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# The Role of Information Systems and Information Technology in Reverse Logistics

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## The role of information technology and systems in reverse logistics: a case study

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**Abstract:** Reverse logistics is a process whereby a manufacturer accepts products from consumers for possible remanufacturing, recycling, reuse or disposal. Recovery of used products is receiving increased attention due to growing environmental concerns. Though studies have shown that reverse logistics practices can result in substantial cost savings for companies, there has been some reluctance implementing these methods. Our research shows that information systems and information technology may play an important role in the support of this process. To this end, we address several questions related to reverse logistics: What are the drivers – internal, external, and legislative – that impact reverse logistics? What exemplar companies have saved money by implementing reverse logistics programs? What is the role of information technology within reverse logistics? Our paper will explore this area through a case study of a company that is involved in the practice of reverse logistics. We hope that this application will shed light on the operations of a recycling outfit and the role of information technology and systems within this reverse chain. For the purpose of this paper, the company will be referred to as XYZ.

**Keywords:** reverse logistics; information technology; recycling; industry examples.

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**Biographical notes:** Kanwalroop Kathy Dhanda, PhD in Operations Management/Management Science from the University of Massachusetts at Amherst, is an Assistant Professor at the University of Portland. She has co-authored about 20 papers in the area of environmental modelling, public policy, computational economics, and reverse logistics. Her research has been published in numerous journals.

Ronald Paul Hill, PhD in Business Administration from the University of Maryland College Park, is the Bank of America Professor and founding Dean of the College of Business at the University of South Florida St. Petersburg. He has authored over 75 journal articles on a variety of topics. Areas include environmental management, corporate social responsibility, impoverished consumer behaviour, business ethics, and public policy.

## 1 Introduction

Reverse logistics is a process whereby a manufacturer accepts products from consumers for possible remanufacturing, recycling, reuse or disposal (Dowlatshahi, 2000). In the traditional supply chain, the logistician manages the flow of products from the producer to the consumer. In reverse logistics, the backward flow of products from the consumer to the producer is managed. It typically is much more than simple recycling since there is an emphasis on an actual reduction of materials employed through the remanufacture or reuse of these materials. Other manufacturers also attempt to reduce the amount of materials used in the input process. Issues arising in reverse logistics encompass distribution, inventory, and production management.

Notable companies that have used reverse logistics in their operations include BMW, DuPont, General Motors, Hewlett Packard, among others (Dowlatshahi, 2000). These companies use reverse logistics to extend the life cycle of a product and to promote alternate use of resources that can be both cost effective and ecologically friendly (Melbin, 1995). For example, such activities may reduce the cost of manufacturing a new product as much as 60% by improving the ratio of outputs to inputs (Heeb, 1989; Toensmeier, 1992; Wilder, 1988).

### 1.1 Internal and external drivers for reverse logistics

There are three primary intra-organisational activities that impact reverse logistics. These are:

- a sincere commitment to environmental issues
- successfully developed and implemented ethical standards
- the existence of managers who are responsible for their operationalisation (Carter and Ellram, 1998a).

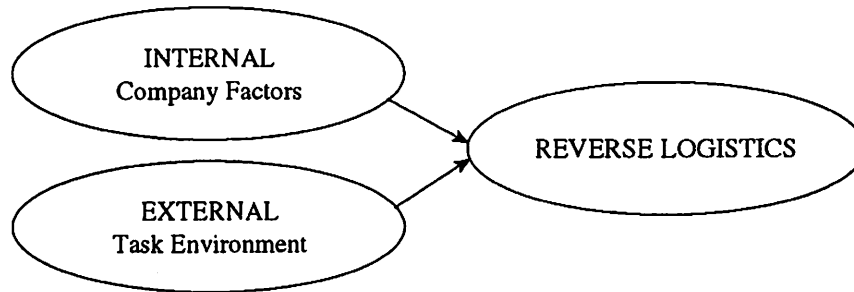
In addition, four environmental forces also directly impact the reverse logistics activities of an organisation, including customers, suppliers, competitors, and government agencies. These internal and external factors are not mutually exclusive; rather both sets impact reverse logistics simultaneously (see Figure 1).

