.14).

Table 4.14. Results of *T*-Tests Comparing Inventory Level with Various Factors.

Factor	*Firms Carrying More Inventory in 1996*	*Firms Not Carrying More Inventory in 1996*	*T-test value*
	Mean Values		
Number of production workers	56.9	43.3	-0.8534
Age of facility (years)	56.8	76.6	2.0263 *
Plant capacity (cwt.)	8,931.5	8,248.2	-0.4534
Distance from primary markets (miles)	449.0	482.3	0.2239
Firms measuring outbound transit characteristics (1 = yes, 0 = no)	0.8	0.6	-1.1832
Distance to an important customer (miles)	491.1	393.7	-0.5383
Transit time (days)	3.1	5.1	-0.5383

Note: A * denotes a statistical difference between means for firms carrying more inventory in 1996 and firms not carrying more inventory in 1996 at the 95 percent level of significance.

The *t*-test used in SAS computes sample means for two groups of observations and tests the hypothesis that these are the same.[2] The *t*-test procedure computes a *t* statistic based on an assumption that variances for the two groups are equal, and it also computes an approximate *t* based on the assumption that variances for the two groups are unequal.

Based on the computed *t* tests, the only factor which significantly influenced whether firms are carrying more inventory now is the age of the facility. Interestingly, older firms with a mean age of approximately 77 years indicated they are not carrying more inventory in 1996 as opposed

[2]See the *SAS/STAT User's Guide: Volume 2, GLM-VARCOMP*, Version 6, 4th Ed., Cary, NC: SAS Institute, 1990, for more information about the procedure.

to five years ago. However, firms with a mean age of 57 years indicated they are carrying more inventory in 1996. This may be due to the experience curve effect where older, established firms are efficient with regard to inventory policy. Another explanation may be that older plants are limited in their capability to expand to produce and hold more product.

Surprisingly, modal choice, distance from primary markets, and plant capacity were not significant factors impacting the trend of some firms carrying greater amounts of inventory. In addition, there was no correlation between firms who are measuring outbound transit times and inventory levels.

An industry profile of an average plant is shown in Table 4.15. This shows the mean attributes of plants in the study, along with minimum and maximum characteristics.

Table 4.15. Industry Profile of an Average Flour Milling Plant, 1996.

Characteristic	*Mean*	*Minimum*	*Maximum*
Number of production workers	46.9	5	350
Age of facility (years)	63.5	1	226
Plant capacity (cwt.)	8,234.2	150	25,500
Distance from primary markets (miles)	451.0	0	3,000

Characteristics of Origin and Destination Mills

This section examines if there are statistical differences in characteristics of origin and destination mills. In this study, a destination mill is defined as one that is 200 miles or less from its primary markets. At this distance, a mill should be able to serve customers in less than four hours. In addition, responses to the plant survey are almost equally split into two groups at this distance. There are 32 responses in the destination mill group and 33 responses in the origin mill group.

According to the results, the only variables statistically significant at the 95 percent confidence level are distance to an important customer and transit time, which are expected results (Table 4.16). A surprising result is the comparison of means regarding age of the plant. From the results, the mean age for destination mills is actually higher than the mean age for origin mills. This is unexpected since newer mills are being located near final destination markets (Wilson, 1995). This may be explained by the wide variation in ages in the destination mill group. There were 10 mills older than 95 years in the destination group compared to only four in the origin group.

Table 4.16. Results of *T*-Tests Comparing Origin and Destination Mills.

Factor	*Destination Mill (200 miles or less from primary markets)*	*Origin Mill (Greater than 200 miles)*	*T-test value*
	Mean Values		
Number of production workers	42.0	51.7	0.6739
Age of facility (years)	69.5	57.7	-1.2001
Plant capacity (cwt.)	7,904.4	8,564.1	0.4652
Firms carrying more inventory in 1996 compared to five years ago (2 = yes, 1 = no)	1.4	1.5	0.0255
Firms measuring outbound transit characteristics (1 = yes, 0 = no)	0.7	0.7	0.0874
Distance to an important customer (miles)	121.4	705.0	4.5112 *
Transit time (days)	1.2	6.8	2.3476 *
Mode (1 = truck, 0 = rail)	0.5	0.2	-1.9331

Note: A * denotes a statistical difference between means for origin and destination mills at the 95 percent level of significance.

