ECONOMIES OF IT SYSTEMS AT WAL-MART --- AN HISTORICAL PERSPECTIVE

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ABSTRACT

This paper takes a retrospective look over Wal-Mart's IT systems. Major types of IT systems used by Wal-Mart are listed chronologically. The paper then explains the economies of IT systems at their application areas and how such economies have contributed to Wal-Mart's everyday low price strategy. The paper explores how distribution centers and IT systems function strategically at Wal-Mart, how Wal-Mart uses point-of-sale data and data warehouse technology, how Wal-Mart has used Retail Link in inventory management, and how economies of scale and scope and external economies are realized in the implementation of IT systems at Wal-Mart Stores, Inc. The paper concludes with the challenges Wal-Mart is facing.

INTRODUCTION

Researchers have attempted to reveal the importance of the relationships between retailers and suppliers using Wal-Mart as a case (Bloom et al., 2001; Bloom and Perry, 2001; Kumar, 1996). Stalk et al. (1992), on the other hand, have advocated capability-based competition by comparing Wal-Mart and Kmart. They have suggested that Wal-Mart's strategic vision was fully expressed in Wal-Mart's cross-docking system. None of the previous studies, however, have ever tried to take a comprehensive overview of Wal-Mart's IT systems and reveal how its IT systems have helped Wal-Mart in realizing its everyday low price strategy. This case study takes a retrospective look over Wal-Mart's IT systems. Major types of IT systems used by Wal-Mart are listed chronologically. The paper then explains the economies of IT systems at their application areas and how such economies have contributed to Wal-Mart's everyday low price strategy. IT systems at Wal-Mart are applied in major areas such as inventory management, administrative management, customer management and supplier management, etc. Efficiency and performance of IT systems in these areas apparently affect each other. Wal-Mart seeks to achieve not only the efficiency of individual systems, but also that of the integrated systems. Finally, the paper clarifies the existing challenges that Wal-Mart is facing. Cost control and inventory management are one of major concerns for Wal-Mart, though cost control goes beyond inventory management. Wal-Mart also has to control and reduce its cost of operation and administration and cost of sales.

The case is divided into a few sections. Section one is a brief overview of Wal-Mart's IT systems; section two explain the case study approach and data; section three discusses the strategic

role of Wal-Mart's distribution centers; section four describes how Wal-Mart uses Point-of-Sale systems to collect customer data and uses data warehouse and datamining to analyze customer behavior; section five is about Electronic Data Interchange (EDI) and Retail Link systems at Wal-Mart; section six discusses productivity improvement from IT systems; section seven shows the economies of scale and scope at the distribution centers with IT systems; section eight is about the business process standards and external economies with IT systems. Section nine covers Wal-Mart's integrated structure and major challenges Wal-Mart is facing. The final section concludes the case study with a summary.

THE CASE STUDY APPROACH

The case study approach in this paper follows Yin (1994). Yin (1994) gives very detailed instructions of how to conduct a case study. According to Yin (1994),

> A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical propositions to guide data collection and analysis (p.13).

This paper explores the economies of IT systems at Wal-Mart from the perspectives of transaction cost theory, information asymmetry, information sharing, economies of scale and scope, and externalities are useful in explaining the economies of IT systems at Wal-Mart. The author collected data about Wal-Mart from a variety of resources: SEC filings, Wal-Mart annual reports, news reports, available interviews with Wal-Mart officers, and publications about Sam Walton and Wal-Mart.

Wal-Mart annual reports often provide valuable information about information systems or technologies used in prior years. Especially when some information systems were successfully implemented and applied, the annual report for a given year often tells stories and gives comments by Wal-Mart officers. News reports about Wal-Mart are scattered around numerous sources. They also provide very important evidence about Wal-Mart IT systems. The author did not have the opportunities to interview the Wal-Mart officers, whose comments are cited in this paper, and thus must rely on the sources for veracity. Editors or journalists of many magazines such as Fortune, Information Week, Computer World, CIO, etc, interviewed Wal-Mart executives at different times. This paper incorporates those interview reports. The Wal-Mart Corporate Office provided all the annual reports and answered some of the author's questions.

A BRIEF OVERVIEW OF WAL-MART IT SYSTEMS

Accounting systems were first introduced into Wal-Mart in the late of 1960s. In 1972, Wal-Mart reported to have "considerable additions in Accounting, Data Processing and other management areas. A number of new programs and control systems were activated in 1972, both at store and management levels." (Annual Report, 1972)

In 1973, Wal-Mart developed a complete vendor system for its distribution center rebuyers and converted from an IBM 360/20 to an IBM 370/125 computer. That required physically changing all the existing programs (Annual Report, 1973).

In 1974, Wal-Mart reported that the Company realized significant freight savings through the Traffic Department's ability to obtain the most economical landed cost on merchandise purchased and to utilize the most economical modes of transportation (Annual Report, 1974).

In 1975, Wal-Mart leased an IBM 370/135 computer system, which was utilized to maintain inventory control on an item basis for all merchandise in the warehouse and distribution centers and on a classification basis for each Wal-Mart store, and to prepare income statements on a store-by-store basis. Singer electronic cash registers in 64 Wal-Mart stores and NCR mechanical and electronic registers in 61 Wal-Mart stores recorded point of sale data used to maintain inventory control (Annual Report, 1975).