### 1.2 Qualitative models for reverse logistics

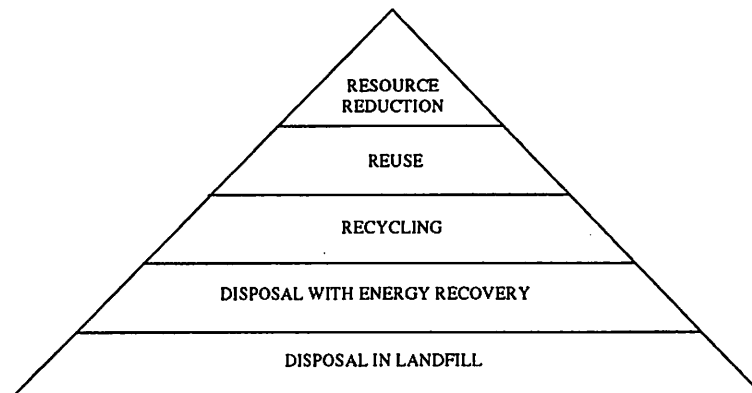
A reverse logistics hierarchy proposed by Stock (1992) and Kopicki *et al.* (1993) suggests that resource reduction is the ultimate goal (see Figure 2). This resource reduction would include both the minimisation of materials used in the product along with the minimisation of waste and energy achieved through the design of more environmentally efficient products. Once the option of resource reduction has been exhausted, the next aim is to reuse materials followed by recycling of as much waste as possible. Disposal typically is the last option employed and, even in this case, incineration is preferable since some form of energy recovery is likely (Carter and Ellram, 1998a). At times, the categories in the reverse logistics hierarchy are not mutually

exclusive. For example, Figure 3 illustrates that a rebuilt component might be neither strictly reused nor completely recycled (Carter and Ellram, 1998a).