Intra-firm Comparisons

The goal of this section is to determine if results within the firm are consistent with each other. Individual business units or departments within a company should be coordinated to maximize its value chain. A firm's value chain is defined as "a collection of activities that are performed to design, produce, market, deliver, and support its product" (Porter, 1985). The sum of the components in the value chain make up value to customers. The greater value a firm creates for its customers results in a greater competitive advantage over rival firms (Porter, 1985). In this section, comparisons are made between responses from different surveys to see if there is mutual understanding and coordination within firms in the industry.

Comparisons were made between the number of products a firms produces and the opinion questions from the president/CEO survey (Table 4.17). The goal of this comparison was to see if opinions from these questions vary with the number of products a firm produces. The total number of products a firm produces is simply the cumulative number of bulk and bagged products indicated in the marketing survey. Firms producing 20 products or less were put is one group while those firms producing over 20 products were put in another group. Paired *t*-tests were conducted to determine statistical significance. Recalling the survey, questions were based on a "1" to "5" scale, with a response of "5" indicating strong agreement or importance.

Table 4.17. Results of *T*-Tests Comparing Number of Products and Opinion Questions.

Question	*Producing 20 or Fewer Products*	*Producing Over 20 Products*	*T-test value*
	Mean Values		
Do you feel inventory management practices have progressed to reflect current management philosophies?	3.27	3.00	0.9512
Do you feel EDI will continue to evolve and become a greater influence than it is now in your business?	3.82	4.40	-1.5493
Do you think the trend towards closer relationships with suppliers and customers will result in lower levels of inventory for your firm in the future?	2.82	2.60	0.9633
Do you think improved information will allow you to reduce inventories?	2.91	3.00	-0.1631
Is inventory control critical to remaining competitive in the flour milling industry?	3.45	3.40	0.0975

Note: A * denotes a statistical difference between means for origin and destination mills at the 95 percent level of significance.

It should be noted that none of the comparisons were statistically significant in Table 4.17. In fact, four of the questions showed little difference in the mean values of the two groups. However, firms producing greater numbers of products indicated that EDI will continue to gain importance. This is an expected result since more products require greater amounts of information to be managed. Surprisingly, there was little difference in the mean values for the question concerning improved information and its impact on reducing inventories. Responses to this question would be expected to be similar to the EDI question. This further exemplifies the confusion in the industry regarding EDI.

Similar to the previous discussion, a comparison was done regarding the number of customers, or buyers, a firm has and the opinion questions from the president/CEO survey (Table

4.18). In this case, firms with 30 or fewer customers were put in one group and firms with greater than 30 customers were put in another group.

Table 4.18. Results of *T*-Tests Comparing Number of Buyers and Opinion Questions.

Question	*Having 30 or Fewer Buyers*	*Having Over 30 Buyers*	*T-test value*
	Mean Values		
Do you feel inventory management practices have progressed to reflect current management philosophies?	3.09	3.20	-0.3731
Do you feel EDI will continue to evolve and become a greater influence than it is now in your business?	3.82	4.40	-1.5493
Do you think the trend towards closer relationships with suppliers and customers will result in lower levels of inventory for your firm in the future?	2.64	2.80	-0.2973
Do you think improved information will allow you to reduce inventories?	2.82	3.10	-0.5088
Is inventory control critical to remaining competitive in the flour milling industry?	3.36	3.50	-0.2442

Note: A * denotes a statistical difference between means for origin and destination mills at the 95 percent level of significance.

Once again, there is no statistical significance in the difference between mean values for any of the questions (Table 4.18). Results for the EDI question produced identical results as Table 4.17. In this case, there was a similar result regarding improved information and its impact on reducing inventories, with firms with a higher number of buyers having a larger mean value. For the remaining three questions there was little difference in results, although in each case the mean was slightly larger for firms with greater numbers of buyers.

