THE CASE FOR CASEIN FIBER:
LOCAL DESIGN SOLUTIONS FOR SUSTAINABILITY IN MANUFACTURING

BY

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Abstract

In order to propose solutions to known problems, designers must consider the system in which their creations exist and design with the entire system in mind. Through literature research and expert interviews on the subject of textile and apparel manufacturing, this paper examines the problem of environmental harm caused by the creation, use, and disposal of garments inherent in the current global system. Localizing the production of textiles using casein fiber sourced from waste milk offers a unique solution to the issues of sustainability as well as opportunities for the development of unique regional fashion businesses.

Keywords: Textile, apparel, manufacturing, sustainability, localizing, casein.

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Introduction

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe." (John Muir *My First Summer in the Sierra,* 1911, p.110)

In his 2011 book *World on the Edge*, author Lester Brown addresses the prospect of social collapse on a global scale, and stresses that "if we use environmental indicators to evaluate our situation, then the global decline of the economy's natural support systems – the environmental decline that will lead to economic decline and social collapse- is well under way" (p.7). The coupling of population growth and industrial activity has led to climate change caused by anthropogenic CO_2 emissions, water scarcity and environmental degradation. With an increasing global population, the negative environmental consequences of using nonrenewable resources must be addressed (Brown, 2011). The International Energy Agency's 2010 executive summary claims "industry" is responsible for 20% of global CO_2 emissions (IEA, 2010). As one part of the industrial sector, textile and apparel production create additional environmental, social and economic problems requiring specific solutions.

The challenge of sustainability[i] has been described as a "super wicked problem" (Levin, Cashore, Bernstein, Auld, 2010)[ii], characterized by the following "key features":

> Time is running out; the central authority needed to address them is weak or non-existent; those who cause the problem also seek to create a solution; and hyperbolic discounting occurs that pushes responses

> into the future when immediate actions are required to set in train longer-term policy solutions. (p.3).

Sustainability concerns in global textile and apparel manufacturing fit the description of the "super wicked problem", but with particular needs. The alteration of the current global system can only have a marginal effect on problems in the industry due to the complex structure of global textile and apparel production. What are now needed are innovative approaches that can redesign the system to be locally sustainable.

In his article "Active, Local, Connected: Strategic and Methodological Insights in Three Cases", Nicola Morelli writes; "Design's contribution {to industry} has been to help define the social and economic role of industrial production in modern society. . . " (2011, p. 90). To address global challenges, designers must reframe the work they do from focusing solely on the job the product does for the user, to include considerations of the environmental, economic, and social impact of the products they create. Decisions need to be made throughout the design process to support the health of larger systems (McDonough & Braungart, 2002). By specifically designing manufacturing systems in reference to local contexts, it creates opportunities both for addressing problems of sustainability, as well as, creating opportunities for small designers to increase their production and impact global issues.

This paper considers the textile and apparel industry from the perspective of the designer in the United States. There are various models that could be offered, but this work explores casein, a protein in milk, as an alternative element in textile and apparel production. By using the casein in milk waste as a regionally available raw material, and

shifting the focus to local economies, designers can seize opportunities not available to them in the current system of global manufacturing. By expanding current regional systems it will create opportunities for users to participate in the design and manufacture of products, and it will offer individuals a personal stake in the environmental and social impacts of production, allowing them to take responsibility for a component of the design process.

Redesigning the textile and apparel industry to be a local and sustainable industry also offers unrealized business opportunities. As non-renewable resources diminish, innovative ideas regarding materials and new manufacturing possibilities are needed, and those willing to explore new approaches are in a position to thrive. Global manufacturing operations are shipping dependent which in turn depends on cheap fuel. The price of fuel and its availability is subject to change and dependent on many factors. As the world's resources are used up, sustainable innovations will have to become the norm for economic activities. Investing in sustainable business ideas now can ensure strong economies in the future. Obviously, designers and producers who embrace these changes will be positioned for long-term economic success.