**Figure 1** Causal antecedents and determinants of reverse logistics activities

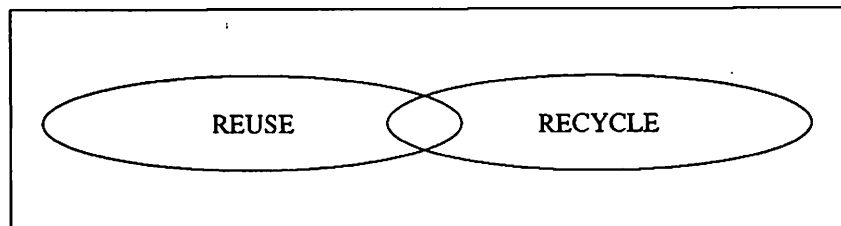


**Figure 2** The reverse logistics hierarchy

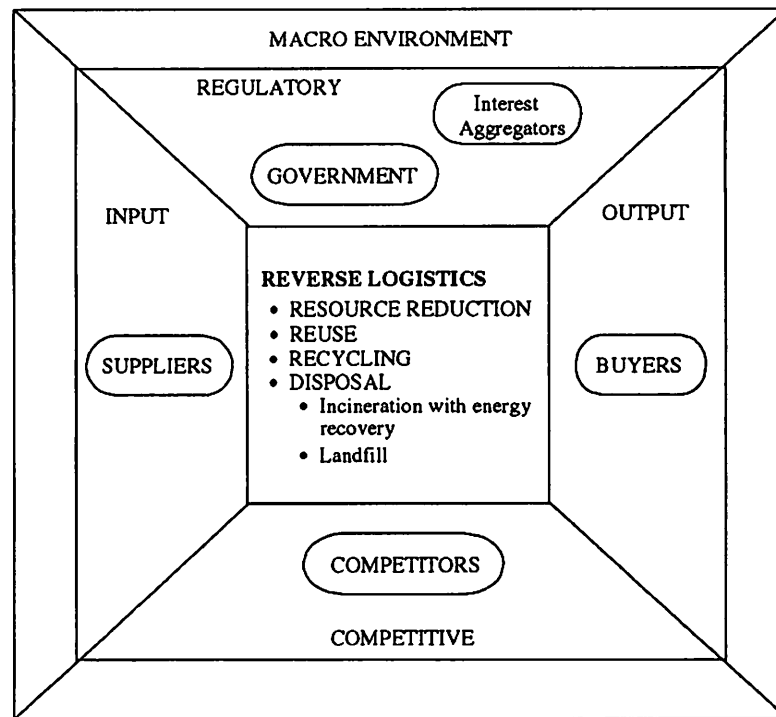


Note: Based on the work of Stock (1992) and Kopicki *et al.* (1993)

**Figure 3** The relationships among resource reduction, reuse, and recycling



Another exhaustive model (see Figure 4) found in the literature illustrates all the organisations that affect a firm's reverse logistics activities. These organisations can be the suppliers, government agencies, nonprofit organisations, competitors, etc. The environment in this model is divided into four sectors: input, regulatory, output and competitive. The macro environment surrounds the task environment and consists of social, legal, political and economic trends (Carter and Ellram, 1998a).

**Figure 4** A model of the environmental forces affecting reverse logistics activities

Note: Adapted from Achrol, Reve and Stem (1983)

### 1.3 Industry examples

There are a number of examples of companies that have successfully employed reverse logistics. The areas of application are highly diverse and range from cosmetics to automotive and transportation to printing and electronics. In the cosmetics industry, Estee Lauder Companies Inc. used to dump about \$60 million worth of products into landfills (Caldwell, 1999). However, the company decided to develop an IT system to cut back on waste. It invested \$1.3 million into a RL system consisting of scanners, business intelligence tools, and Oracle data warehouse. More than half of the money was recovered in the first year through reductions in staffing and costs. The problem was the time taken to sort out returned merchandise was very long. Now, scanners immediately calculate whether the box of merchandise can be resold, repackaged, given away or discarded. During the system's first year, Estee Lauder was able to evaluate 24% more returned products, redistribute 150% more of its returns, and save \$475,000 a year in labour costs. The company had to destroy only 27% of returned products because they were beyond their shelf life compared to 37% previously. The long-term goal is to reduce this number to 15%.

Within the transportation and distribution industry, CF MotorFreight, a nationwide full-service trucking company, introduced reverse logistics to help manage return programmes for recycling, remanufacturing and reclamation of all types of goods, from televisions to exercise equipment. By taking on the role of a third party logistics company, it helped to manage warranty returns, collection of reusable containers, and

product recalls. They also provide documentation for companies using reverse logistics, and categorise data by product type, cycle time, etc. In addition, they manage transit schedules as well as provide a toll free 800 number to help figure out where and how to send parts (PR Newswire, 1995).

In the automotive area, Ford Motor Company has a program to recycle plastic bumpers into tail light housings. GE Plastics has an experimental programme to recycle bumpers into internal automotive components, plastic benches, building materials, and fuel for incinerators (Thierry *et al.*, 1995). Mitsubishi Motor Manufacturing originally hired GATX Logistics to deliver parts on a just-in-time basis. Later they focused on a returnable container strategy that identified the volumes of defective or mismatched parts received at the plant and required suppliers to pick up these parts when they drop off new loads (Minahan, 1998).

Deere & Co. implemented a returnable container programme because legislation in several states made it very expensive to dispose of corrugated packaging. Caliber Logistics and Ryder Integrated Logistics have created a system where empty containers are returned to a particular supplier when the container inventory drops below a certain level. Deere had to spend \$50 million on information technology costs to purchase the first 200,000 reusable containers, but these costs were recouped in the first year (Minahan, 1998).