Comparisons also were done between the logistics/transportation, marketing, and president/CEO surveys to compare responses about EDI usage. The logistics/transportation and marketing surveys directly asked respondents if their firm uses EDI, while the president/CEO survey had an opinion question about continuing importance of EDI. Again paired *t*-tests were conducted to determine statistical significance among results (Table 4.19).

Table 4.19. EDI Comparisons with the Marketing Survey.

Groups	*Using EDI*	*Not Using EDI*	*T-test value*
		Mean Values	
Logistics/Transportation vs. Marketing	1.86	1.25	-2.9861*
President/CEO vs. Marketing	4.25	4.00	-0.6160
President/CEO vs. Logistics/Transportation	4.56	4.00	-1.7386

Note: A * denotes a statistical difference between means at the 95 percent level of significance.

The president/CEO survey produced similar results when compared to the other two surveys. In both cases, firms who are currently using EDI felt more strongly about its importance than those firms not using EDI. However, the mean for firms not using EDI is still relatively high, indicating they felt it was an important trend in the industry.

While there was a significant difference in the means between the marketing and logistics/transportation surveys for firms using EDI and firms not using EDI, there were still conflicting results. In each set of results, there was not complete consistency in responses. Some firms indicated using EDI in one survey but responded differently in another survey. We would expect consistent responses within each firm about EDI usage. However this is clearly not the case (Table 4.19). It is difficult to explain differing responses within the firm. Perhaps some firms who are close to implementing EDI responded they are currently using it, resulting in differing responses from managers within the firm. Another explanation may be people confusing EDI with some other management tool.

The next group of comparisons involved the number of products a firm produces and inventory measurement tools. Recalling Table 4.6, the three most popular tools currently being used by firms are inventory records for each item stocked, carrying costs, and return on investment. Firms producing more than 20 products were once again put in one group, while those producing 20 or less products were placed in another group. Means for these two groups were compared for each of the three most popular tools to see if there any differences (Table 4.20). There were a range of six responses for each tool. A response of “1” indicated the tool is not being used and a response of “6” indicated daily usage (Table 4.6).

Table 4.20. Results of *T*-Tests Comparing Number of Products and Inventory Measurement Tools.

Measurement Tool	*Producing 20 or Fewer Products*	*Producing More Than 20 Products*	*T-test value*
	Mean Values		
Inventory Records for Each Item Stocked	5.00	5.10	-0.1798
Carrying Costs	2.89	3.30	-0.5627
Return on Investment	3.11	3.10	0.0172

Note: A * denotes a statistical difference between means for origin and destination mills at the 95 percent level of significance.

The only tool with noticeably different means for each group was carrying cost, which had a larger mean for firms producing higher numbers of products. This means that carrying costs are being calculated more frequently at these firms. This is an expected result since higher numbers of products may result in larger inventory levels, necessitating the need to maintain an accurate estimate of the carrying costs involved.

There was not much of a difference in the means for inventory records or return on investment. However, the means for inventory records are both relatively high, indicating this tool is being used by most firms in the industry on a regular basis. Similarly, return on investments are being calculated by most firms in the industry, just not as often as inventory records.

Conclusion

In this chapter, results of the survey were presented. These included overall results, in addition to results based on plant criteria and location factors. In addition, intra-firm comparisons were made to see if there is coordination among departments within firms in the industry. In Chapter Six, strategic implications of these results is addressed, in addition to conclusions drawn from the study.

CHAPTER 5. STRATEGIC IMPLICATIONS OF INVENTORY POLICIES FOR FLOUR MILLS

In this chapter, a summary of the study is first presented. Following the summary is a discussion of strategic implications for flour mills based on survey results. Finally, limitations to the study and the need for further study are addressed.