The Current Global System of the Textile and Apparel Industry

In order to understand what elements are needed to reform the current system, it is first necessary to understand how the system operates. Many different countries and political influences play a part in activities related to global textile and garment production (Rivoli, 2005, Doeringer & Crean 2005). Industry participants include agricultural workers, skilled laborers, global corporations, politicians, chemists, machinists, artists, designers and others. The textile industry's activities touch

governments, communities, transportation companies, energy and water departments, agriculture and chemical industries. Consensus among participants revolves around cost as it relates to the point-of-sale, and the end-of-product life cycle is not generally considered. The global garment production system is extraordinarily efficient in terms of production and cost, yet it is inefficient in terms of sustainability and systems design. No value is assigned to the negative environmental or social impacts of production, and the final "cost" of garments does not include these expenditures. By not assigning value to the harmful aspects of production, they are effectively being ignored. In the long term, this denial will no longer be feasible from either a business or social perspective.

Manufacturing for the textile and apparel industry serving the United States market is characterized by complex global supply chains that inhibit opportunities for participants to coordinate efforts addressing environmental concerns (KPMG International, 2011). The complexity of the system has the effect of diverting responsibility from its participants, but understanding the structure of textile and apparel production is important to uncovering opportunities for improvements. The supply chains in garment manufacturing for United States consumers are dominated by "branded garment retailers", multinational retail corporations in charge of the social structure of the global garment manufacturing business (Aspers, 2010). A typical garment sold in the United States has been shipped to three or more countries during the production process. A garment that has been moved several times before being consumed (sold at retail), will then be used, discarded in land fill, or in a lesser percentage, recycled or shipped to yet another country for resale in a second-hand market (Rivoli, 2005). Materials, energy and water used in the production of the textiles and garments are not likely consumed in the

same country they are made, so precious natural resources often originate in one land and are discarded, presumably forever, in another.

The complexity of the industry is revealed in the textiles themselves. There are 136 distinctly different fibers according to Swicofil, a fiber sales company representing textile manufacturers.[iii] Each fiber and textiles made from blends of those fibers have environmental costs that go along with their creation. Of the fibers listed by Swicofil, 73 of them come from plant or animal sources, and they are therefore dependent in some way on natural earth systems and cycles. Environmental problems with textile manufacturing include water, waste, pollution, energy use, and the use of non-renewable resources. Up to 2500 chemicals are used in the processing of textiles, many in the finishing and dyeing stages (Lacasse & Baumann, 2004). Environmental concerns such as land stewardship, water use and waste, all problems managed at the local level, are directly affected by the production of textiles. The use of energy and natural resources in the production of textiles and apparel upsets the natural balance of ecosystems (United Nations Environment Program, 1994). Water is used throughout the textile manufacturing process. In water-stressed areas, water pollution caused by manufacturing activities can have serious consequences.

Solutions addressing environmental problems are available, however, investing in them does not always make business sense, due to the structure of the current system. Closed-loop systems, where chemicals and water are recycled and used repeatedly, eliminate some of the environmental problems caused by chemical pollution in waste and water use that occurs in traditional textile manufacturing. There is also a significant cost savings associated with implementing a chemical reuse system (EPA, 1997, p.83). Clean

energy technologies, such as solar or wind-powered manufacturing operations, are in use, but they are not dominant in the industry. Solutions for curbing waste by using fibers made from recycled materials are available, but not widely used (Hawley, 2006). Energy initiatives under the jurisdiction of governments and utilities companies are generally seen as a local problem or not an investment opportunity for an international garment retailer. Companies can see sustainability initiatives as a brand-strengthening opportunity and consider returns on investments with their efforts (KPMG, 2011). Though these concerns seem miles away from the consumer or even the designer, the extended health of the industry is dependent on increasing environmental sustainability.

Environmental Problems with Global Textile and Apparel Manufacturing

Garments sold in the United States are generally shipped several times during the production process before reaching the customers or retail locations (Rivoli, 2005). According to the International Maritime Organization, ocean liner shipping, the major form of transportation used for global garment production, accounts for an estimated 2.7 percent of anthropogenic carbon dioxide emissions annually (International Maritime Organization (IMO), 2009). Immediate improvements can be made towards increasing environmentally friendly practices by localizing production to reduce the number of miles products are shipped from raw material to distribution of the finished garment. There are additional materials and chemicals used in packaging items specifically for the shipping journey that could mostly be eliminated for local production, reducing both the cost and environmental problems. Wooden crates, plastic packaging, and chemical sprays to protect the garments from insects are all used in the shipping process and add cost to

the final product. Ancillary costs associated with global manufacturing could be eliminated and therefore be factored in as cost offsets when developing a local industry.

