Digging for Diamonds: A Conceptual Framework for Understanding Reclaimed Textile Products

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Abstract

Recycling textiles is a process that affects many entities. It avoids the punitive costs of landfill, provides employment, helps charity, and moves clothing to areas of the world where it is needed. This study uses systems theory as a theoretical framework. The purpose of this study is to present a conceptual model and a schematic of the textile recycling process for postconsumer apparel and textile waste. The conceptual model presents the categories of sort classifications and suggests that an inverse relationship exists between the volume of goods and the value of goods. The schematic presents the wide variety of textile recycling markets that are available for the sorted goods. This research is based on nearly 5 years of qualitative data collection.

Key Words

Textile Recycling, Postconsumer Waste, Environmentalism

Nothing in the textile industry should be wasted. Sheepskin coats go to Tibet, neckties to Vietnam, raincoats to London, cotton shirts to Uganda, sleepwear to Belize, and shoes to Haiti. Levi's are coveted all over the world, and worn out promotional T-shirts are made into shoddy or wiping rags. The process of recycling and reclaiming textiles affects many entities and contributes significantly, in a broader sense, to the social responsibility of the textile and apparel industries. According to one informant, textile recycling can contribute to larger profits because landfill costs are avoided. But the recycling of textiles also contributes to goodwill associated with environmentalism, employment for marginally employable laborers, charity contributions, disaster relief, and the movement of used clothing to areas of the world where it is needed.

The purpose of this article is to present a model that contributes to a better understanding of textile recycling processes. It is based on 5 years of qualitative research. The textile recycling effort is concerned with recycling and source reduction of both preconsumer and postconsumer waste. The per capita consumption of manufactured cotton, wool, and other fibers amounted to 83.8 pounds in 2003 (F. Horn, personal communication, August 13, 2003), and the Council for Textile Recycling (1997b) reported that at a national level, the postconsumer waste is about 35 pounds per person. The textile recycling industry annually diverts approximately 10 pounds per capita or 2.5 billion pounds of postconsumer waste from landfills. These pounds represent about 30% of the total postconsumer annual textile waste (Brill, 1997). As an example, although there are several well-established uses for denim waste, the denim industry still deposits more than 70 million pounds of scrap denim in U.S. landfills annually (McCurry, 1996). Furthermore, analysis of municipal solid waste indicates that unrecovered textile waste contributes to approximately 4.5% of the U.S. landfills (Hammer, 1993). According to the Environmental Protection Agency (2005), this

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equates to 4 million tons of textiles going to the landfills each year. This comprises 5% of the total municipal waste, which may not seem like a large amount, but it is when one considers that nearly 100% of the postconsumer waste is recyclable. Cognizant of this, the textile industry's current efforts, inspired by the American Textile Manufacturer's E^3 (Encouraging Environmental Excellence) program, focus on trying to increase recoverable textile waste that would otherwise end up in the landfills.

Although textile and apparel recycling is a recognized process, no model of the process has been proposed. The purpose of this article is to present a descriptive model of postconsumer textile recycling and a clarification of categories of postconsumer textiles and apparel that are reclaimed by the textile recycling industry. A model of the analysis will be presented in the findings. This research, as part of a system-level study on the textile recycling industry, focused on reclaimed, or sometimes referred to as postconsumer, textile products and markets.

Background

Sociohistorical Background

In China, more than 2000 years ago, used clothing was shredded and hand-carded for blending with virgin fibers to make yarns. During the Napoleonic war, a shortage of wool for military uniforms advanced the need for recycling postconsumer fibers. And in the United States, textile recycling is one of the oldest, yet most misunderstood, recycling industries (Nousiainen & Talvenmaa-Kuusela, 1994).

Prior to World War II, the United States was a major importer of rags, cuttings, and other textile waste materials because the United States was a leader in mechanization for converting the used textiles into manufactured raw materials. The flow has been reversed since World War II, however. Now the United States exports tons of textile waste materials primarily because of the overconsumption of textile goods that eventually results in textile waste. Another factor that contributed to the United States' becoming a textile waste exporter is the passage of the Textile Fiber Products Identification Act and the Wool Products Labeling Act, which diminished the demand for certain types of textile waste materials. Furthermore, the Wool Products Labeling Act had an impact on U.S. consumer attitudes toward reprocessed wool (Colford, 1991).

Western lifestyle is a significant contributor to landfill waste. Not only are products consumed at a high level, but Western goods are often overpackaged, which contributes even more to the waste stream (Johnson, 2001). As landfill capacity continues to be scarce, the costs of dumping will continue to rise. These rising costs continue to be of concern for businesses as they seek ways to reduce their overhead costs (K. Stewart, personal communication, March, 17, 2004).

Compounding the notion of overconsumption is the notion of fashion itself. The very definition of fashion fuels the momentum for change, which creates demand for ongoing replacement of products with something that is new and fresh. In addition, fashion has reached its tentacles beyond apparel to the home furnishings industry. Thus, fashionable goods contribute to consumption at a lever higher than need. But without the notion of fashion, the textile, apparel, and home furnishings industries would not be able to maintain viability. Many of today's retailers no longer have four to five fashion collections per year. Instead, new fashions arrive daily to sustain consumer interest, thereby stimulating sales and profits (Frings, 2005).