Witco Corporation, a global manufacturer of specialty chemicals, manages returns of reusable stainless steel totes from customers in Canada. The process is complicated because each container must be tracked in order to ensure compliance with both US and Canadian transport laws and customs documentation. Witco hired CF Reverse Logistics to track, monitor and arrange the return of reusable equipment. The process requires that customers call a toll-free number to notify the company when the totes are ready. CF picks up the totes, and follows Witco's guidelines to return them (Gooley, 1999). GNB Technologies Inc. manufactures automotive batteries that contain over 90% recycled or reused lead, acids, and plastic.

There are additional examples from the printing and copying industry. Printronix is a printer manufacturer whose reverse logistics programme focuses on repair and return of two primary printer components, one of which is the shuttle. The shuttle is where the majority of mechanical failures and wear-out items are located. As soon as an order for a shuttle exchange is placed, a new shuttle is shipped with a reusable container, an ID label and a phone number of a transport company to pick up the return. When the part comes back, it is examined to determine if it is repairable, irreparable, or unused (Schwartz, 2000). Xerox gives its customers incentives to return used toner cartridges. To help with recycling, Xerox mails new cartridges in a package that is ready made to return old cartridges, including the mailing label. In order to get the most use out of reverse logistics, they actually redesigned the toner cartridges to make them easier to reuse (Saccomano, 1996).

Food retailers have saved money by reusing a variety of containers. NKL, a vertically integrated Norwegian food cooperative, experienced a 220% increase in the sale of environmental products in 1997 and has used 1.5 million reusable containers for fruits and vegetables (Stock, 1998). Sainsbury's, a UK retailer, stated that they saved 2.3 million pounds in packaging costs reductions in 1997 and expected to save another 10 million pounds in 1998 (Stock, 1998). Also, the fast food chain KFC has received all of its poultry in reusable containers for the last fifteen years (Materials Management & Distribution, 1996).

In the electronics market, Thomson Consumer Electronics ships recoverable items from the US to Mexico for refurbishing. They work with a third-party distributor, Genco, to facilitate returns. Instead of taking back expensive, irreparable, obsolete or low value items, inspectors evaluate which items should be sent to Mexico and which items would be cheaper to dispose of in the US (Gooley, 1999). Cerplex Group built a reverse logistics and repair system (RLRS) business in the computer and electronics industry. The group provides services that range from the physical return of failed information technology units to the refurbishment, repair and modification of parts, subassemblies and whole units (Blumberg, 1999). 3Com, the manufacturer of the PalmPilot, had been shipping items returned by customers in the Caribbean and Central and South America back to the US, Europe or Asia. Often there was nothing wrong with these items, but the costs had already been incurred. This programme has been replaced with a process that allows 3Com to screen returns without hurting their high level of customer service (Gooley, 1999).

There are numerous other examples of companies that have cut costs employing similar initiatives. Baxter saved \$11 million through reduction of raw material usage, changes to production processes, and modifications to packaging (Stock, 1998). Smith & Vandiver, Inc. reuses boxes from received shipments and saves \$20,000 on an annual basis by cutting cardboard boxes into smaller case cartons for their own use (Stock, 1998). AT&T Network Systems saved nearly \$100 million in 19 months through a reverse logistics programme for telephone switching equipment (Carter and Ellram, 1998a). Mexico City's Coca-Cola Femsa S.A., the world's fourth largest bottler, employs systems that improve coordination of its production schedule with returns of reusable bottles (Caldwell, 1999). EVTC Inc. brings refrigerant services directly to a customer's site in response to EPA compliance issues mandated by the Clean Air Act. EVTC acquired Refrigerant Management Services, Inc. and now can provide onsite recovery and sales of most refrigerant (PR Newswire, 2000).

These many cases suggest that the services of third-party logistics companies have provided invaluable support for reverse logistics processes. Some of these third party distributors include Genco Distribution System, UPS Worldwide Logistics, GATX Logistics, Caliber Logistics, Ryder Integrated Logistics, GeoLogistics, USF Logistics, Burnham Services Corporation, BHP Logistics, Processors Unlimited, Federal Express, Yellow Freight System, and CF Reverse Logistics, which is a division of Consolidated Freightways.