Cotton fiber serves as a good case study for analyzing environmental concerns with textile manufacturing. According to the USDA, cotton accounts "for nearly 80 percent of natural fiber use and more than one-third of total fiber demand worldwide" making cotton the world's most in-demand fiber (USDA, 2006, para.1). The Environmental Justice Foundation states:

> Cotton is the world's most important non-food agricultural commodity, yet it is responsible for the release of US$ 2 billion of chemical pesticides each year, within which at least US$ 819 million are considered toxic enough to be classified as hazardous by the World Health Organization. Cotton accounts for 16% of global insecticide releases – more than any other single crop. (2007, p.3)

Clearly, the amount of pesticides and chemicals used in non-organic cotton agriculture methods are an environmental concern. Chemicals used in the process may be toxic to workers and environments where textiles are made (EJF, 2007). Although cotton can be grown organically, changing farming methods requires an investment not feasible to all producers due to their limited power and financial resources. Cotton is just one example of how a desired crop can have unforeseen long term costs not always associated with the traditional bottom line.

Several private and government organizations such as the USDA have worked towards providing a method of communicating sustainability concerns through labeling

systems within agricultural industry frameworks (USDA, 2012). Many businesses and private organizations have also offered labeling systems and certifications in order to communicate organic farming methods to consumers. However, participation in certifying products is voluntary, and label and certification organizations "derive credibility from their membership" (Lackman, 2006). The USDA certifies crops as organic and manages a labeling system directed at standardizing organic farming methods for food consumption, however it was not designed to identify environmental concerns related to industrial manufacturing. Because it does not certify the entire textile process, the organic label on clothing falls short of addressing sustainability concerns connected to garment production. For example, up to 5% of a garment certified as organic by the USDA can be made of non-organic materials and still use the USDA organic label, if there is no organic choice available (USDA,2012, Lackman, 2006.). In the case of fabrics, which are often blends of fibers, this can make a significant difference as to the environmental impact of the product and its use. Therefore, a garment certified with the organic label as an indicator of an environmentally favorable product may be disingenuous to consumers not versed in the details of the labeling system. The burden is on the consumer to educate themselves, and few would have the time or inclination to become versed in the complexity of these issues. Instead, most consumers simply respond to a label without understanding its true meaning.

In 2006 the Global Organization for Textile Standard or GOTS, made up of stakeholders from several countries, introduced a labeling system meant to address environmental and social problems throughout the supply chain of textile and apparel manufacturing. The GOTS organization developed standards that attempt to "define

organic textiles as being processed with the least possible impact and residual natural and synthetic chemical inputs" (GOTS, 2012, para.4). Again, certification is voluntary, and there is a cost for retailers to attain certification for their products. Additional licensing fees are also charged to companies to use the GOTS symbol on products. There are other organizations with similar missions to organize standards around environmentally sustainable textiles (Lackman, 2006). Many companies wishing to participate in sustainable efforts through certifying their garments may not be able to justify the investment of time and money required - much less pay for the cost of improvements to their processes - and stay competitive when compared to those who do not participate. This is another example of the potential pitfalls for companies seeking a more responsible business model. The current geopolitical system often seems to be antagonistic to implementing sustainability into the industry.