As consumers continue to buy, waste will continue to be created, further compounding the problem of what to do with manufacturing waste and discarded apparel and home textile products. Clothes in today's marketplace are different from those of several years ago, not only in design but also in fiber content. After synthetic fibers came onto the market in the 20th century, textile recycling became more complex for two distinct reasons: (a) Fiber strength increased, making it

more difficult to shred or "open" the fibers, and (b) fiber blends made it more difficult to purify the sorting process. Nonetheless, the recycling industry must cope with everything that the fashion industry has generated (W. Shapiro, personal communication, July 22, 2000).

Textile Recycling Industry

The textile recycling industry is one of the oldest and most established recycling industries in the world (Council for Textile Recycling, 1997b), yet few people understand the industry, its myriad players, or reclaimed textile products in general. Throughout the world, used textile and apparel products are salvaged as reclaimed textiles and put to new uses. This "hidden" industry (Divita, 1996) consists of more than 500 businesses that are able to divert more than 1.25 million tons of postconsumer textile waste annually (Council for Textile Recycling, 1997a). Furthermore, the textile recycling industry is able to process 93% of the waste without the production of any new hazardous waste or harmful by-products. The Council for Textile Recycling has indicated that virtually all after-use textile products can be reclaimed for a variety of established markets (E. Stubin, personal communication, July, 17, 2001). Even so, the textile recycling industry continues to search for new viable markets for value-added products made from used textile fiber.

Little scholarly research has been conducted on the textile recycling industry as a system. Rather, research on textile recycling has focused primarily on consumer perceptions of recycled textile products as a concern for the environment. Shim's (1995) exploratory work looked at the relationship between consumer environmental attitudes and their clothing disposal patterns. Kim, Forney, and Arnold's (1997) study examined whether or not environmental concerns influenced consumers' response to fashion advertisement. Kim and Damhorst's (1998) work focused on the knowledge consumers have with regard to textiles and the environment and its relationship to consumer behavior. It is established that consumer knowledge of disposal options (Koch & Domina, 1999) and current waste-recycling behavior (Daneshvary, Daneshvary, & Schwer, 1998) have an impact on recycling methods. It also has been found that consumers were more apt to buy used clothing that was clean, clearly sized, and creatively merchandised (Steinbring & Rucker, 2003). Although all of these works have contributed in an important way to the literature, all focused on consumers. Hawley (2000) took the recycling process beyond the consumer in an article that presented the micro-macro dimensions of the textile recycling industry, and Divita (1996) studied apparel manufacturers to determine the variables that had the greatest impact on manufacturers' support for textile recycling. Only one study reported postconsumer market applications (Chang, Chen, & Francis, 1999).

Systems theory provides a useful theoretical framework for understanding the textile recycling process. Because of a holistic view (Olsen & Haslett, 2002), systemic thinking helps to explain the connectedness, interdependencies, feedback processes, and integration of the textile recycling system. Textile recycling can be classified as either preconsumer or postconsumer waste that is removed from the waste stream and recycled back into the market (both industrial and end consumer). Preconsumer waste consists of by-product materials from the textile, fiber, and cotton industries that are remanufactured for the automotive, aeronautic, home building, furniture, mattress, coarse yarn, home furnishings, paper, apparel, and other industries. Through the efforts of the textile recycling industry, 75% of the preconsumer waste that is generated is diverted from our landfills and recycled (Council for Textile Recycling, 1997a).

Postconsumer waste is defined as any type of garment or household article made from manufactured textiles that the owner no longer needs and decides to discard. These articles are discarded either because they are worn out, damaged, outgrown, or outdated. These textile products are sometimes given to charities and passed on to friends and family, but in addition are disposed of into the trash and end up in the municipal landfills.

Method

Van Maanen (1998) pointed out that qualitative research is a style of research that takes "an inductive, interpretive approach most often marked by a reliance of multiple sources of information" (p. xi). He further noted that the aim of qualitative studies is to "produce a more or less coherent representation, carried by word and story" (p. xi). Finally, Van Maanen reminds us, "Qualitative research, as critics gleefully point out, remains loose and unspecified" (p. xxiii). That, too, is the case of this project, which remains ongoing, ever-evolving, and always fascinating to me. In addition, because this article suggests a systems analysis, a wide range of unobtrusive observations were made.

Qualitative research is usually most interested in coming to terms with specific social phenomena in a given period of time. This qualitative project is based on 5 years of interviews, participant observation, and case studies of members of the Secondary Materials and Recycled Textiles (SMART, 2003) organization, as well as international brokers from Italy and Thailand, a retired textile executive from the United Kingdom, and a textile engineer from the United Kingdom. The convenience sample of *rag dealers* was selected based on geographic area, size of operation, type of operation, and willingness to participate. Site visits were made as case analyses to eight of the SMART members' facilities. Three annual SMART conferences were attended where one-on-one unstructured interviews were conducted with 53 SMART members, the executive director of SMART, and the president of the Council for Textile Recycling. In addition, data were collected from textile scientists who conducted research on used fiber in England, owners of two reprocessing facilities in Prato, Italy, and with street vendors of used textiles in Thailand.