#### *1.4 Role of information technology*

All logistics costs are estimated at 9.9% of the US economy (Delaney, 2000), but reverse logistics costs are rather difficult to estimate since most companies do not track them. However, according to managers who participated in a recent survey, approximately 4% of logistics costs were spent on reverse logistics (Rogers and Tibben-Lembke, 2001). When this statistic is applied to Gross Domestic Product values, the total cost is approximately \$921 billion for the year 1999 (Delaney, 2000). Another study by the Reverse Logistics Executive Council reported that reverse logistics costs exceed \$35 billion a year for US companies alone (Caldwell, 1999).

A survey was conducted of logistics executives who were members of the Council of Logistics Management (Rogers and Tibben-Lembke, 2001). One of main barriers to

implementing reverse logistics strategies was found to be the lack of an operational reverse logistics information system among 35% of the respondent base. The researchers also found that there were only a small number of good role models within the reverse logistics management systems currently in place. One reason is that few firms have automated systems tracking their returns. Since information systems (IS) department resources are rather constrained, revenue for developing reverse logistics applications often are not available. Some scholars suggest that reverse logistics systems may not be an organisational priority for companies, or managers may not be able to justify reverse logistics systems on a cost basis (Rogers and Tibben-Lembke, 2001).

Unpredictability in the quality, quantity, and timing of product returns ensures that managing the supply chain will remain a serious challenge (van Hillegersberg *et al.*, 2001). Nonetheless, effective information and communication technology (ICT) support that goes beyond current practice is needed to deal with returns effectively and efficiently. Enterprise resource planning (ERP) packages and advanced planning systems (APS) focus primarily on forward flows. With regards to recovery processes, the ERP system should be able to include return flows by having the ERP calculations take into account the parts that can be retrieved and reused (van Hillegersberg *et al.*, 2001). Also, APS can assist manufacturing by determining the optimal production plan in relation to customer service and total cost, thereby providing assistance in designing an optimal production sequence. At present, the APS algorithms do not address recovery.

A senior analyst at AMR Research stated, 'no one plans to develop commercial reverse logistics software.' The reasons are that this software would require too much customisation and reverse logistics are not a priority for IT (Caldwell, 1999). However, some vendors such as Baan, Great Plains Software, and Oracle provide support for reverse logistics in the maintenance, repair and overhaul functions of their enterprise resource planning suites. Some advanced planning and scheduling vendors such as LPA Software, Inc. and Numertix Ltd. are also addressing how a manufacturer might forecast returned goods (Caldwell, 1999). However, most of the reverse logistics systems are all or nothing propositions with little integration capabilities with other enterprise applications.

## **2 XYZ recycling company**

### *2.1 An overview of the company*

XYZ<sup>1</sup> is a privately owned recycling firm that serves a metropolitan area in the north-western part of the US. It is conveniently situated a few miles off a major interstate. XYZ is locally owned and operated by long-term residents of the community who have extensive experience in the trucking industry.

XYZ is enclosed within a 20,000-foot facility that includes 1.67 acres for parking and external and internal storage. A state-of-the-art 80-foot Unitec scale is used to determine delivery tonnage, and two dock-high loading areas, several forklifts, and a high-volume baler allow trucks to complete their drop offs in as few as seven minutes. This facility is open for business sixteen hours a day during the workweek, with limited weekend operations. If requested in advance, deliveries can be made at any time of day.

The company specialises in the recycling of a wide variety of paper waste and a limited range of plastics. Paper products include office supplies, catalogues, newspapers,



books, and other discarded paper. Additionally, XYZ recycles old corrugated containers made of cardboard that are flattened, compacted, or baled and free of waste. Plastic is restricted to stretch film that is tied in bundles or baled, and without contamination from paper or other materials.

The primary customers of XYZ fall into two categories. The majority are small haulers who contract with corporate clients and businesses to remove all or part of their refuse. These materials are sorted into recyclable and non-recyclable waste and delivered in bulk to XYZ. The other category includes commercial customers who ask XYZ to handle a portion of their waste, doing the hauling as well as the recycling of these materials. Once these marketable products are sorted, baled, and stored, XYZ seeks to sell them at competitive prices to mills and select buyers in both domestic markets and abroad.