Susan Strasser discusses the topic of waste in her book *Waste and Want, the Social History of Trash*, describing consumerism in the following passage: "Economic growth during the twentieth century has been fueled by waste - the trash created by packaging and disposables and the constant technological and stylistic change that has made 'perfectly good' objects obsolete and created markets for replacements" (Strasser, 1999, p.15). Over-consumption and its inherent waste is a troubling factor in promoting sustainability in textile and apparel manufacture because it is linked to economic growth (Strasser, 1999). The United States Environmental Protection Agency reported in 2010 that U.S. post consumer textile waste made up 5.3 percent of municipal solid waste (USDA, 2010) with consumers discarding 35 pounds of clothing per person annually (Hawley, 2006). Because the end-of-life cycle management is not calculated in the

textile and apparel system, the consumer is tasked with the responsibility of what to do with used clothing. Susan Strasser writes "trash is created by sorting, everything that comes into {the modern} home . . . eventually requires a decision" (Strasser, 1999, p.5). Although there are many methods of recycling, repurposing, and reselling used clothing (Hawley, 2006), the process of sorting is time-consuming and there is little incentive for consumers to do it other than a personal belief that it is a morally and ethically correct decision. Those participating in textile recycling usually have made an effort to understand and seek out options for recycling clothes. In describing the system of recycling unwanted cloth for use in paper in the U.S. in the 1800s, Strasser describes the past system as "generally cyclical, if not perfectly so: waste products were important to economic growth because they served as raw materials for other industrial processes." (Strasser, 1999, p.15). New industrial processes and modern consumption practices replaced the economics of the past. Strasser describes the change in consumer attitudes to the more recent understanding: "disposability {became} a kind of convenience, and a metaphor for freedom" (1999, p. 270).

In discussing sustainable design in their article, "Localisation and the Design and Production of Sustainable products", Dogan and Walker assert:

> Environmental degradation, exploitation of working conditions, and depletion of the natural resources are not simply the results of mass-production technologies, rather they are the outcome of how we develop and materialize the systems and technologies as well as how we design and plan the production processes and workspaces. (2008, p.284).

Planning for the reuse of a product can be a part of good design practice and many of the environmental problems caused by industrial manufacturing could be eliminated in the design stage. As the past shows us, thoughtful consideration of waste and its potential use has economic benefits for the industry.

Company Self Reporting

Textile and apparel manufacturing is a global business, with an estimated production of 60 million kilograms of fabric per year (Rupp, 2008). Determining the size of the industry and how it relates to the issue of sustainability depends on what measurements are used and their context. Metrics include economic activity, trade activity, or revenue factored by country, currency or other differentiator. Sustainability measurements might include metrics from countries that consume the most, pollute the most, or produce the most units (thus producing the most waste). This ambiguity of description holds true for gathering measurements across the system. Understanding how information about sustainability is gathered is useful to define problems with the system. In their 2011 publication "Measuring Up: Improving Sustainability in Consumer Markets", the advisory firm KPMG points out: "One of the key objectives for many firms engaging with sustainability is the desire to enhance their brand." (p.11). They argue that, "A lack of standard measurements, or benchmarks for the industry, makes it seemingly impossible to derive consistent figures from a variety of suppliers to tabulate reliable results." (Kruh, KPMG 2011, p.b). Companies have difficulty deciding which measurements to track as there are often hundreds to choose from (KPMG, 2011), and they may face a problem with transparency of reporting as they may also expose unavoidable but harmful practices. Still companies see a financial incentive to

sustainability initiatives as a way to strengthen their reputation (KPMG, 2011). In order for companies to communicate the value of these improvements, consumers must be both educated about the issues and convinced that there is added value to the product from these improvements. The complexity of supply chains and conglomerate products made with a lack of clear sustainability standards make it difficult to communicate improvements to stakeholders and consumers (KPMG, 2011). KPMG observes that companies see sustainability as a competitive differentiator (p.7), and their research shows that consumers will choose the more sustainable option when products are equal. They claim: "Industry is keenly aware that consumers will factor in a brand's social and environmental track record in purchasing decisions" (p.24). Because sustainability involves a combination of both non financial and financial issues, the lack of numerical data makes them difficult to track and any investments made, therefore must be communicated to consumers as value-added (KPMG, 2011). For the information to be effective and valid, consumers must be convinced that an increased price is warranted. There is an inherent ambiguity in this situation as consumers sometimes depend on the companies themselves to explicate the product's impact on the environment, and then, in turn, pressure the company for change. As a result of this lack of disinterested clarity, it is hard for consumers to make the best choices, and it is also difficult for companies to differentiate their brands from others less desirous of sponsoring real environmental change. For the customer and the company to both meet their desired ends, clearer standards are needed industry-wide.