In 1977, Wal-Mart built a company-wide computer network. With this communication network, messages pertaining to any phase of its operations could be sent to and from the stores immediately. The system was also used by the stores to place orders for merchandise, which expedited processing. Wal-Mart, as well, installed the cross-docking system in the Searcy Distribution Center. With the cross docking systems, merchandise in incoming trucks is unloaded at an entrance, processed, and conveyed automatically onto trucks on an exit, which are bound to branches stores (Annual Report, 1977).

Wal-Mart also developed a system for management of the corporate payroll. This system allowed store management to know, on a daily basis, their exact payroll costs and also permitted the stores to forward their payroll data to the general office without delay (Annual Report, 1977).

In 1978, the fashion distribution center utilized a computer-programmed split-ticket system of marking, where over a half a million fashion tickets could be received in an average week and quickly evaluated by buyers. Items were pre-marked and inspected for quality before leaving the distribution centers to ensure the condition of merchandise and uniform low prices in all stores. Buying decisions, reorders on hot-selling items, markdown percentages, and the automatic replenishment program could be calculated rapidly and with more accuracy (Annual Report, 1978).

Because of rapid growth in its computing power, Wal-Mart built a computer center in 1979. The first installed store computer terminal was the IBM 3774 (Annual Report, 1979).

Wal-Mart's computer development group set priorities on projects and studied the constant changes in computer technology. The aim of this department, in addition to rapid company communication, was to refine the information acquired and render it more useful and easier to read.

Computer specialists and management constantly evaluated programmed data for accuracy, simplicity, and usefulness. As a result,

Outdated reports can be discontinued immediately and necessary adjustments can be made to improve existing computer programs. The financial savings and the number of personnel hours saved daily by using the computer center is incalculable---even by the computer. (Annual Report, 1978)

In 1981, Wal-Mart implemented a new purchase order system and successfully tested a point-of-sale scanning system (Annual Report, 1981).

In 1983, Wal-Mart finished a two-year project to upgrade its in-store, backroom computers in all stores. Wal-Mart began to use Uniform Product Code as its product barcode in electronic scanning of point-of-sale (POS) data (Annual Report, 1983).

As the number of stores continued to increase, the timeliness of data became more critical. In 1984 Wal-Mart decided to establish a satellite communication network to allow the simultaneous sending and receiving of information to all stores (Annual Report, 1984). As the Wal-Mart Annual Report of 1985 noted,

The network will assure direct store-to-store and store-to-general office voice and data communication at a fixed future cost in a general environment of escalating cost. Communications will be enhanced further by WSN's capacity to beam live video presentations from the general office to the balance of the system.

Wal-Mart's Satellite Network (WSN) was successfully set up in 1987.

In 1984, Texlon handheld terminals were used as a direct assistance to store associates in re-ordering merchandise. Upon scanning a shelf label, the unit provided a description of the merchandise and information on prior quantities ordered, cost and retail of the merchandise item and the extended cost and retail of quantity being ordered. This device and accompanying system saves significant time in the ordering cycle, which in turn improves services to Wal-Mart customers (Annual Report, 1984).

In 1987, the Universal Product Barcode (UPC) was applied to all the stores and distribution centers. A check-in system designed to take full advantage of container bar code labeling, was also in the backroom of every Wal-Mart store in summer 1987. The use of the UPC brought new convenience in inventory control and distribution management: more accurately sorted shipments and immediate paperless billing; cost efficiencies in the stores' backroom freight processing and automated receiving (Annual Report, 1987).

In 1988, Wal-Mart deployed EDI systems.

In 1990, a prototype of data warehouse system was created at Wal-Mart, which stored historical sales data. In 1992, as a response to the suppliers' request for sales data sharing, Wal-Mart deployed the Retail Link system to further their partnership by moving beyond electronic data sharing. With the Retail Link system, Wal-Mart provides its vendors quality information concerning sale trends and inventory levels to facilitate genuine partnering. The actual system capitalizes on UPC and satellite communications capacity to bring its suppliers closer to its individual stores.

Wal-Mart invested $2.5 billion in capital expenditures in 1990 and $2.8 billion in 1993 for building and maintaining systems, distribution, and transportation infrastructure capacity. The goals are to not just sustain growth, but improve its productivity and reduce expense in the existing operation (Annual Report, 1993).

In 1996, Wal-Mart made Retail Link and EDI available through the Internet and began to use the Internet as an application platform. As one report estimated, up to the year 2001, Retail Link cost Wal-Mart about $4 billion and its suppliers $40 billion (Technological Review 03/2002). Wal-Mart, in 2001, further invited Atlas Commerce to add to Retail Link functions of a private online marketplace.

Wal-Mart and Sam's Club went online in June 1996. The online sites use Secure Socket Layer and Secure Transaction Protocol for secure online card transactions. In November 2004, Wal-Mart Stores launched one-hour digital photo service online. Wal-Mart customers and Sam's Club members can now upload digital photos online and pick up prints at local stores and clubs after one hour.

In 1997, Wal-Mart further increased the size of its data warehouse to 24 terabytes with 30 decision support applications. The data warehouse could process up to 50000 queries per week. In the same year, Wal-Mart installed data mining software developed by NeoVista Software, Inc. in Cupertino, Calif. (now part of the JD software group). NeoVista data mining system allows Wal-Mart to analyze point-of-sale data from each store down to the item level and assists automated product ordering and replenishment systems. Rob Fusillo, director of replenishment systems at Wal-Mart, explained that the system can further help Wal-Mart reduce inventory costs. In 2004, the storage of data warehouse amounted to 423 terabytes.