XYZ is in an unusual situation since it must conduct marketing efforts in both directions of its production process. A traditional manufacture normally only needs to conduct its marketing efforts down the supply chain, to its customers. Its potential suppliers conduct their own marketing from up the supply chain. XYZ, on the other hand, must conduct marketing in both directions of the supply chain. Just like a traditional manufacturer, XYZ conducts marketing down the chain to its customers. But it also must conduct marketing up the supply chain as well, selling its services in order to obtain its raw materials.

Typically, companies at the front end discard their waste and pay a third party for removal. While XYZ charges for removal, they pay back a rebate based upon the tonnage of recoverable materials that can be sold for recycling into final goods. For example, XYZ might charge \$60 for each pickup, which often occurs on a weekly schedule. During a particular week, a customer may deliver three tons of materials priced at \$100, resulting in a \$40 rebate. On the other end of the production process, XYZ management continuously seeks the best prices locally, nationally, and abroad among the firms that use these materials to manufacture finished paper and plastic products.

## 2.2 Facility operations

The three key parts of XYZ's operations are the weighing of inbound and outbound product, the sorting process, and the baling process. When a truck arrives with product at the facility, it proceeds immediately to the scales to have its inbound weight recorded using the scale computer. The truck then unloads and returns to the scale to have its outbound weight recorded. The weight of the product delivered is  $(\text{product weight}) = (\text{inbound weight}) - (\text{outbound weight})$ . The process is similar for trucks shipping product from XYZ. Empty trucks enter the scale to get an inbound weight and proceed to the loading dock to be filled. They are then weighed again prior to leaving. The shipped product is calculated as  $(\text{product weight}) = (\text{outbound weight}) - (\text{inbound weight})$ .

Sorting of recyclable materials from non-recyclable materials and contaminants begins soon after the product arrives at XYZ. If the materials are already in a homogenous form, they are moved to the raw product holding or the finished product area. Usually the product is a mixture of diverse materials and must be 'source-separated', or sorted. In most cases, this mix consists of predominantly one material, such as cardboard. In this case, the employees will pick through the material to extract the other types of useable material such as plastic and paper, and prohibitive

materials such as metal, wax-coated cardboard and unusable plastics. This is simply done in the process of moving the material into the baler. Sometimes, the material does not have a dominant material in the mix. In this case, employees simply spread large quantities of material over the yard and discard prohibited items such as metal, wax-coated cardboard, and unusable plastics. The useable paper products are put in the mixed paper pile at the warehouse, and the useable plastic is put in the 'dirty plastic' pile where it will be sorted into clean and dirty at a later time. Paper products are later dumped into the sorter where higher-grade materials are separated out from other recyclable paper and any remaining contaminants.

The baling process utilises a conveyor belt onto which recyclable product is placed. It is carried up and falls into the charging chamber of the baler, and when enough material has accumulated, a hydraulic piston compacts and binds it with heavy gauge stainless steel wire. Once the product is baled, it is moved to a finished products portion of the facility. A bale typically weighs about 1400 lbs, but this number varies according to product type and density. It can also be affected by the weather conditions such as rain, high heat, or humidity. Variability is of little concern since prices are based on actual weight rather than the number of bales. Flow diagrams of the production processes for cardboard, plastic, and paper are provided in Figures 5, 6, and 7 respectively.