Supply Chain Structure and Sustainability Initiatives

Textile and garment manufacturing operations in the United States have not competed well with the efficiency and cost advantages of the global system. In their 2005 analysis of the global fashion industry, "Can Fast Fashion save the US Garment Industry", Doeringer and Crean explain the supply chain power structure of the apparel manufacturing system as follows: "The structure of apparel supply chains is critical to understanding how the U.S. apparel industry has responded to global competition and why it has taken so long to develop effective alternatives to traditional comparative advantage" (p.2). The supply chain structure of large U.S. retailers is characterized by Doeringer and Crean in the following excerpt:

> Manufacturers can contract all or part of the production process to smaller contractors and their intermediaries {known as jobbers} . . . {and} use the contracting process to stabilize their own production and to meet peak demand, relying on jobbers {contractors} to invest in fabric and manage contracting. Because they have little capital, no design capability and experience volatile demand and chronic excess capacity, contractors have the least market power in the entire supply chain" (2005, p. 3).

Many jobbers, under pressure to provide the best prices, have difficulties justifying investments for improvements. In developing nations, textile and apparel manufacturing have offered laborers a path out of extreme poverty (Rivoli, 2005). Manufacturing operations serving the U.S. markets are important to economies in many of these countries and competition may keep some contracted businesses from making

improvements towards sustainability for fear that cost increases will cause the big retailers to move their business elsewhere. This disconnect in the structure of supply chains also limits the information that consumers can effectively gather about the products' environmental footprint.

The complex supply chain structure that diverts responsibility from the participants is the main roadblock to implementing sustainable technologies and addressing the issue of waste. Textiles and apparel produced in foreign countries are subject to governmental decisions of which the United States retailer cannot participate. Change is dependent on the consumer demanding it, understanding what it is and the corporations being able to track, measure, improve, and communicate the improvements. This situation is characterized by dependent and hierarchical relationships, rather than networked, collaborative ones (Morelli, 2011). The burden for investments in sustainability improvements often lies on the contractor who may have the smallest interest in implementing actual change.

With many actors involved, no central organization can effectively address the problems, which makes it difficult to measure the impact that any one company has on both the natural and market environments. The most effective way to reign in the problems created by the global system is to design local industries where governments and community members can participate in sustainable design solutions. In their highly regarded book on sustainable design solutions *Cradle to Cradle*, William McDonough and Michael Braungart suggest designing systems for the entire lifecycle of the product (2002). They direct designers to re-think materials by considering them as either biological or technological nutrients to be reused in other products or to "nourish" the

environment (2002, p.105-110). This design philosophy can be applied to guide the design of a local textile and garment manufacturing industry. The designer's job in global manufacturing for the U.S. market is typically situated in the United States, close to fashion markets (Doeringer & Crean 2005). Designers are in the right position to make positive changes towards sustainability and should realign their skills and knowledge to address sustainability with a local focus to create a strong textile and apparel manufacturing industry in the United States itself. It seems that, as long as production is a world away from the designers themselves, the harder it will be for actual change to occur.

Local Economies

It seems clear that in order to exercise good stewardship one must have control, and local economies have been proposed as a way to address sustainability in a meaningful fashion. In his 2002 article, "Economies for Life" David Korten describes the benefits of localization in the following passage:

> When needs are met locally, by locally owned enterprises, people have greater control over their lives, money is recycled in the community . . . jobs are more secure, economies are more stable and there are the means and incentives to protect the environment and to build the relationships of mutual trust and responsibility that are the foundation of community (para. 16).

By making businesses local, money stays in the community, which in turn generates local wealth. The growth in farmers' markets across the U.S. has shown that people are

willing to participate in the change towards sustainable local agriculture.[iv] In local economies, community members generally care about the health of their land and buying food from local suppliers, whom they know and trust strengthens those values. When the needs of consumers are met locally, less waste is produced in speculation on what will sell, and consumers are able to communicate their opinions through personal relationships. Much research has been published about the effects of localizing markets for "green" consumers, in the context of food and buildings, or local small businesses (BALLE website 2012, Shuman 1998). The principles that make localizing food a more sustainable and economically beneficial choice apply when it comes to non-food products also. It is time for these principles to be applied in other industries and not just food production alone.