In 2002, Wal-Mart chose Internet Protocol for electronic data exchange with thousands of its suppliers in the world. With the use of the Electronic Data Interchange-Internet Integration Applicability Statement (EDIINT AS2) protocol can lower costs for the company and its suppliers. The adoption of EDIINT AS2 means that Wal-Mart suppliers will not need to resort to deploying value-added networks, which are usually expensive to use.

In 2004, Wal-Mart started to deploy RFID (Radio Frequency Identification) tags or electronic product codes. In April, it first tested the RFID tag in seven stores and a regional distribution center in Texas. Wal-Mart required its top 100 suppliers to have cases and pallets RFID tagged starting January 2005. Wal-Mart has plans to implement the electronic product code in its stores and distribution centers one after another. And Wal-Mart is urging its top suppliers to follow suit. Though there are debates about the functionality and cost problems of the RFID tag, Wal-Mart top management believe that the electronic product code is going to bring huge benefits to Wal-Mart and its suppliers and further cut their inventory and supply chain costs. Electronic product code through RFID tag will allow more data to be packaged and collected and speed up checkout for customers and provide better visibility in inventory management. RFID, together with EDI and UCCnet, can provide a huge convenience in synchronizing the supply chain[1].

The Wal-Mart Information System Division agenda includes projects such as revamping supply chain processes, synchronizing product data with suppliers using the UCCnet standard, and improving E-commerce platform, developing talent, and fostering regulatory compliance across the globe.

DISTRIBUTION CENTERS

Wal-Mart was not the first organization to set up a distribution center. In 1969 it built a distribution center, following Kmart and WoolCo's[2] lead. Before 1969, Wal-Mart bought most of its merchandise from wholesalers and some directly from suppliers. The distribution centers changed the way the merchandise was purchased and distributed. The distribution centers internalized services that were previously provided by external suppliers: manufacturers, trucking companies, and wholesalers.

A distribution center is usually equipped with many advanced information systems and robotics. Advanced systems in a distribution center includes: a system for product barcode, a cross-docking system, a stock location system, systems for tachograph analysis, vehicle routing and scheduling, systems for information processing and flow between a distribution center and the Merchandising Division such as ordering and accounting systems. Wal-Mart has been upgrading its distribution centers with new advanced systems. McKinnon (1990) analyzed four ways through which distribution centers can improve inventory control at levels of both distribution centers and stores and thus reduce inventory costs. In the case of Wal-Mart, the benefits of distribution centers include:

1. Volume buying from manufacturers brings huge savings. As its Annual Report of the year 1973 read, "The Distribution Center does not carry any item that would not result in at least a 5 percent savings, unless there were other reasons involved." Later annual reports have further confirmed this principle.
2. Better scheduling control of its own trucks dramatically reduces freight costs: "Approximately 60 percent of the trucks returning to the distribution centers from store deliveries are used to backhaul merchandise from suppliers" (Annual Report, 1973). The year 1977, 1980, and 1997 Annual Reports emphasized that Wal-Mart private truck fleets brought in large savings in freight costs, and was a key source of competitive advantage.
3. Reduction in inventory cost because of frequent and quick replenishment from distribution centers to local stores instead of slow replenishment from suppliers to local stores. All stores are one-day's drive away from the distribution centers. The year after building the first distribution center, 66 percent of merchandise was distributed to local stores through the

distribution center. In 1984, this percentage rose to approximately 77 percent of the merchandise sold in Wal-Mart stores. Now this percentage rate is kept around 80 percent.

4. More effective quality control results in less shrinkage loss and reduces return service from local stores to manufacturers, saving money.

Distribution centers internalize a variety of services that were previously provided by manufacturers, wholesalers, and outside carriers. Efficient managerial hierarchies and smooth information flow enabled by IT systems have replaced market mechanisms in coordinating distribution and logistics activities. Building a distribution center, however, needs a large amount of investment. Only when the business scale is big enough will this be possible and justifiable. Without adequate economies of scale, a distribution center can be prohibitively costly. Information systems and automations from robotics almost fix the costs of running a distribution center when the merchandising volume increases, because marginal cost of handling an additional unit of commodities or additional transaction is very small or insignificant in the short term.

Comet, a British retailer, has also reported that centralized distribution centers save costs by delivering merchandise from its centers to branch stores (McKinnon, 1990). It should be noted that small and medium sized retailers have to buy distribution service from wholesalers.

Wal-Mart has described the importance of distribution centers in its annual reports (1974, 1980, 1984, 1988, 1992, and 1998):

Distribution is a key in our ability to remain competitive. Logistics, distribution centers and transportation-the Wal-Mart distribution team is a key in our ability to remain competitive. Our 22 centers, averaging almost one million sq ft, received and shipped more than 769 million cases to our stores this past year. Our private fleet enables customized cost-efficient delivery to our stores, accommodating peak seasonal periods, night deliveries, and accelerated delivery. Our 2500 drivers and 16 000 distribution associates hard work and commitment to continuous improvement make this investment in centers and equipment pay by improving the in-stock position of our stores and making just-in-time inventory management a reality for us and our vendors. (Annual Report, 1992)

Combine these information systems with our logistics—our hub-and-spoke system in which distribution centers are placed within a day's truck run of the stores—and all the pieces fall into place for the ability to respond to the needs of our customers, before they are even in the store. In today's retailing world, speed is a crucial competitive advantage. And when it comes to turning information into improved merchandising and service to the customer, Wal-Mart is out in front and gaining speed. (Annual Report, 1998)

COLLECTION AND MANAGEMENT OF POS DATA

Wal-Mart recognizes that if it can control the sources of information and intelligently analyze and process information, it can influence those entities, which need these types of

information for their decision making. Wal-Mart, through its collection and analysis of POS data, has tried to develop information asymmetry over its suppliers and competitors. Though economies of information asymmetry may vary with respect to specific situations, such asymmetry may enable Wal-Mart to extend its business areas over production processes, devote its resources for product development, and create a series of own-label products.