The objective of this research was to examine the textile recycling of postconsumer waste from a systems perspective. Thus, informants were selected on the basis of purposeful sampling to get a broad perspective of the process. Unstructured interviews with the informants were designed to uncover underlying motivations, beliefs, behaviors, and feelings on specific topics. Field notes and interview data were coded and analyzed from the beginning and were reanalyzed as the research progressed. Occasionally, follow-up telephone interviews were conducted for clarification and when deeper understanding was needed.

Findings

The textile recycling industry has a myriad of players that includes consumers, policy makers, solid-waste managers, not-for-profit agencies, and for-profit retail businesses (Hawley, 2000), but the focus for this article is on the textile sorting companies, known as "rag graders," that acquire, sort, process, export, and market pre- and postconsumer textile products for various markets. Most rag-sorting companies are small, family-owned businesses that have been in operation for several generations (Allebach, 1993; Shapiro & Sons, 1961). Start-up entrepreneurs have begun new textile recycling businesses, however, because they perceive it as a low-cost, easily accessible form of entrepreneurship. What many of the start-ups fail to realize, however, is that this business is highly dependent on global contacts that take years of nurturing in order to have markets to sell their sorted goods. As one informant told me,

> I have spent as much as a year at a time away from my family while I developed and nurtured markets across Africa, Asia, and Latin America. Now that these business contacts have been established, I can pass the contacts on to my son who will be taking over the business soon.

An informant from a different company said, "Establishing contacts in Africa is particularly difficult. But once those contacts are made, the bond between us is very strong and full of respect." And an international broker from Europe stated,

> Buying and selling in Africa is an underground business. The used-textile brokers in Africa are substantially wealthier than many of the citizens

> who are the customers for the used clothing. They must hide their wealth in order to maintain credibility among the citizens. One of our buyers has a beautiful burled-wood and gilded office that is actually located underground. When we go to Africa to do business, we have to be secretly escorted underground to conduct business!

Depending on the current economic climate (primarily associated with materials availability and the current commodity price for used textiles), for-profit rag-sorting companies realize both success and hardship. Although the primary goal for these small businesses is to earn profits, the business owners also are very committed to environmental philosophies and take pride in their contribution to waste reduction. As one informant offered:

> This is not a particularly lucrative business. The profit margin is so small, that when the commodity prices increase, policy makers put up barriers, or the market becomes too saturated, it becomes very difficult to make a living. But, we in the textile recycling industry also take great pride in the role we play in improving the environment.

These business owners continue to seek, develop, and nurture markets for reclaimed textiles to not only increase their company profits but also to continue to increase the amount of pre- and postconsumer textile goods diverted from the landfills.

Many of the textile recycling companies in the United States are in their third or fourth generation. But as the competitive nature of the business has increased and profit margins are threatened, the younger generations have opted for careers different from their parents. A result has been the closing of several textile recycling companies in the past decade (E. Stubin, personal communication, July 17, 2001).

Many markets exist for used textile and apparel. This means that sorting companies have had to evolve with the markets and remain sensitive to its requirements, whatever they may be. A recent discussion at an annual meeting of the members of SMART focused on the need for the textile sorting industry to consider ISO 9000 certification. ISO 9000 certification would facilitate quality assurance in used textiles. Although these discussions have not yet been finalized, many of the members recognize the importance of this, especially in light of competition from their European counterparts who have already adopted ISO 9000 certification for the used textile and apparel-sorting industry.

The Sorting Process

Consumers often take apparel that is worn, out of fashion, and wrong sized to charity organizations such as Goodwill or Salvation Army. Charity agencies then sort the clothes, choose items for the sales floor, and then the "leftovers" are sold to rag sorters for pennies on the pound. The price per pound of used clothing is dependent on current market value but often ranges from three to six cents per pound. At regularly scheduled times, trucks are dispatched to pick up merchandise. Textile recycling companies are often located in large metropolitan areas because it is imperative to keep transportation costs to a minimum. It has been found that transportation and sorting costs can be the decisive criteria for profitable business (Nousiainen & Talvenmaa-Kuusela, 1994). The merchandise is then taken to the warehouses, emptied onto a sorting deck, and the sorting process begins. Newer employees make the initial crude sorts from the picking belt.

Crude sorts include the removal of coats and the sorting of trousers, blouses, and dresses. As the process proceeds, the sorts get more and more refined. For example, once all trousers are picked, they are further sorted based on women's or men's, fabric (e.g., woolens go to cooler climates, whereas cottons and linens go to hot climates), condition (e.g., tears, missing buttons, and discoloration), and quality. Certain brands and styles (e.g., Levi's, Tommy Hilfiger, and Harley Davidson or Boy Scout uniforms and bowling shirts from the 1950s) are sorted because they are considered *diamonds* based on the premium prices they bring in certain