Summary

In recent years there has been increased management interest in managing and reducing inventories (Loar, 1992). Actively managing inventories provides opportunities for cost savings, greater efficiency, and better customer service. To assist in these efforts, tools exist such as EDI and JIT which are designed to improve information and reduce uncertainty, which historically has been a major reason for holding inventory. This study specifically looked at the flour milling sector of the agricultural processing industry to see how inventory management is being impacted by changing tools and philosophies.

To understand how flour mills are managing their inventory issues, a survey was mailed to U.S. firms in the industry. The overall survey was broken down into four smaller surveys which were designed to be addressed by the appropriate individuals in the milling operation. These included logistics/transportation, marketing, president/CEO, and plant surveys. Data collected were used to evaluate inventory policies in the flour milling industry. Included were impacts of tools such as EDI, JIT, and EOQ. In addition, some questions allowed managers the opportunity to provide their opinions about current trends regarding inventory management. Other questions attempted to answer trends in the industry, such as product characteristics and implementation of tools.

Some data were ranked using the Aitchison-Silvey model (Appendix B). Other data were analyzed using paired *t*-tests to determine statistical significance between various factors. The following section discusses implications to the results of the study.

Strategic Implications

From the results of the survey, conclusions can be drawn about how firms in the industry are behaving with respect to certain characteristics. Specifically, these include estimated carrying cost, EDI usage, and effects of preferred supplier programs. There are some interesting results that in some cases differ from the literature.

Estimated Carrying Cost

Based on results from the survey, firms in the industry do not fully understand the cost magnitude that inventories represent. The mean inventory carrying cost from firms in the sample was approximately 9.2 percent. This is an extremely low estimate compared to the literature (Table 2.5). In addition, a number of firms indicated an inventory carrying cost of less than 5 percent. "Without an accurate assessment of the costs of carrying inventory, it is unlikely that a company would choose the logistics policies that would minimize costs" (Lambert and Stock, 1993). These policies include transportation modes, production schedules, minimum production runs, customer service levels, where to hold inventory, and inventory levels (Lambert and Stock, 1993). Understanding and estimating accurate inventory carrying costs is critical since inventories represent such a large investment in assets which impact firm profitability (Table 5.1).

Table 5.1. Comparison of Carrying Costs and Their Financial Impact.

	Survey Result	*Conservative Estimate*	*Hurdle Rate*
Inventory Carrying Cost (Percentage)	9.2	12	25
Total Yearly Carrying Cost*	$46,000	$60,000	$125,000

* Assuming an average inventory of $500,000

EDI Usage

There was strong agreement from respondents that EDI will continue to evolve and become more important in the industry (Table 4.1). However, there were some unexpected results associated with EDI and its effect on inventories.

One of the major reasons to use EDI is improved information flows. This is due to reduced labor intensive efforts such as paper transactions and duplicate data entry, resulting in improved speed and accuracy of data (Coyle, Bardi, and Langley, 1996). One of the benefits of improved information is reduced inventory levels. However, survey respondents indicated they did not think improved information would allow them to reduce inventories.

There may be a couple of explanations for the discrepancy between EDI and inventory reduction. First, EDI is in its infancy throughout the industry. Many firms indicated they recently incorporated EDI into their operation, or will be doing so in the near future (Table 4.8). Undoubtedly, with limited experience to EDI technology, firms are not entirely aware of the benefits it may offer them. This is reflected in the responses to EDI features being currently utilized (Table 4.5). The vast majority of EDI usage in the industry is for purchase orders and invoices. Other features which are not yet popular such as forecasting, scheduling, and quick response initiatives may result in inventory reduction.

Another reason for the limited impact of EDI on inventory levels may be the fact that large flour buyers are requiring EDI usage by their suppliers. Recalling Tables 4.9 and 4.10, inventory policies being determined by customer requirements was ranked highest for large accounts for both bulk and bagged products. This implies that large flour customers are driving changes within the industry such as EDI and JIT implementation.