At Wal-Mart, a POS data table usually consists of: store number, item number, department number, activity sequence number, selling unit quantity, selling amount, selling cost, Monday unit quantity, Tuesday unit quantity, Wednesday unit quantity, Thursday unit quantity, Friday unit quantity, Saturday unit quantity, and Sunday unit quantity (Westerman, 2001). Data are recorded with product bar codes, through which product and supplier information is coded and can be read and tracked. POS data can be analyzed for the studies and forecasts of customer demand changes, processed to display instant inventory movement down to the item level, and mined to find consumption patterns of customer and desired patterns of product display. Today all the Wal-Mart stores have POS systems connected with the Wal-Mart data center and integrated with the Wal-Mart data warehousing systems.

Back in 1984, Wal-Mart found that the data amount became too large and it became very burdensome to analyze without the aid of more advanced information systems. To simplify the use of POS data, the Data Collect system was developed in 1985 to speed data gathering and provide decision support for people who needed to analyze these data. It provides accurate tracking of merchandise sales by item for sale management on a daily basis. The system creates opportunities to maximize sales on "hot items" by maintaining proper in-stock position. Scanning also serves to reduce shrinkage by providing control over the capture and recording of markdowns (Annual Report, 1985).

Wal-Mart's IT department created an Executive Information System (EIS) in 1988 (Westerman, 2001). The EIS incorporated information from POS systems. Most of the data were about store operations, such as yearly or monthly sales, some information down to store and department level and article level. IBM's earlier version of SQL could be run in the system. Data were usually updated nightly, but there was a contest for computing sources between functional analysis and transactional processing.

To relieve the conflict, a data warehousing project was suggested and approved in 1990 to support analytical processing. The prototype system was first tested at the Merchandising Division where buyers and their assistants liked to do time series analysis over data concerning orders, receiving, and articles. The prototype system was very welcomed and proved to have a high return of investment (Westerman, 2001). POS systems were the data sources for the data warehousing system and were soon integrated with the data warehousing system. Two years later the data warehousing system was expanded and became a company-wide system, becoming an integral and fundamental block of the Wal-Mart information system network. With data warehouse available, data mining was also started in 1990 (Annual Report, 1998).

The control and analysis of POS data give Wal-Mart powerful sources to better understand its customers, enable more delicate decision-making processes, and motivate Wal-Mart to integrate some activities and risks that are originally undertaken by manufacturers and suppliers. Lee Scott, the current CEO and President of Wal-Mart, marked in the Annual Report 2003 that Wal-Mart had made big strides in internal product development. He noted, "our product development team, working with Wal-Mart buyers, is driving significant improvement in key product categories such as apparel, domestics and electronics." Wal-Mart now owns a rich series of private label products, and makes decisions on its own on how brand-name products should be presented and displayed.

Before 1992, there were few own label products at Wal-Mart. Own label products consisted of a very small portion of its revenue. In 1992, a series of Sam's American Choice was introduced as private label products. Actually Sam Walton began to plan such private labels in 1985 when Data Collect system was installed. Today Wal-Mart Stores' own label products include: OI' Roy; Great Value; Equate; Spring Valley; White Cloud; Glory; Sam's American Choice; Neighborhood Market; EverActive; Member's Mark; Special Kitty. Wal-Mart is deeply involved with private label products design, production, packaging, etc. Own label products are more profitable than national brand products because own label products do not need as large of advertising fees as national brands.

In 1997, Rob Fusillo, Director of Replenishment Information Systems at Wal-Mart, explained that Wal-Mart had started a data mining application that analyzed sales of individual items "at a lower level than we could ever have done previously."

Limited sharing of POS data with its supplier also enables new type of collaboration and coordination and extends Wal-Mart's control into the boundaries of its suppliers' business, such as production planning, forecasting, and package size and design decisions. Information sharing is limited to the sales data of suppliers' products. A supplier can only know the inventory movement of their own products. Wal-Mart discontinued the sharing of its POS data with retailing consultancy companies in 2001 (retailinfo.com 2001). Wal-Mart never shares any of its proprietary information with its suppliers, such as Wal-Mart's cost information. That is, no information sharing is intended to affect Wal-Mart's bargaining power when its buyers negotiate with its suppliers. Information sharing is often designed to increase mutual understanding between Wal-Mart and its suppliers and help its buyers convince its supplier representatives to yield and shorten negotiation processes.

INVENTORY CONTROL WITH EDI AND RETAIL LINK

In the early 1970s, Wal-Mart used computer systems to keep track of inventory down to the item level. It also developed a vender system to aid its distribution center rebuyers. To further reduce lead time, Wal-Mart installed the purchase ordering system in 1981. EDI was deployed to improve information coordination and processing with its suppliers in 1988. In 1983, Wal-Mart reported an obvious reduction in its lead time between ordering and receipt of merchandise. In 1984 Wal-Mart associates could use Texlon handheld to reorder merchandise and get information about any item inventory. In 1986 UPC was applied in inventory management. In 1987 the WSN project

was finished. This made both inside and outside coordination quicker and smoother. Simultaneous information sharing was enabled across the company and stores.