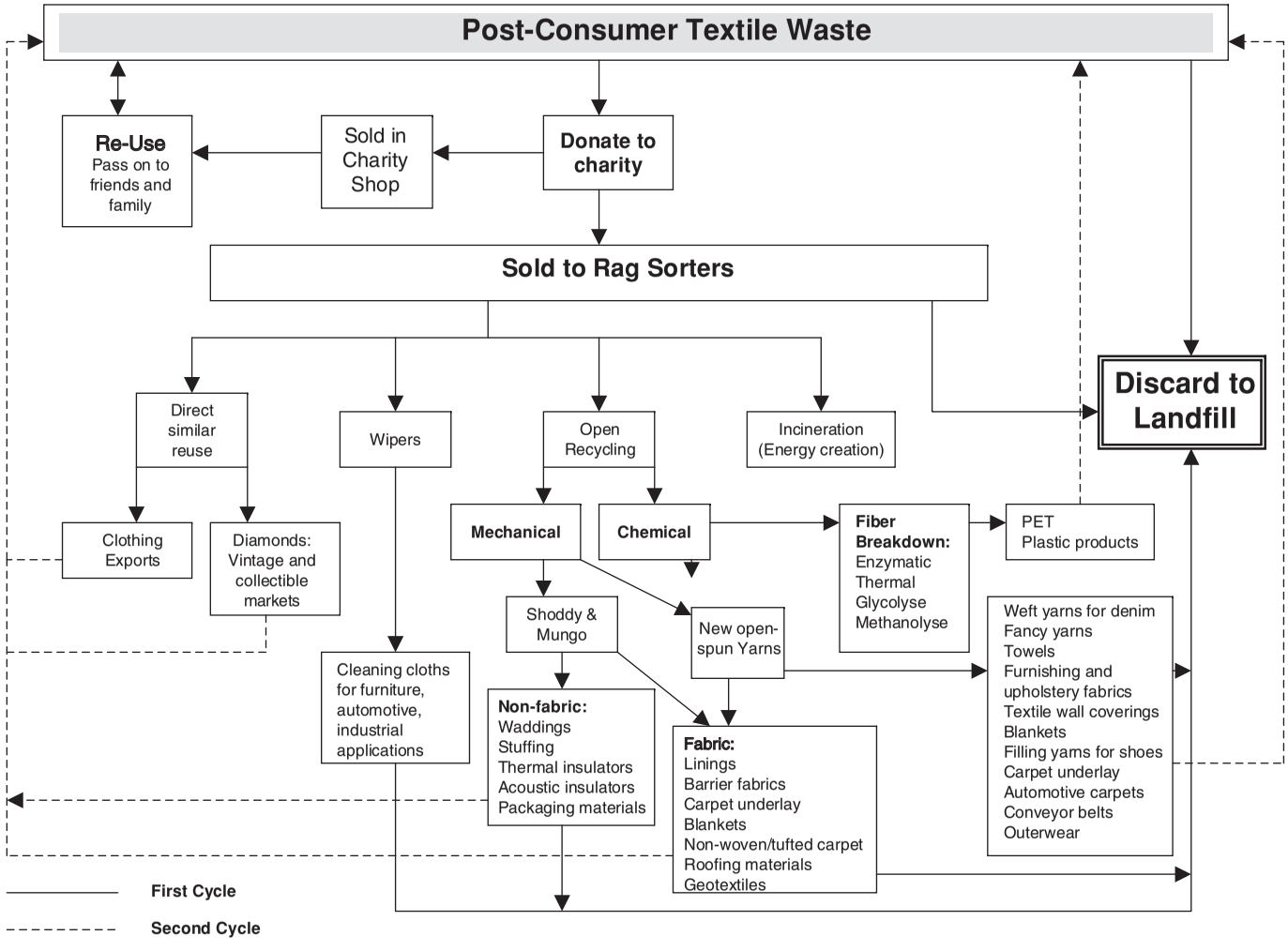


Figure 1. General Life-Cycle Schematic for Postconsumer Textiles

Figure 2. Pyramid Model for Textile Recycling Categories

markets. As the recycled goods are sorted, they are also graded to meet specific markets. It is not uncommon for a fully integrated rag sorter to have more than 400 grades that are being sorted at any given time (T. Haxton, personal communication, August 17, 2002). It is often the quality of the grading process that distinguishes a competitive advantage of one rag sorter over another. One of the largest U.S. sorting houses is in El Paso, Texas, where they sort a semitrailer load of postconsumer textiles per day. This adds up to more than 10 million pounds per year (S. Hull, personal communication, February 12, 2000).

Most rag sorters have a division of labor whereby the newest employees are trained to do the *rough sorts*, that is, sorting into categories such as heavy outerwear and bedding from the rest of the apparel items. As expertise increases, employees are promoted to more complex sorting and fine grading. For example, Marguerite, a head sorter and supervisor with several years of experience at one of the facilities in the United States, can "tell cashmere from wool at the touch of a hand." One textile recycling facility employs a person with a Master of Fine Arts degree to forecast fashion trends in the vintage markets. Goods that are torn or stained are separated from the wearable goods and used for a wide variety of markets, as will be explained below. A schematic for the sorting process of postconsumer textiles is illustrated in Figure 1.