Along with being the driving force behind changes in the industry, large customers are attempting to minimize their own inventories. Due to the nature of the industry and the seasonality of raw materials such as wheat, inventory must exist somewhere in the supply chain. When large companies who buy flour minimize their inventory levels, product is then forced back to milling firms and wheat producers. According to the survey, nearly half of responding plants indicated they are carrying more inventory in 1996 as opposed to five years ago (Table 4.12). This shift in who is holding inventory makes it even more imperative that milling firms understand their inventory carrying cost.

Effects of Preferred Supplier Programs

Related to the previous discussion is the effect of preferred supplier programs. One characteristic of preferred supplier programs is movement away from adversarial customer relationships to close procurement programs (Miller and Dooley, 1995). A goal of these programs is improved communication and information between the partnering firms, thus reducing uncertainty and reducing inventory (Miller and Dooley, 1995).

As results of the survey indicate, the industry mean for developing close relationships was approximately 65 percent of customers. However, there was a wide variation in responses with some firms indicating close relationships with all of their customers, while other firms reported having no close relationships with customers. This indicates a differentiation in the industry (Table 5.2).

Table 5.2. Characteristics of Preferred and Non-Preferred Suppliers in the Flour Milling Industry.

Characteristic	*Preferred Supplier*	*Non-Preferred Supplier*
	(Industry Averages)	
Plant Capacity (cwt.)	5879.2	5963.1
Plant Age (years)	62.5	64.9
Distance from primary markets (miles)	342.9	864.2
EDI usage	50.0%	33.3%
Carrying more inventory now compared to five years ago	58.3%	57.1%
Transportation modes (Truck/Rail)	50.0% / 50.0%	75.0% / 25.0%

The main difference between preferred and non-preferred suppliers is distance from primary markets (Table 5.2). Not surprisingly, preferred suppliers are located relatively close to their primary customers. Shorter distances between suppliers and customers may reduce variances in delivery schedules and improve customer service. Reducing uncertainty is one of the main requirements of preferred supplier programs (Miller and Dooley, 1995).

Interestingly, only 50 percent of firms involved in preferred supplier relationships indicated using EDI. However, many firms not currently using EDI said they will be implementing it in the near future. Undoubtedly EDI will prove to be a characteristic of most preferred supplier relationships in the future.

Study Limitations and Need for Additional Study

One limitation to the study may have been confusion by respondents to some of the questions in the survey instrument. There were some contradictory results which were difficult to explain. Perhaps these results were reflective of confusion in the industry about topics such as preferred supplier relationships and Electronic Data Interchange (EDI).

Further analysis comparing financial factors with inventory management performance would have been beneficial. However, limited financial data were available for this study. Since many of the firms surveyed in this study are privately held it would be difficult to acquire this information. This type of analysis would be interesting because it would be possible to determine if there is a correlation between logistics performance and financial performance in the flour milling industry.

Another opportunity to expand on this research would be to survey flour milling customers to find out their impressions on driving forces in the industry. After conducting this research, our hypothesis is that milling customers drive much of the change regarding preferred buyer/seller relationships and technology usage. Surveying other components of the supply chain in this industry would give further insight about changes taking place and who is driving them.

Finally, repeating this study in a few years by conducting a similar survey of flour mills would be beneficial. The results from a new study could be compared with these results to see how trends identified in this study are progressing in the milling industry. It also would be interesting to see how inventory policies are being affected by these trends.

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APPENDIX A

Surveys sent to flour milling managers

Plant Manager Survey

BASIC PLANT INFORMATION

This section asks you to provide some brief information to assist in categorizing your firm.

Q-1. Approximately how large is your plant in terms of production workers employed?

_______________ Employees

Q-2. What is the approximate age of this processing facility?

_______________ Years

Q-3. What is the approximate daily capacity of this mill? _______________ cwt

Q-4. Within what radius (in miles) are your primary markets located from your production facilities?

_______________ Miles

Q-5. Does your plant carry more total inventory now than 5 years ago? (Circle number)

1. No
2. Yes
3. Do not know

Q-6. Is this plant measuring outbound transit times? (Circle number)

1. No
2. Yes - What are the following for an important customer?

Distance _______________ Miles

Transit time _______________ Days

Mode _______________ (Rail, truck, or container)

Do you have any other comments?