Figure 5 Cardboard flow model

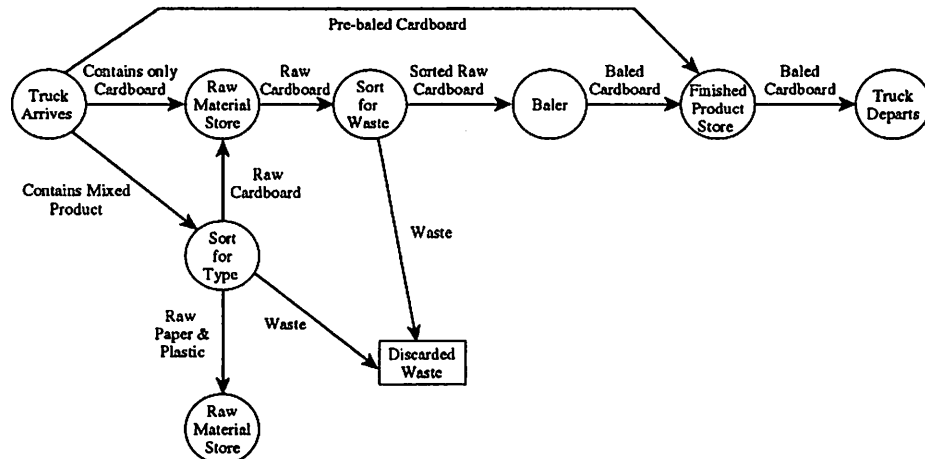


Figure 6 Plastic flow model

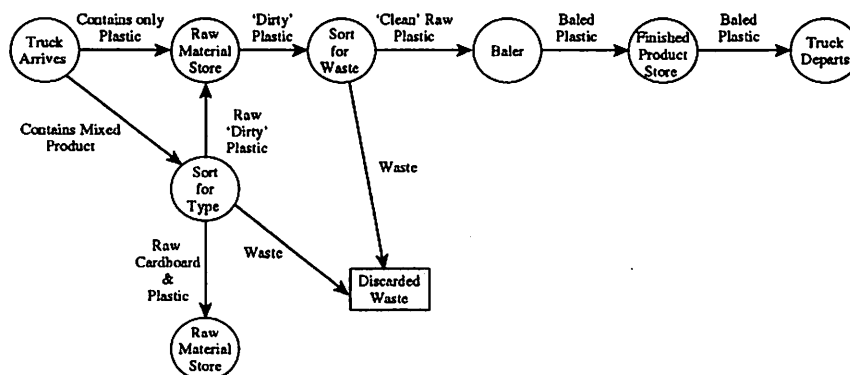
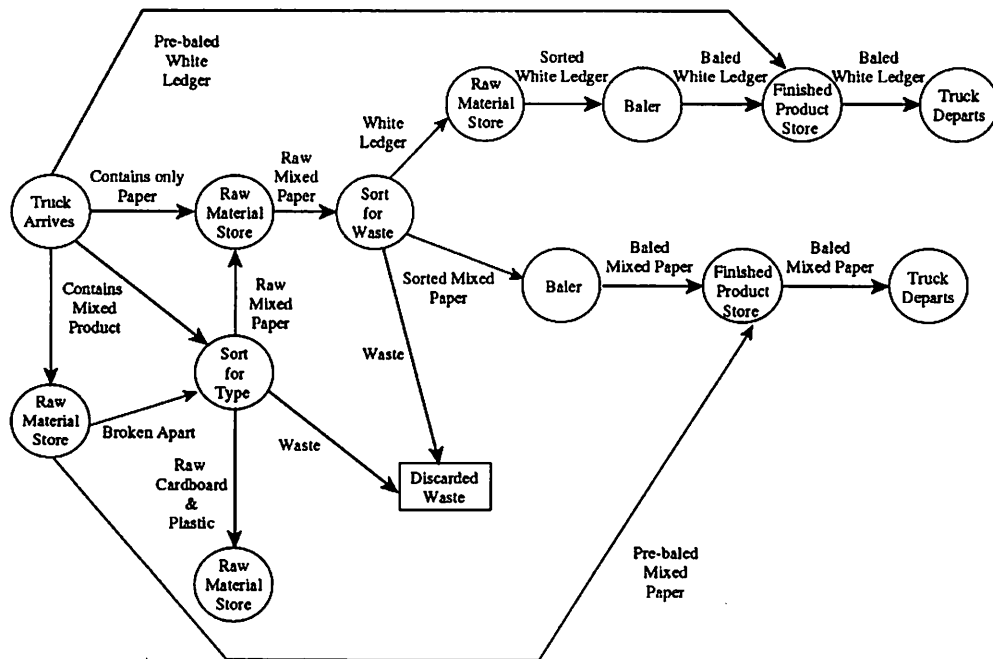