Many environmental problems are location specific. For instance, renewable energy (wind, water, solar) is generally sourced locally, and without elaborate and expensive infrastructures, will remain local resources. Water and systems for water treatment are different from one location to another (dependant on climate). In his article "The Idea of a Local Economy", Wendell Berry asserts that because global economies are "beyond local influence" they are inherently unstable (Berry, 2001, para.6). David Korten describes the positive social benefits of local economies in his article "Economies for Life" as follows: "when enterprises are locally rooted, human-scale, owned by stakeholders, and held accountable to rule of law by democratically elected governments, there is a natural incentive for all concerned to take human and community needs and interest into account" (Korten, 2002, para.16). People are more likely to care about what is happening in their own backyard than what occurs around the

globe. Local economic activity gives community members "direct, long-term interest in the prosperity, health and beauty of their homeland" (Berry, 2001, para.4). Local systems also allow people to take responsibility for and share in the solutions to the problems of industry. Woodin and Lucas authors of *Green Alternatives to Globalization: A Manefesto*, describe the prospects for workers in developing nations in the following passage:

> Economic localization has the developmental advantage of enabling poorer countries to protect their infant industries and food production systems from the ruthless and often devastating competition from cheap imports, thus allowing them to develop diverse and resilient local economies that respond to local needs" (2004, p.70).

Localizing production awakens human resources, and supports regional design cultures (Morelli, 2011). When community stakeholders partner with existing industries and co-develop new systems alongside existing ones, efforts toward sustainability take on a new importance. The local manufacturing solution addresses the issue of over-consumption directly as designers keyed into their customers' interests are more likely to make exactly what the customers want by offering personalized solutions. Moving production locally shortens the supply chain at every leg of the journey, cutting time, participants and costs. Though these changes may have initial costs, the eventual benefits seem clear.

Nicola Morelli explains designers' roles in industry in the following passage:

> When industrial production models—and the development model they supported—have been identified as one of the most critical nodes in the question of sustainability, designers have been seen as part of the problem and perceived the urgence to change their perspective, methods, and role. (2011, p. 90)

Therefore designers need to change their perspective to address concerns associated with sustainability in their work. Morelli also makes the point that by relieving people of tasks (participation in the process), "people are also deprived of their own practical, operative, and even social skills" (2011, p.92). As a consequence of a lack of participation, the skills themselves are no longer valued. Susan Strasser explains:

> In cultures based on handiwork, handmade things are valuable without being sanctified as art: they embody many hours of labor. People who have not sewed, or at least watched others sews, value that labor less that those who have, and lack the skills and the scraps that enabled so many women to see old clothing worthy of remaking. (1999, p.12).

Tacit knowledge and unspoken, hands-on experience are key to innovation and participation is essential to solving manufacturing and design problems (Dogan & Walker, 2008, p.283-284). While these models may seem archaic to some familiar with current global production, these approaches have been effective for generations while the current global model is still in its infancy.

One description of "local" is an area where people share resources. In an urban metropolitan center, transportation, government, and employment opportunities are

shared between citizens. The United States Government Office of Management and Budget categorizes locations as Metropolitan Statistical Areas of 50,000 or more people centered around a principle city for the purpose of determining funding areas (2010). Metropolitan statistical areas include 84% of the U.S. population ("2010 Standards", 2010, p.2). The Kansas City, Missouri metropolitan statistical area is the focus for this analysis of local design opportunities for the textile and apparel industry using milk waste as a locally sourced, raw material.