In 1992, Wal-Mart started to deploy Retail Link. Retail Link has relied on Wal-Mart data warehousing systems since it was first developed (Westerman, 2001). Retail Link allows suppliers to access their products' sales and inventory data at Wal-Mart Stores. Information sharing through Retail Link significantly reduces negotiating time and lead time between Wal-Mart and its suppliers (Westerman, 2001; Wal-Mart Annual Report, 1998).

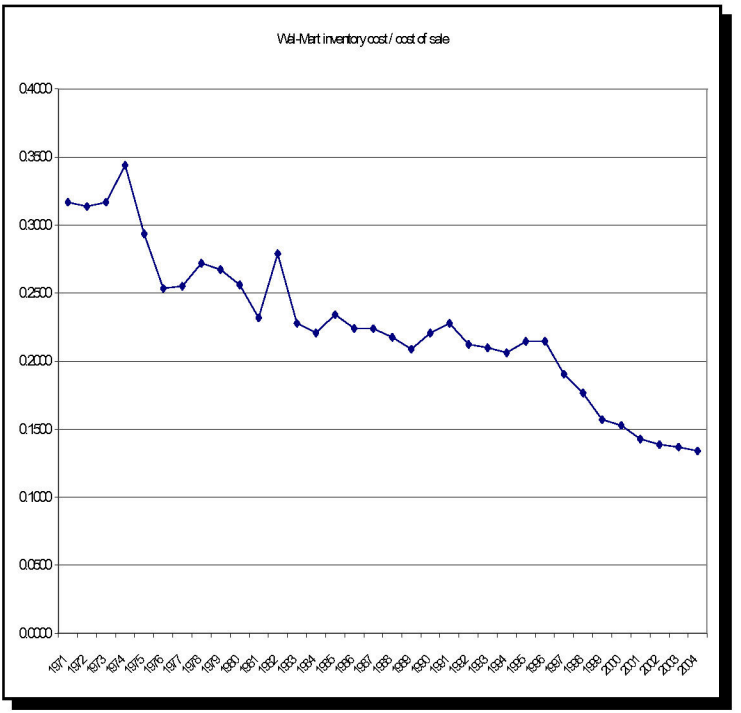
Data warehousing and data mining systems enable Wal-Mart to better understand and forecast its customers' demands and increase the probability of buying the right merchandise for its customers at the right amount and at the right time.

These systems contribute to reducing the inventory level and increasing inventory turnover as described by the CIO and other executives of Wal-Mart in the Wal-Mart Annual Reports of 1997, 1998, 1999 and 2001. As we can see from Figure 1 and 2, there are apparent increases in inventory turnover and obvious decreases in the ratio of inventory cost over cost of sale.

Figure 1: Wal-Mart Inventory Turnover 1971-2004

Data Source: Wal-Mart Annual Reports 1971--2004

Figure 2: Wal-Mart Inventory Cost/ Cost of Sale



Data Source: Wal-Mart Annual Reports 1971--2004

Retail Link has cost Wal-Mart about $4 billion up to 2001. According to Kevin Turner, then-CIO and Vice Executive President of Wal-Mart:

> Retail Link is the business leader for supplier collaboration via the Internet and has been a source of competitive advantage for Wal-Mart and SAM'S Club since 1991.

> Retail Link is an Internet application that is a free offering to our suppliers so that our suppliers may collaborate with our buyers to make better decisions that result in a lower cost of goods for our customers. Retail Link allows Wal-Mart suppliers and Wal-Mart merchants to view, manipulate and access 104 weeks of on-line, real-time, item level data that is kept at the lowest level of detail.

Since there is instant information sharing between Wal-Mart and its suppliers, the suppliers can use better data of inventory change at Wal-Mart when they schedule their production. Wal-Mart leads the retail industry with its version of a "just-in-time" supply system in which "computers track every product and automatically alert warehouses when it's time to restock the shelves" (Wal-Mart Annual Report, 1997). On the one hand, Wal-Mart suppliers are able to better plan production and reduce their inventory level though Wal-Mart may just be one of their product outlets. On the other hand, Wal-Mart itself is able to reduce its inventory level through timely replenishment of more wanted products at more accurate amounts or by simply asking its suppliers to take care of their products inventory management at Wal-Mart stores.

Wal-Mart is also testing new systems. It is implementing and applying CPFR (collaborative planning, forecasting and replenishment) and CTM (collaborative transportation management) with P&G.

Bob Connolly, Executive Vice President of Merchandising in 1997, said that there were four keys to the improvement in inventory management: 1) Systematic reduction of unproductive inventory; 2) Reduction of orders by 15 percent, enabling stores to manage their own inventory; 3) Reduced pack size across many categories; 4) Timely mark-downs. Rather than blindly slashing inventory, Wal-Mart has used the data gathered by technology to make more inventory available of the key items that customers want most, while reducing inventories overall (Annual Report, 1997).

The deployment of the electronic product code is simply to further improve the efficiency of inventory control and supply chain management. Linda Dillman, current CIO and Executive Vice President of Wal-Mart, believe that RFID will bring $7 billion benefits to Wal-Mart and its suppliers in year 2005 (InformationWeek.com, 2004).