The Conceptual Model

The pyramid model (Figure 2) represents the sorting categories of textile recycling. Whereas the largest volume of goods (48%) is sorted for secondhand clothing markets, primarily for export markets in developing countries or disaster relief, other sorting categories include sorts that are converted to wiping cloths, new products from open recycling,[1] landfill dumping or incineration for energy, and what is referred to as *diamonds*. An interesting finding revealed that, for the most part, volume is inversely proportional to value. For example, the largest volume category (by the pound), used clothing for exports, earns a range of 50 to 75 cents per pound, whereas the rare finds, called *diamonds,* can bring several thousands of dollars per item, depending on its market and/or collectible value. Figure 2 illustrates the pyramid model.

In recent years, rag sorters have realized that to stay viable, sort categories must be further refined to meet the demands of unique markets. They also work with textile engineers to engineer new products from used textiles. Available markets for used apparel flux in the marketplace. For example, wool has received a renewed interest because European flammability legislation for upholstered furnishings and protective clothing has demanded higher wool content. Thus, recycled woolens can now command a higher price. Refer again to Figure 1 for a sampling of markets for recycled or reclaimed textiles. The following discussion illustrates how the pyramid model should be conceived in a volume-to-value ratio. The percentage listed represents the average volume as discussed by the informants.

[1]Open recycling refers to the process of mechanically or chemically "opening" the fabric so as to return it to a fibrous form. Mechanically, this involves cutting, shredding, carding, and processing the fabric. Chemically, it involves enzymatic, thermal, glycolyse, or methanolyse methods. Once the postconsumer textiles are "opened," they can be further processed into new products for renewed consumption.

Used Clothing Markets

The category of used clothing from reclaimed textiles and apparel accounts for approximately 46% of the total volume of reclaimed goods. One informant reported that the "used apparel serves as the largest export from the United States based on volume" (Y. Wang, personal communication, May 10, 2004). Most of these goods are sorted for export or disaster relief markets. On many street corners throughout the developing world, racks of Western clothing are being sold (e.g., the author has seen such racks in Taiwan, Thailand, and Mexico). The United States exports $61.7 million in sales to Africa. One of its primary export sites is Uganda, where an Ugandi woman can purchase a designer T-shirt for US$1.20 (Packer, 2002). Western clothing is a highly valued commodity and perhaps serves as the only source of affordable clothing in many developing countries where levels of income are so low that food and clean water are the primary concern. However, some have argued (Hansen, 1994) that the export of clothing to these nations could threaten the traditional dress for many indigenous cultures and at the same time may threaten the fledgling textile and apparel industries of those countries. Although this is certainly a profound issue, wearable, climate-appropriate, and affordable clothing is a valuable commodity for most of the population in less-privileged areas of the world.

Not all used clothing is exported to poorer countries. One informant shared that he has a new market in the United Arab Emirates where used clothes are not intended for the wealthy local population. Instead, used clothing is intended for the immigrant labor from Bangladesh, Pakistan, and Indonesia because labor jobs do not allow the worker enough discretionary income to purchase the designer labels that are offered in the local shops.

Once sorted, the goods are compressed into large bales (usually 600 kg), wrapped, and warehoused until an order is received for export. Several things are considered when sorting for this category: climate of the market, relationships between the exporters and importers, and trade laws for used apparel. For example, recent negotiations between the U.S. Department of Commerce with the Tanzanian Bureau of Standards and the U.S. Embassy in Tanzania are concerned with the following: (a) requirement of fumigation certificates; (b) ban on used undergarments, socks, stocking, and nightwear; (c) a requirement that bales should not exceed 50 kg; (d) a requirement for a health certificate to prove the country of origin is free from diseases; (e) certification of used garments; and (f) sampling of consignment (http://www.smartasn.org/news.html). These stringent guidelines require special packaging and sometimes repackaging of goods so that they meet export guidelines. For instance, goods intended for the Tanzanian market would need to be rebaled into the smaller 50-kg bales.

Conversion to New Products

Shoddy (from knitted textiles) and *mungo* (from woven garments) are terms used for the category of recycling that "opens" textile waste and used clothing and returns them to fibrous form. Uses for shoddy and mungo include stuffing, automotive components, carpet underlays, building materials such as insulation and roofing felt, and low-end blankets. The majority of this category consists of unusable garments—garments that are stained, torn, or otherwise unusable. But some goods are used for wipers because of their fiber properties (e.g., oleophilic or hydrophilic). This process represents an economic and environmental saving of valuable fiber that would otherwise be lost to the landfill. Ironically, the most unusable and damaged of postconsumer textiles has the highest level of specifications forced upon it by the end-use industries (e.g., building, auto, aeronautics, or defense). There are two primary methods for conversion, mechanical and chemical.

Mechanical processing. This category includes the breakdown of fabric to fiber through cutting, shredding, carding, and other mechanical processes. Both economic and environmental savings of valuable fiber are used that would otherwise be lost to the landfills. This category also

serves the useful function of supplementing the world's supply of textiles (W. Shapiro, personal communication, July 22, 2000). A vast number of products are made from reprocessed fiber because much of this fiber is respun into new yarns or manufactured into woven, knitted, or nonwoven fabrications including garment linings, household items, furniture upholstery, insulation materials, automobile sound absorption materials, automobile carpeting, and toys.