____

____

THANK YOU!

Logistics Manager Survey

MEASUREMENTS USED TO EVALUATE YOUR INVENTORY SYSTEM

This section focuses on metrics, or measurements, used to evaluate inventory methods. The goal is to determine a set of benchmarks for the flour milling industry regarding inventory policy measurements.

Q-1. Please check how often you use the following tools to measure the effectiveness of your inventory policy. (Circle number)

		Not Used	Yearly	Quarterly	Monthly	Weekly	Daily
1	Inventory Turnover Ratios	1	2	3	4	5	6
2	Inventory Records for Each Item Stocked	1	2	3	4	5	6
3	ABC Classification	1	2	3	4	5	6
4	Statistical Process Control (SPC)	1	2	3	4	5	6
5	Return on Investment	1	2	3	4	5	6
6	Inventory Service Levels	1	2	3	4	5	6
7	EOQ amounts	1	2	3	4	5	6
8	Carrying costs	1	2	3	4	5	6
9	Stockout costs	1	2	3	4	5	6

Q-2. What other tools are you using to evaluate your inventory policy?

____

____

Q-3. What is your estimated inventory carrying cost?

______________ Percent

Q-4. What is your inventory turnover ratio?

____

Q-5. If you are calculating return on investment, what is it (approximate range)?

______________ Percent

Q-6. When were the following items incorporated into your inventory management system?
(Circle number)

	Not In Use	Over 10 Years Ago	5-10 Years Ago	2-5 Years Ago	Under 2 Years Ago
1 Scheduling (MRP)	1	2	3	4	5
2 Electronic Data Interchange (EDI)	1	2	3	4	5
3 EOQ to determine production amounts	1	2	3	4	5
4 Just-In-Time (JIT)	1	2	3	4	5
5 Computerized Inventory Management Systems	1	2	3	4	5

Q-7. Please indicate the relative importance of the following inventory policies to accounts of different sizes for *bulk* products (i.e., is it more important for smaller or larger accounts). (Circle number)

	More Important For: Large buyers		Equally		Small buyers
1 Inventory policies are determined by production runs	1	2	3	4	5
2 Inventory policies are determined by product volume (ABC classification)	1	2	3	4	5
3 Inventory policies are determined by customer requirements (JIT, EDI, etc.)	1	2	3	4	5
4 Inventory policies are determined by product value	1	2	3	4	5
5 Inventory policies are determined by shipment methods (truck, rail, etc.)	1	2	3	4	5
6 Inventory policies are determined by market prices for wheat	1	2	3	4	5

Q-8. Please indicate the relative importance of the following inventory policies to accounts of different sizes for *bagged* products (Circle number)

	More Important For: Large buyers		Equally		Small buyers
1 Inventory policies are determined by production runs	1	2	3	4	5
2 Inventory policies are determined by product volume (ABC classification)	1	2	3	4	5
3 Inventory policies are determined by customer requirements (JIT, EDI, etc.)	1	2	3	4	5
4 Inventory policies are determined by product value	1	2	3	4	5
5 Inventory policies are determined by shipment methods (truck, rail, etc.)	1	2	3	4	5
6 Inventory policies are determined by market prices for wheat	1	2	3	4	5

OUTBOUND INVENTORY MANAGEMENT CHARACTERISTICS

This section asks you to please provide some basic information on your current inventory management system for ***outbound*** materials.

Q-9. What percentage of your bulk and bagged flour is produced for:?

	Bulk	**Bagged**
1. Inventory		
2. Directly to order		
3. Other (specify)		
	100%	100%

Q-10. Where is your produced bulk and bagged flour stored?

	Bulk	Bagged
1. At the production facility		
2. Near customer's location		
3. Rail to truck transfer stations		
	100%	100%

IMPACTS OF TECHNOLOGY ON INVENTORY POLICY

This section is used to determine how technological resources such as EDI and information systems are affecting your inventory policies.