PRODUCTIVITY IMPROVEMENT

In 1980 Wal-Mart reported that:

> Merchandise productivity is enhanced by the Distribution and Transportation Divisions. Merchandise flows from the manufacturers to the Company's distribution centers. Distribution center facilities efficiently sort the large quantities received into outbound shipments to each store. Deliveries are made on Wal-Mart trucks which backhaul other merchandise to the warehouses, eliminating as many miles traveled with empty trailers as possible. . . . Merchandise productivity is improved by the

> utilization of the store terminal network systems, which provides a means for replenishment as well as tracking of item movement and changing sales trends. Having information immediately available enables Management to respond quickly to any problems or opportunities . . . Wal-Mart continues to explore all areas for productivity improvement possibilities (Annual Report, 1980).

"Make technology pay" is frequently cited within Wal-Mart stores as new equipment, software, and communications are applied to reduce costs and improve productivity. As the Annual Report for 1992 stated Wal-Mart's "aim is the simplification of what we do, elimination of waste, and access to more meaningful information." Wal-Mart in its 1996 Annual Report revealed some information of its IT strategy:

> With an annual technology and communication budget of $500 million and an information system staff of 1200, Wal-Mart leads the industry in information technology—and we're not slowing down. We know our future earnings growth has to come not just from increased market share, but also from increased productivity. (Annual Report, 1996)

McKinsey Global Institute reported in 2002 that:

> In 1987 Wal-Mart had just 9 percent market share but was 40 percent more productive than its competitors. By the mid-1990s, its share had grown to 27 percent while its productivity advantage widened to 48 percent. Competitors reacted by adopting many of Wal-Mart's innovations, including . . economies of scale in warehouse logistics and purchasing, electronic data interchange and wireless bar code scanning. From 1995 to 1999, competitors increased their productivity by 28 percent while Wal-Mart raised the bar by further increasing its own efficiency another 20 percent. (Technology Review, March 2002)

ECONOMIES OF SCALE AND SCOPE

Economies of scale and scope are extremely important to any retailers. Economies of scale mean a decreasing marginal cost for processing an additional unit. In system application, it means applying systems to their reasonable maximum scale such that marginal cost for additional unit of information processing can be minimized or even ignored. Economies of scope mean a decreasing marginal cost for an additional unit of a relevant service or product. In system application, economies of scope mean that systems can be applied to different business processing with a decreasing additional cost.

Construction and operation of distribution centers reveal how Wal-Mart has looked for economies of scale and scope. The information systems can be used to handle information processing and distribution for Wal-Mart Stores, SuperCenters, Sam's Clubs, and Neighborhood Markets. They are used to process information for retailing of both grocery and general merchandise.

A distribution center usually has to handle a large variety of commodities. Before 1992, Wal-Mart was just a general merchandise retailer. Now a Wal-Mart discount store has about 36,000 different kinds of commodities. About 80 percent of merchandise is delivered from a distribution center. So a distribution center should be able to handle about 28,800 kinds of commodities. After Wal-Mart Supercenters and Sam's Clubs are opened, distribution centers have to deal with the double number of kinds of commodities, including general merchandise and grocery. A Supercenter usually has about 72,000 items of commodities; and a Sam's Club has more to cope with. So systems must be designed with capabilities to handle a large variety of merchandise. The growth of Wal-Mart International increases the complexity of information systems. Nevertheless, Wal-Mart Information System Division has been developing systems that can be used across different countries since Wal-Mart acquired a Canadian retailer in 1994.

That is why UPC is so important. It is used to integrate information from different terminals and systems. Information about merchandise can be traced by using UPC, regardless of the physical shape or the physical property of that product. Because of UPC, Wal-Mart merchandising systems can be applied to manage merchandise flow for different retailing channels. The implementation of the electronic product codes will lift system efficiency to a higher level.

The economies of scale and scope in system use are tremendous. The setup cost or fixed cost of building a system is high. But the marginal cost for processing an additional unit of information is very low--just some utility fees. Depreciation in the short term can almost be ignored. So the cost efficiency of large-scale IT systems requires a larger scale whenever reasonable and possible. Wal-Mart is strongly motivated to increase its scale to reduce system costs amortized to any additional dollar sale.

In 1973, the Bentonville Distribution Center distributed goods for 64 Wal-Mart discount stores. In 1975, the Bentonville Distribution Center was responsible for 104 stores with the sales of $236.2 million. In 1992, the 22 distribution centers provided service to 1928 Wal-Mart stores and Sam's Clubs with revenues of $43.9 billion. In 2001, the 33 distribution centers distributed goods to 3719 Wal-Mart discount stores, Supercenters, Sam's Clubs, and Neighborhood Markets in the USA, Mexico, and Canada with sales revenues at $191.3 billion. In 1977, the only Distribution Center at Bentonville handled about 70 percent of $478.8 million goods. In 2001, each distribution center on average had to cope with 80 percent of $4.72 billion goods and more kinds of goods. See Table 2 and 3 and Figure 3 for the detail.