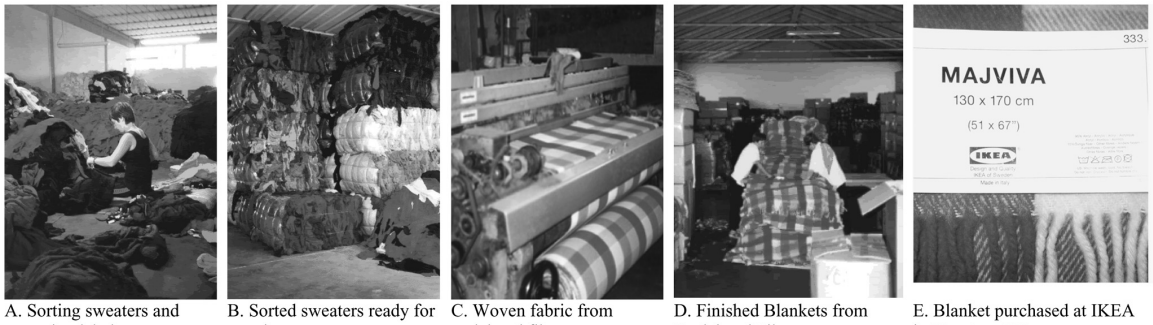
Considerations during the mechanical sorting process include color, fiber content, removal of findings such as zippers and buttons, and removal of labels. Yarns cannot normally be spun using 100% recycled fiber, because the mechanical processes reduce the original fiber length. Thus, a certain percentage of virgin fiber must be added to strengthen the final yarn. Once the clothing or textile is returned to a fibrous form, several products are made. The following is a brief description of these products.

Much of the nonwearable (e.g., torn or stained) textile and apparel products are often chopped into small pieces; further carded to return to fibrous form; and used for stuffing for mattresses, toys, and envelope padding. One informant finely chops unwearable used clothing and sells it to a manufacturer who uses it to stuff punching bags and other sporting equipment.

Some of the reclaimed fiber that is mechanically processed is used in paper making. According to PPI, a global paper company headquartered in Norway, about 36% of today's paper contains recycled fibers, including textile fiber. In an effort to enforce Section 6002 of the Resource Conservation and Recovery Act of 1976 and "reduce the municipal solid waste stream," the Environmental Protection Agency now mandates the use of recycled paper when federal funds are used for procurement (Environmental Protection Agency, 2005). This proves to be an increasingly important market for recycled fibers. An informant reported that a problem with using postconsumer textiles for paper production lies in the soapy residue that persists from repeated washings of the garment. He cited the example that preconsumer denim is commonly used in paper making, but when engineers tried to use postconsumer (old jeans) denim, the suds from soapy residue that has built up on the denim are so profuse that it interferes with the paper-making process. "Dealing with the excess bubbles is simply not worth the extra effort when new fiber can be obtained from the factories." Another informant reports that used fibers are being used in the production of U.S. currency.

Another mechanical process, known as "opening," "picking," or "garneting," reduces cuttings or other textile waste materials to fibrous form. High-quality used clothing, particularly knits, can be reduced to fibrous form and respun into coarser yarns with traditional ring and open-end spinning methods. Much of this processing occurs in Prato, Italy; Dewsbury, United Kingdom; and more recently, in India and the Philippines. In Prato, for example, a used clothing broker locates bales of sweaters from around the world. They are then sorted based on color and fiber content, reduced to fiber, stored until ready for use, spun into yarns, and then woven into blankets for mass market consumption. Fiber content varies from acrylic, to wool, to cashmere. The photos in the Figure 3 sequence were taken during data collection in Prato, Italy, and illustrate this process. After returning from data collection in Prato, the author was in an IKEA store in Houston, Texas, and, by chance, found the blankets that were being made in the Prato factory during her visit. The label on the blanket reads, "Made in Italy of Reclaimed Acrylic Fiber."

Many trade laws exist regarding used apparel. Countries cite protectionist claims, arguing that shipment of used clothing and fiber to certain countries would harm fledgling textile and apparel industries in developing nations. At times, the protectionist cry is hidden in a list of concerns including infestation of harmful insects, chemicals, and microorganisms (E. Stubin, personal communication, July 17, 2001). The fact remains, however, that many people in developing nations, even those working in the fledgling textile and



A. Sorting sweaters and removing labels

B. Sorted sweaters ready for opening

C. Woven fabric from reclaimed fiber

D. Finished Blankets from Reclaimed Fiber

E. Blanket purchased at IKEA in Houston, TX.

Figure 3. Sequence of Used Acrylic Sweater Handling to Produce New Acrylic Blankets, Prato, Italy
Source. Photographs courtesy of author.

apparel industries, cannot afford the clothing that is produced in those factories, particularly clothing that is manufactured with intent for the Western world. Instead, they are thankful to be able to buy used clothing imported from developed nations. The following example, shared by an informant, illustrates how companies maintain global markets while still maintaining trade requirements:

> India has developed a substantial industry of manufacturing wool blankets from used wool clothing. Trade laws between the United States and India do not allow the export of wool clothing from the United States. To meet this market demand, used wool clothing in the United States must be sent through a machine that slashes the garment beyond wearable condition, yet keeping it in one piece so that it can be more easily baled and shipped to India. Thus, the clothing is no longer *clothing* but is, instead, *used fiber*. India manufacturers further process the fiber to a more fibrous state, into new yarns, and then into the manufacture of blankets.