Fashion Markets in the United States

In the article "Can Fast Fashion save the U.S. Apparel Industry?" Peter Doeringer and Sara Crean discuss the competitive advantages the United States has for renewing fashion production in the United States. They assert "what is needed are solutions that focus on developing new domestic markets and constructing new types of supply chains that specialize in producing small orders of high value products quickly" (2005, page 15.) In describing the current state of U.S. apparel manufacturing they assert: "{relying} heavily on traditional technology, the industry lacks the substantial scale economies and the new production techniques" (p.1) to compete globally. They describe fashion manufacturing in New York City as "small manufactures and contractors serving highly uncertain fashion markets, and other niche markets where order sizes are too small for mass production to be efficient" (p.7). Because the system of global mass production requires lengthy production lead times, they claim there are business opportunities for the U.S. manufacturer with the flexibility to produce small production runs. Fashion is a fast paced business and is expressed in the concept of "hyperbolic discounting", meaning humans will discount the value of later rewards

relative to the delay. Proximity to markets is significant with regard to production times and design.

Doeringer and Crean describe the advantages U.S. manufacturing operations have when considering the desires of the consumer with current system of manufacturing: "The market power in upstream textiles has been used to reinforce scale economies in fabric manufacturing by imposing large minimum orders and slow delivery times on apparel manufacturing." (2005, p. 3), and explain that "young designers often lack operating capital to meet minimum order sizes for clothing". (p.17).Generally, fashion production lifecycles begin one year in advance. They assert: "Such slow and inflexible mass production requires retailers to select styles and place orders far in advance of the start of each season, long before consumer demand can be predicted with much accuracy" (2005, p.6) and continue with: "Large retailers are locked into a supply chain model that depends on scale economies of designing and marketing mass fashion produces supplied by low cost offshore suppliers." (2005, p. 8). Because mass production efficiency "depends on large orders and it requires long production lead times and is too inflexible to offer clothing where demand is volatile or time-sensitive" (p. 5-6), manufactures have an advantage if they can supply fashionable clothing quickly. This method of smaller production is a competitive factor that offers opportunities for the smaller fashion producer in the United States that the larger international retailers cannot provide through the current global manufacturing system.

Moving design locally creates a situation where small designers have opportunities. Design is the value-added factor that can support cost increases in garments. There are also many cost offsetting advantages to local manufacture including

lower transportation costs, faster supply times, greater proximity to centers of fashion and design, and a greater ability to respond quickly to changing market demand make small designers competitive. Countries like Italy and France have been able to use these offsetting factors to maintain a vibrant local fashion industry and "a positive trade balance in apparel" (Doeringer & Crean, 2005, p.2). Countries close to global production centers have thriving design cultures because small production runs are possible[v]. "Craft workshops" are manufacturing operations for designers' haute couture lines (Doeringer & Crean 2005). These workshops employ highly skilled workers and offer the flexibility of sewing a few garments at a time, in order to quickly meet the needs of their customers, as local fashion dictates without the restriction of large minimum order runs required by big manufacturing facilities. Nicola Morelli characterizes current design methods as having a "'top-down' structure {that} clearly separates producers from users" (2011, p. 92). The networked structure of the local model supports a fashion culture that supplies customers' desires quickly. The global industrial system does an excellent job of providing value at low cost to U.S. consumers, but it does so with lengthy production schedules, and limits opportunities for small design businesses. Local manufacturing can work in conjunction with global systems by offering advantages that address individual and community needs as well as sustainability concerns.

Textile and apparel manufacturing systems should be re-designed to be local by using raw materials available regionally in order to develop sustainable business opportunities in the manufacturing sector of industry. By forming cooperative ventures with existing companies businesses will strengthen the viability of the local apparel industry, while creating new business opportunities for themselves and for local

designers. Rethinking corporate roles as part of a larger local system may provide a bottom line that includes the three principles of sustainability: people, planet, profits. Working in conjunction with other businesses may support and encourage a new sustainable industry framework.

Moving Manufacturing to Main Street

A challenge to localizing textile production is finding raw material suitable for making fabric. Opportunities differ depending on the location. In this focus area (Kansas City, Missouri) corn, soy, and casein are available in abundance due to strong agricultural industries. Cotton is grown in the southeast corner of Missouri,[vi] however it is outside of the metropolitan statistical area and not considered for this analysis (USDA, 2010). A more realistic solution lies with the dairy industry. Textiles can be made from waste milk, which is available in abundance. Casein fiber or "milk fiber"[vii] is a good solution for designing a sustainable textile business as it addresses three important concerns of sustainability, reducing waste, localizing production to control environmental damage and creating jobs. By utilizing a well-established industry, the development of a new local industry is a more stable endeavor. Unlike much local business, dairy is both a national and local offering, and manufacturing systems designs could transfer more easily to other local economies.