Table 1
Sales Supported by Bentonville Distribution Center

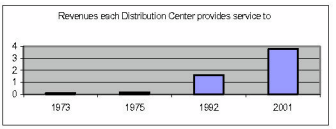
	1973	1975
Bentonville Distribution Center (236, 800 sq ft)	64 stores	104 stores
Sales supported by the distribution center	55% of $124.9 ($ million)	65% of $236.2 ($ million)
Sales supported by per sq ft at a distribution center	$290.1	$648.3

Table 2
Sales Supported by an Average distribution center

	1992	2001
Number of Distribution Centers with average size of about one million square feet	22	33
Revenues	$43.9 billion	$155.8 billion*
Average sales supported by the distribution center	80% of $1.99=1.592 ($ billion)	80% of $4.72=3.77 ($ billion) **
Sales supported by per sq ft of a distribution center	$1592	$3776

*Wal-Mart in 2001 revenue was $191.3 billion. Sales outside North America were $35.5 billion. Data are derived from Wal-Mart annual reports.
** In 1973, only 55 percent of its merchandise was distributed through its distribution center. The ratio rose to 65 percent in 1978. Since late of 1980s, the ratio has been kept around 80 percent.

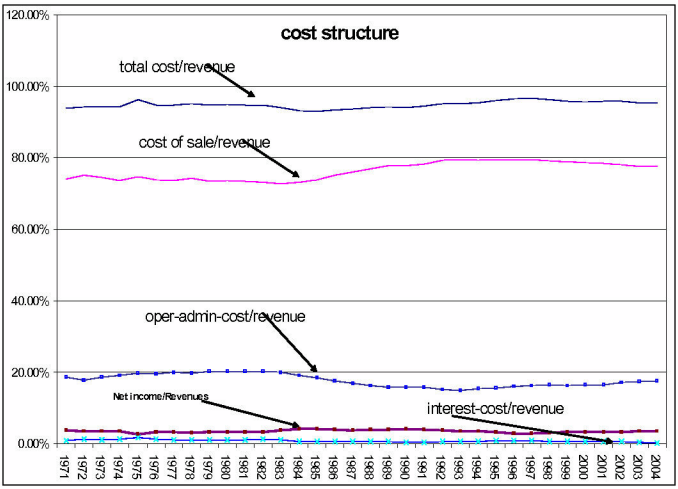
Figure 3: Average Sales Supported by A Distribution Center ($ billion)



Data Source: Wal-Mart Annual Reports 1971--2001

As IT systems contribute to the economies of scale and scope in Wal-Mart's merchandising processes, many people have expected that such a firm would have a declining ratio of administration cost over revenue. In Figure 4, we can see the operation-and-administration-cost/revenue curve declined from 1982 to 1993, but has slightly increased since 1994.

Figure 4: Wal-Mart Cost Structure 1971-2004



Data Source: Wal-Mart Annual Reports 1971--2004

BUSINESS TECHNOLOGY STANDARDS AND EXTERNAL ECONOMIES

Worcester (1969) found that external economies might enable a company to grow into a monopoly. External economies of highway, telecommunication network and technologies have been widely discussed and agreed by economists (Worcester, 1969). External economies of software technologies, termed "network externalities" by Katz and Shapiro (1985), also have been discussed. External economies of prevailing use of a software system among the public are well acknowledged though some authors would prefer to use other terms and think that network externalities are actually economies of scale in the use of software (Liebowitz and Margolis, 1994).

Technological development in telecommunication, computing, and networking have brought down the cost for information and communication processing. Prevailing use and thus wide availability of these technologies enable firms to enjoy the external economies such that marginal cost for information and communication processing has been decreasing. Wal-Mart has enjoyed external economies from the adoption of general IT technologies such as POS, UPC, telecommunication network, EDI, and Internet.

From 1983 to 1987, Wal-Mart changed its product barcode to the UPC system, resulting in many improvements in coordination consistency and convenience and big cost savings (Annual Reports 1983, 1984, 1985, 1986 and 1987). In 1988, Wal-Mart adopted EDI systems to further its effort for paperless document processing, making distribution centers online. By the early 1990s, Wal-Mart had set up arrangements with about 1810 of its approximately 5000 suppliers, making it the nation's largest user of the technology. The EDI system combined with the improved ordering system provides a more rapid replenishment of merchandise at a reduced cost (Vance and Scott, 1994).

In the mid 1990s, Wal-Mart upgraded EDI and Retail Link and made them available through the Internet. Efforts are being made to upgrade Retail Link to be XML-based, which enables compatibility between different transmission systems. Wal-Mart IT division carefully controls the software cost as the hardware cost dramatically decreases.

But Wal-Mart has hesitated in some areas about whether it should adopt any standards created by standard bodies or follow any technology vendors. In an April 2002 interview with *CIO.com* Editor-in-Chief Abbie Lundberg, Kevin Turner, CIO and Executive Vice President of Wal-Mart, said that Wal-Mart rarely buys any packaged software to avoid being tied by any software vendors. As he emphasized, Wal-Mart doesn't "have to run at the pace the software company wants to." Wal-Mart IT department does everything internally to, "take the best parts of software programs, get rid of the worst and customize to fit Wal-Mart's goals, and benchmark its progress against outsourcers and software developers.[3] That has been Wal-Mart's tradition in the management of IT system development.

Retail Link actually has had some features as a private online exchange since its start in 1990. There are retailing online exchanges (B2B) for suppliers and retailers, such as Transora and WorldWide Exchange (WWRE). But according to a report by Forrester Research, because Transora and WWRE are each seeking exclusive rights to retailer-supplier transactions, retailers are hesitant to invest resources in either one for fear of backing the loser in the contest. As a result, members have limited their participation to low-level activities like auctions, preventing any growth in exchange adoption. So Wal-Mart has decided to build its own B2B exchange based on Retail Link. Wal-Mart has invited Atlas Commerce to join its efforts to build a Web exchange. Retail Link actually set standards for supply chains when many system vendors developed their systems to be compatible with Retail Link and now connects Wal-Mart with its more than 10,000 suppliers. Vendors cannot ignore its existence when they try to develop a supply chain system.