As in many other types of waste materials, both the material itself and the end usage vary greatly. The key to successful marketing therefore lies in the identification of original production methods and classification of the fiber content so that the consuming industries can be sure of obtaining a product that meets specifications required for the manufacturing process of the given industry. Careful sorting based on fiber content requires experienced sorters; in cases where specifications are particularly important, textile testing in laboratories may be required. Evidence from the research revealed that cases have been filed against some companies for selling used cashmere as 100% cashmere. Because it is often necessary to mix used fiber with virgin fiber to increase fiber quality and performance, DNA tests are needed to reveal the actual fiber content.

Another conversion product is flocking. Flocking is the process of reducing fibrous materials to a dustlike powder that is then used for decorative effects or to provide a soft plushlike finish. In some cases, flocking is also used as an ingredient for certain types of molded plastics. Informants reported that flocking may become one of the common value-added products made from mixed apparel fiber.

Chemical processes. Polyester (PES and PETP) has become one of the most common synthetic fibers in the world market. The polymer is also widely used in the production of plastics, adhesives, and film. Through melting and chemical processes, PES and PETP polymers can decompose through glycolysis or methanolysis. The resulting monomers, ethylene glycol and dimethyl terephthalate, are produced and are basically the same as the original fibers. So far, however, this process is not economically viable compared to mechanical and melting methods of recycling. Other chemical processes are described below.

Vulcanized fiber may have both mechanical and chemical processes applied. Shredded fibers are treated with chemicals, metallic chlorides, added to polyresins to form a strong and flexible substance. Vulcanized fiber is used for automotive components such as dashboards or building materials such as composite decking boards or fencing posts.

Research at the Bolton Institute in Manchester, England, is experimenting with the enzymatic breakdown of blended fibers. As one informant at the Institute explained,

> Blended fibers are difficult to handle in the textile recycling process. We are trying to find ways to capture the synthetic fibers, primarily polyester, from cotton/poly blends. When we put shredded poly/cotton fibers in this vat of enzymes, the enzymes break down the cotton fibers, leaving polyester behind. We are taking the remaining polyester, melting it, and then the resulting polyester can be used to form the base for computer motherboards. This is an exciting project for us.

Wiping and Polishing Cloths

Clothing that has seen the end of its useful life as clothing may be turned into a wiping or polishing cloth for industrial use. T-shirts are a primary source for this category because the cotton fiber makes an absorbent rag and polishing cloth. Bags of rags can be purchased at retail stores such as in Wal-Mart's automotive department. But in some cases, because of its excellent wicking and oleophilic properties, some synthetic fiber waste (particularly olefin) is cut into wipers to serve in industries where oily spills need to be cleaned up or wiped. One informant said that he sells wiper rags that he has reclaimed from the sorting process to a washing machine manufacturer for use-testing of the machines. Another informant sells oleophilic wipers to the oil refining industry. And yet another informant reported that oil spills are being cleaned up with large "snakes" that are made with a combination of oleophilic and hydrophobic used fibers.

Landfill and Incineration for Energy

This category has two components. For some reclaimed fiber, no viable value-added market exists, so the used goods must be sent to the landfill. Rag sorters work hard to avoid this for both environmental and economic reasons. Rag sorters are charged by the pound for goods that must be taken to the landfill. As stated earlier, most rag sorters also are committed to recycling for environmental reasons. Recent research has begun on the process of incinerating reclaimed fiber for energy production. Although emission tests of incinerated used fibers are above satisfactory and the British Thermal Unit is respectable, the process of feeding the boiler systems in many North American power plants is not feasible (A. Weide, personal communication, March 20, 2004). Evidence exists, however, that incineration of used textiles as an alternative fuel source is more common in Europe than in the United States. This is primarily due to the higher costs of fuel in Europe, resulting in a more innovative use of alternative fuels.

Diamonds

In May 2001, an anonymous seller placed a pair of century-old Levi's on the E-bay auction platform. Believed to be the oldest in existence, the jeans (technically denim waist coveralls) were found buried in mud in a mining town in Nevada. In fair to good condition, the anonymous seller opened the bid on May 17, 2001 for $25,000. One week later, after a frenetic final few hours of bidding, Levi Strauss & Co. won the bid and paid $43,532 for the 120-year-old dungarees (L. Downey, personal communication, July, 23, 2001). This is believed to be the highest price ever paid for denim jeans. Although the jeans were classified by the Levi Strauss & Co. historian to be in "*fair to good condition,*" they provide a paragon for *Digging for Diamonds.*

The *Diamond* category in the model accounts for approximately 1% of the total volume of goods that enter the textile recycling stream, yet this category also accounts for the largest profit center for most textile recycling companies. Many of the wives of the family-owned and -operated facilities in the United States take charge of the fine sort or "diamond" category of sorting. One informant

told me that she and her peers call these diamonds because the process of finding them is very much like mining diamonds. "When you find them, they are still diamonds in the rough, but once they are cleaned, pressed, and packaged, they are worth a lot in the marketplace."