Figure 7 Paper flow model



A major source of XYZ's raw product is Company A<sup>2</sup>, a 'total waste management' company. This means that company A provides all possible disposal services for clients and requires them to separate materials such as office paper, cardboard, plastic, and unusable trash. They deliver recyclable products to XYZ and dispose of the trash in a landfill. On the other end of the production process is Company Z<sup>2</sup>, a major producer of wood and paper products, who is also a major recycler of high-grade paper products. Company Z purchases bales of cardboard and paper, which are broken down into pulp and used in the manufacture of new paper and cardboard. In between these two operations is another Company M, operating as both a recycler and a paper mill. Company M is both a customer and competitor to XYZ. As a competitor, Company M seeks raw recyclable product from the same sources as XYZ. As a customer of XYZ, Company M purchases bales of mixed-paper. Being a larger facility, they are able to take advantage of economies of scale and machine automation. In a process known as 'upgrading', Company M breaks down these mixed-paper bales and uses automated sorters to extract the higher grades of paper from the bales. Due to its smaller size and labour-intensive sorting process, XYZ does not find it profitable to perform this upgrading in their own facility.

### 2.3 Information technology and systems challenges

IT usage at XYZ is very limited even though there is a network of computers in the main office. They are used primarily for general tasks such as internet access, e-mail, and word processing, and they operate on Windows 98 or Windows 2000. There is a computer connected to the truck scale that runs on DOS and has software that keeps a simple database. This system tracks inbound and outbound shipments, clients served, and

weights of the trucks. However, it is not on the network and only has a dot-matrix printer as an output method. As a result, all shipping data must be manually entered into the network with Peachtree accounting software.

The baler keeps track of the weights and number of bales generated, but these measures are manually recorded. XYZ has the long-term goal of 24-hour operation of this baler, which requires a steady stream of materials that is not always available. This inconsistent use of the baler goes against the manufacturer's instructions, causing frequent jamming and work stoppage. Additional problems with the baling system are the result of inefficient sorting. For example, a typical bale of low-grade mixed-paper often contains significant amounts of higher-grade materials. This loss of potential income is due to the labour-intensive nature of the sorting process and the smaller margins of the operations.

A final challenge faced by XYZ involves their trucking routes. Management has tried a variety of ways to organise their fleet and maximise its usage within the greater metropolitan area. Each vehicle takes a different route every day of the week in an attempt to cover the entire city and its suburbs. The primary decision heuristic for routing is to increase the customer base by making their services accessible regardless of location. While an informal attempt is made to select the most efficient path for each day, no information technology or system has been utilised in the past.

### **3 Conclusion and future research**

This paper presents the concept of reverse logistics along with some examples to illustrate how some companies achieved cost savings by implementing reverse logistics. The paper aims to explore the operations of a recycling company, one that is an integral part of the reverse logistics chain. The research question posited was to determine the role of information technology and systems within this company. Upon closer inspection, we found that information technology usage is rather limited. This is not surprising, given the small scale of the facility. Even though the IT usage in the operations portion is limited, the company does employ the web to research competitors and potential clients. In addition, the web is also used to watch the spot prices on the market for their products. The employees use email to keep in contact with their clients and the company has a new website that is primarily used for marketing and outreach purposes. Given the size of the facility and the scale of its operations, it seems that the company operates well with the above-mentioned information technology. If this facility were to become a part of a larger supply chain, one could speculate that it would need to rely on information technology and systems to synchronise their operations within the larger chain. However, since the company is a stand-alone operation, they do not seem to require sophisticated information technology or systems.

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## Notes

- 1 At the request of the company, the actual name is not revealed. Also, a request was made to keep anonymous the names of their suppliers and customers.
- 2 The names of the company's suppliers and customers are being kept anonymous at the request of the company.