Though UCC and ARTS, two technical organizations under VICS[4], are also developing some standards, whether retailers and suppliers would adopt the standards is uncertain. Ken Harris, SVP/CIO at GAP Inc., has doubted the viability of industry-wide standards for supply chains. As he argues, standards bodies cannot accomplish their objectives because leading companies will join in consortiums to create rival camps that will set standards for their own efforts. Actually, Wal-Mart Retail Link has a tendency to be the standard of supply chain coordination in the retailing industry.

A HIGHLY CENTRALIZED AND INTEGRATED STRUCTURE

Wal-Mart has been centralized and integrated in many areas from the start, and has kept a tight control over IT development all along. As Kevin Turner says, Wal-Mart's IT department follows three rules in system development: 1) Maintain a centralized information system infrastructure, 2) Standardize systems and platforms, 3) Be merchants first and technologists second. Wal-Mart has been widely recognized as one of the best places for IT people to work because of its productive and efficient management of system development. Wal-Mart's organizational structure does not conflict in any way with its IT policy, as Wal-Mart itself has been very centralized and integrated. There have been few changes in Wal-Mart's centralized organizational structure since the adoption of IT systems.

IT systems are tightly integrated to assure economies from system security, compatibility, and integrity. The system security, compatibility, and integrity provide the technological foundation for economies of scale and scope.

Tightly integrated IT systems do not necessarily pre-require an integrated business structure or ownership control or centralized administrative structure. With the support of IT systems, a centralized structure can also be very flexible and responsive to internal or external changes. The major problem facing Wal-Mart is the increased cost of sales and the slight but steady increase in the cost of operation and administration.

From Figure 4, we can see that the cost of sale has been at a higher level since 1992. The ratio of interest cost over revenues has been kept at a pretty low level because of Wal-Mart's successful inventory management and category management to provide continuous cash flow. Wal-Mart's major costs include cost of sales and cost of operation and administration. Cost of sales includes actual product cost, change in inventory, buying allowance from suppliers, the cost of transportation to the company's warehouse from suppliers, the cost of transportation from the company's warehouses to the stores and clubs, and the cost of warehousing for the Sam's Club segment. When asked why the ratio of cost of sale over revenue was at a higher level, Wal-Mart's Corporate Office responded, "Because Wal-Mart is not willing to increase its prices." Wal-Mart could reduce the ratio by marking up prices. But then customers would visit Wal-Mart's competitors more frequently. On the other hand, there are limits to reducing suppliers' charges. In this case, what can Wal-Mart do to reduce its increasing cost of sales?

Another issue is whether Wal-Mart has applied IT systems to their potential limits, or how much further can Wal-Mart use IT systems to reduce its costs. This issue is raised because of the steady increase in the cost of operation and administration. The ratio of cost of operation and administration over revenues decreased from 1983 to the early 1990s. Since 1992, this ratio has been slightly but steadily increasing. It is worth asking whether or not Wal-Mart has applied IT systems to their potential limits. Are IT systems at Wal-Mart facing a diminishing return problem with Wal-Mart's current size of business? These are questions waiting for further answers.

CONCLUSION

The economies of IT systems at Wal-Mart are prominent from all the perspectives. IT systems at Wal-Mart reduce costs of transaction at the distribution centers and support Wal-Mart's long-term strategy of owning the distribution centers. While many studies have indicated that IT systems reduce transaction costs and lead to smaller companies, Wal-Mart obviously is a clear case that shows the opposite.

The literature on information asymmetry and IT systems suggests that IT such as Internet can reduce information asymmetry. The POS systems and data warehousing and mining systems definitely work in a different way. While POS systems collect data for Wal-Mart and increase Wal-Mart's visibility about customers and markets, Wal-Mart's suppliers have to rely on whether Wal-Mart is willing to share information with them. There is asymmetry in understanding customers and markets between Wal-Mart and its suppliers.

Improvement in productivity due to IT systems is dramatic at Wal-Mart. Information sharing through the Retail Link between Wal-Mart and suppliers improve inventory control of Wal-Mart and suppliers. But probably we will never be able to get a complete picture of how Wal-Mart is managing and doing those things.

By using standard technologies, Wal-Mart has positive externalities. Standard technologies also provide technical foundations to realize the economies of scale. But with the size it has, Wal-Mart keeps its own standards in some areas such as supply chain management using the Retail Link system.

The economies of IT systems at Wal-Mart are evident and unique. Yet we have to investigate further whether Wal-Mart IT systems are facing a diminishing return problem. This will need further research in the future.

ENDNOTES

1 For benefits of RFID, please refer to Fugerson (2002), Jilovec (2004), and Sheffi (2004). UCCnet is a subsidiary of the Uniform Code Council, Inc. For details about UCCnet, please visit http://www.uccnet.org/.

2 WoolCo was a Canadian discount retailer. It was acquired by Wal-Mart in 1994.

[3] See http://www2.cio.com/conferences/april2002/coverage57_content.html

[4] VICS, Voluntary Interindustry Commerce Standard Association. Please visit http://www.vics.org/home for details. UCC, Uniform Code Council, INC. Details about UCC can be found at http://www.uc-council.org/ean_ucc_system/stnds_and_tech/vics_edi.html. ARTS, the Association for Retail Technology Standards. Please visit http://www.nrf-arts.org/ for details.

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