Categories of diamonds include couture clothing and accessories, Americana items such as Harley Davidson and Levi's, uniforms such as those worn by Boy Scouts, certain branded items, trendy vintage clothes, luxury fibers (e.g., cashmere and camel hair) for new yarn production, and antique items. Many of the customers for diamonds are well-known designers or wealthy individuals. Ralph Lauren and Donna Karan both now have vintage collections. While collecting data at a rag-sorting facility in Brooklyn, New York, I was asked to leave prior to a scheduled appointment with a client because the client did not want to be identified. Other diamond customers include vintage shop owners who sell their *diamonds* in retail boutiques or on the Internet. New yarn producers in Prato, Italy, take used cashmere sweaters, reduce them to fiber, spin new yarns, and produce cashmere blankets for the luxury market. Many diamonds have global markets as evidenced by the fact that used goods move from country to country. For example, Americans are interested in imported French luxury leather goods such as Louis Vuitton, and the Japanese are interested in both Louis Vuitton and Coach, an American leather accessories company.

Americana items are highly prized in other parts of the world. When collecting data at one of the sites, five Japanese buyers were rummaging through piles of diamonds to select what they wanted to buy. The owner of the business said that there are many days out of the month when Japanese buyers are in-house making their selections. Japan is the largest importer of used American *diamonds* and has proved to be very interested in Americana items such as authentic Harley Davidson clothing; Ralph Lauren Polo clothing; or Tommy Hilfiger with the red, white, and blue signature labels. After September 11, 2001, used Tommy Hilfiger goods realized increased interest in the global market.

But perhaps the one item that has had consistent global interest is Levi's jeans, particularly certain older styles. One rag sorter found a pair of collectible Levi's and sold them on the Paris auction block for $18,000. Another rag sorter sold a collectible find for $11,000 to Levi Strauss & Co. One informant claimed that he has collected enough collectable blue jeans to "pay for my three kids' college educations." However, it requires a special eye and a sense of trend forecasting to be able to find diamonds in the huge mine of used textiles that rag sorters must sort.

Many owners of vintage shops are members of the National Association of Resale and Thrift Shops (NART). Founded in 1984, this Chicago-based association has more than 1,000 members and serves thrift, resale, and consignment shops and promotes public education about the vintage shop industry. TRAID (Textiles Recycling for Aid and Development) is a charity organization that finances itself through the sale of quality secondhand clothing. Current fashion trends are reflected by a team of young designers who use and customize secondhand clothes for a chain of specialty vintage clothing stores in the United Kingdom. Its offerings include "cheap chic and occasional designer surprise" (Ojumo, 2002; Packer, 2002). As another example, a young designer in Dallas, Texas, creates new from the old and sells wholesale to various trendy stores such as Urban Outfitters. As evidenced here, even though the *diamond* category consists of only 1% to 2% of the volume of reclaimed goods, the profits for these diamonds can make a big difference to the family business.

Conclusion and Implications

This study provides a useful model for understanding the wide array of viable markets for reclaimed, postconsumer textiles. The conceptual model depicts a pyramid that suggests that an inverse relationship of volume of goods to value of goods exists. Data from informants revealed that special emphasis is given to the identification of *diamonds* because of the high added value they

receive from the items. In addition, rag-sorting companies are committed to constant search for additional value-added markets so that all textile products can be diverted from the landfills. This includes a search for additional markets for the volume of goods in the wiping and new product categories. Finally, as a larger and larger volume of wearable used clothing has entered the recycling process, threats of market saturation in developing countries has occurred. This is a fairly recent phenomenon, but one that has caused several family-owned textile recycling companies to go out of business.

Clearly, recycling textiles is a process that affects many entities. It avoids the punitive costs of landfill, provides employment, helps charity, and moves clothing to areas of the world where it is needed. Generally speaking, supply satisfies demand in the postconsumer apparel and textile arena. Yet it is generally accepted that if demand would increase, so would supply, thereby reducing the amount of goods that go to the landfill. Although established systems exist for collecting garments and processing them back to fiber, consumers and industry need an increased awareness and acceptance of used fiber. The stigma of inferiority and cheapness must be removed by educating consumers about the contributions that recycled textiles make to the environment. The most viable category for growth is in the conversion of used apparel and textiles to new products (e.g., building materials, geotextiles, nonwoven blankets). If strong value-added products are discovered, the pyramid model based on volume to value may have to be revisited.

Additional research is needed to refine the conceptual model presented in this study, to improve the understanding of categories for reclaimed textile products, and to add preconsumer reclaimed textiles to the model. As consumers arrive at a better understanding of reclaimed textiles, they will become more accepting of products made from recycled fiber.

Future studies might investigate municipalities and their commitment toward recycled textiles as a curbside pickup option. Informants from this study have suggested that when municipalities add textiles to their recycling options, they are able to subsidize the cost of the other recycling categories (e.g., plastics, aluminum, and paper). Systematic research is necessary to understand this phenomenon. Previous research has focused on the consumer. This model contributes to a holistic or systemic understanding of the complex process and can provide a springboard for conducting research in other aspects of the textile recycling system.

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