Q-11. Do you use Electronic Data Interchange (EDI)? (Circle number)

1. No
2. Yes

If you answered yes to Q-11, please continue to Q-12. If you answered no to Q-11, please turn to the back page if you have any other comments.

Q-12. With what percentage of your customers, by volume, do you use EDI?

______________ Percent

Q-13. With what percentage of your suppliers, by volume, do you use EDI?

______________ Percent

Q-14. What type of hardware are you using for your EDI system? (Circle all that apply)

1. Mainframe
2. Minicomputer
3. Microcomputer
4. Network

Q-15. What software packages are you using for your EDI system?

Do you have any other comments?

THANK YOU!

Marketing Manager Survey

MARKETING CHARACTERISTICS OF OUTBOUND PRODUCTS

This section asks you to please provide some basic information on your current inventory management system for ***outbound*** materials.

Q-1. Approximately how many flour related products (SKU's) did you produce 5 years ago for industrial and retail use?

Industrial: ________ ***Bagged*** products ________ ***Bulk*** products

Retail: ________ ***Bagged*** products ________ ***Bulk*** products

Q-2. Approximately how many flour related products (SKU's) do you produce in 1995 for industrial and retail use?

Industrial: ________ ***Bagged*** products ________ ***Bulk*** products

Retail: ________ ***Bagged*** products ________ ***Bulk*** products

Q-3. Are you a participant in preferred supplier programs for any of your flour customers? (Circle number)

1. No
2. Yes

Q-4. How many buyers (customers) do you currently have for flour?

____________ Buyers

Q-5. With what percentage of your buyers (customers), by volume, are you developing close relationships?

______________ Percent

If your firm is using Electronic Data Interchange (EDI), please answer questions 6-9.

Q-6. Please check how many of your suppliers and customers use the following features in their EDI data. (Circle number)

	Over 75 Percent	51-75 Percent	25-50 Percent	Under 25 Percent	Not in Use
1 Forecasts	1	2	3	4	5
2 Invoices	1	2	3	4	5
3 Purchase Orders	1	2	3	4	5
4 Freight Bills	1	2	3	4	5
5 Production Schedules	1	2	3	4	5
6 Quick Response Initiatives	1	2	3	4	5

Q-7. How much of a reduction in inventories have you experienced after implementing EDI?

_____________ Percent

Q-8. Have the number of stockouts been reduced after EDI has been implemented? (Circle number)

1. No
2. Yes
3. Do not know

Do you have any other comments?

____

____

THANK YOU!

President/CEO Survey

OPINIONS ON CURRENT POLICIES AND FUTURE TRENDS

This section asks you to provide opinions about some trends affecting inventory management and logistics.

Q-1. Do you feel inventory management practices of the industry have progressed to reflect current management philosophies? (Circle number)

Have not Progressed				Have Progressed as Far as Possible
1	2	3	4	5

Q-2. Do you feel EDI (Electronic Data Interchange) will continue to evolve and become a greater influence than it is now in your business? (Circle number)

Influence will Diminish				Influence will Increase
1	2	3	4	5

Q-3. Do you think the trend towards closer relationships with suppliers and customers will result in reduced levels of inventory for your firm in the future? (Circle number)

Strongly Disagree				Strongly Agree
1	2	3	4	5

Q-4. Are inbound and outbound inventories managed in the same department?

1. No
2. Yes

Q-5. Do you think improved information will allow you to reduce inventories? (Circle number)

Strongly Disagree				Strongly Agree
1	2	3	4	5

Q-6. Is inventory control critical to remaining competitive in the flour milling industry?

(Circle number)

Is not Critical				Is very Critical
1	2	3	4	5

Q-7. How does your firm manage inventory issues? (Circle all that apply)

1. Not managed
2. Formal logistics department
3. Transportation department
4. Accounting department
5. Third party providers
6. Other (specify) ____________________________

Do you have any other comments?

____

____

____

THANK YOU!

APPENDIX B

Aitchison-Silvey Model

The Aitchison-Silvey statistical model used in the study is a valuable tool for ranking responses from questions which use a numeric scale. The model can be used when there is a sense of direction in the response values. Also, the model is appropriate to be used when responses are subjective. A variable in the model exists for each question being ranked. The model utilizes a multiple logistic regression which analyzes the cumulative probabilities of each variable and solves the equations in the model simultaneously. From these probabilities, the model calculates parameter estimates for each variable. These parameter estimates are then used to determine how the variables, or questions, are ranked. The most important criteria for the model is there must be a sense of direction in the values of the numeric scale. An example offered in the literature is a cheese tasting experiment in which the response scale contains nine categories ranging from strong dislike to excellent taste.[3]

To illustrate how the model works, consider the following example. Suppose there is a question which asks respondents to rank their opinions about the importance of four trends in logistics on a one to five scale. The number one represents strong disagreement while number five represents strong agreement, with numbers two through four representing progressing degrees of agreement with each trend.

Data for the model is obtained by summing the number of responses for each trend. For example, the number of respondents who selected number one for the first trend would be determined. Then the number of respondents who selected number two would be calculated and so on until data for all four trends was computed. The resulting data set would be a matrix with five columns, one for each number in the scale, and four rows, one for each trend.

Since there exist four separate trends, four variables exist in the model, one for each trend. In addition, there must be an equation for each possible value that a variable can take. In this

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[3] See example 5.6.1, page 175 (McCullagh and Nelder, 1989).

example, each variable can take a value of one through five. However, since all probabilities must sum to one, or 100 percent, the last equation for each variable is dropped from the model. Its probability is simply the summation of the other four equations' probabilities subtracted from 100 percent. Therefore, four equations are in the model for the first trend. In this example, sixteen equations must be solved simultaneously by the model. The first equation for the first trend is shown below. This equation represents the probability of the first trend having a value of one.

$$Pr_1(y = 1) = \frac{e^{\alpha_1 + \beta_1}}{1 + e^{\alpha_1 + \beta_1}} \tag{B.1}$$

Similarly, the second equation for the first trend is shown next.

$$Pr_1(y = 1) + Pr_1(y = 2) = \frac{e^{\alpha_2 + \beta_1}}{1 + e^{\alpha_2 + \beta_1}} \tag{B.2}$$

The model has the following constraint: $\alpha_1 \leq \alpha_2 \leq \alpha_3 \leq \alpha_n$

The constraint means the model has a continuous, strictly increasing distribution function. Equation B.2 is the probability that the first trend will have a value of either one or two. Notice the only difference between equations B.1 and B.2 is the alpha character. Alpha is the only thing that

$$Pr_2(y = 1) = \frac{e^{\alpha_1 + \beta_2}}{1 + e^{\alpha_1 + \beta_2}} \tag{B.3}$$

changes for all equations related to trend one. Shown next is the first equation for the second trend.

Equation B.3 is the probability that the second trend will have a value of one. Notice the beta is the only change from equation B.1. The rest of the equations in the model follow a similar format. Alpha values change for equations related to the same trend, while beta values change for each trend.

When running the model on SAS, one variable is set to zero and dropped from the program to provide a reference point. Once parameters have been estimated, the trends can be ranked. The order of ranking depends on the direction of the scale used in the questions. In the example previously described, assume that we want to rank the trends in order of agreement. In this particular case, the smallest parameter estimate is ranked highest. Suppose that β_1 is less than β_2. A relatively high beta estimate indicates that respondents are giving that particular trend lower ratings. Therefore, the first trend is ranked higher than the second trend. Each parameter, including the variable with a zero value is similarly inserted into the order of ranking.

The Aitchison-Silvey model is a good tool for analyzing and ranking data. It is better than simply eyeing the data or evaluating means because the model examines cumulative probabilities and decides where each variable should be ranked. Ranking data based on means does not take into account variation that could exist within the data set, whereas the Aitchison-Silvey model will. It is an analytical tool which can be used in a variety of applications, the main requirement being there must be a sense of direction in the values of the scale.