The Case for Casein Fiber

Dairy products are an important source of food in the United States. There are dairy farms in all 50 states and a reported 65,000 dairy farms (USDA, 2010) in Kansas and Missouri, which share the metropolitan statistical area of Kansas City. Both states combined have close to 218,000 dairy cows state wide and produce 3,944,000,000

pounds of milk per year (USDA Agriculture Overview, Kansas & Missouri, 2010). The dairy industry is looking for ways to address the problem of sustainability by diversifying their business model (Dairy Research Institute, 2011). Milk waste offers unique opportunities to develop a local textile and apparel industry. Casein fiber textile products, made from milk waste offer new business opportunities for the dairy industry to compete in "green" markets. By using waste, overall negative environmental impact of producing both fabric and milk is reduced. Casein is a suitable material to produce fiber for textiles.

Available in abundance in the metropolitan area of Kansas City, most grocery stores in the area are careful with their inventories due to the short shelf life of milk and tight profit margins. Unsellable milk from retail stores is usually returned to the supplier during the next scheduled milk delivery or, in the case of very small grocery operations, donated to a food bank or thrown away[viii]. Shatto Milk, a local company and dairy farm using glass bottles, collects unsellable milk to reclaim their containers (M.Shatto, personal communication, August 29, 2011). Since they do not have use for the milk, they have no choice but to pour the unused milk down the drain.[ix]

A larger supply of waste milk can also be found in school cafeterias. In a 2005 study conducted at Woodbury Elementary school in Minnesota, it was found that, in a five day period, a population of 652 students plus a faculty and staff of 100 produced 66 gallons of milk waste in their normal cafeteria operations. This amount represented 45% of their total cafeteria waste. Collection of school and other institutional waste milk can be sourced along regular dairy distribution routes. Information reported in a 1938 article from Time magazine helps to translate these amounts into usable numbers for

casein fiber. The article reports that the then Italian ambassador to England, Dino Grandi, wore a suit made of 48 pints of milk (6 gallons). With more than 50 elementary schools in the Kansas City metropolitan area, the supply is adequate to provide the raw material for a sizable textile industry.

A new textile and apparel industry could be formed by cooperating with an existing one. The casein fiber textiles can be made from 100% wasted milk. Development must be constant, just as the schools agree to use their waste, they will find ways to reduce it, and new innovations will be required. The fact that the raw material will most likely shrink in supply will not portent the end of a local textile industry but can serve as the beginning. When people recognize that the amount of milk wasted offers enough raw materials to create an entire new industry, they will make efforts to eliminate the waste. Product development for the local textile and apparel industry will be constantly evolving. There are opportunities to develop fibers and fiber blends made from locally sourced soy, sawdust, corn, wool, wheat gluten, and possibly other materials for the local textile industry.

Fiber made from waste milk may sound radical, but it is not actually new. Developed in the 1930's, casein fiber was produced under various trade names in several countries around the world. The manufacturing process of casein fiber was well established despite not being widely used early on, but by 1947 the U.S. was producing close to ten million pounds of casein fiber per year (Science in Farming, 1947). In the 1930's the cost of casein fiber was comparable to rayon (Time magazine, 1938). Casein fiber is made up of casein protein which constitutes about 3 percent of skim milk. Aside from fiber, other uses for casein are leather tanning, sizing, paint and glue. In the 19th

century, housewives used casein as a fixative for broken pottery (Strasser, 1999). Casein has been widely used as a plastic for buttons, buckles, imitation tortoise shell, imitation ivory, dominos and shoe horns , and is used in many food items to provide "body", as well as its most common use, cheese (Southward, 1998, p.12). From 1921-1938 production of casein increased greatly in the United States, mostly for use as a paper coating and as a binder in glue and paint (Time magazine, 1938).

The process of making casein fiber for textiles is relatively simple, similar to the process used to make soy fiber, viscose rayon, bamboo and other natural protein and synthetic fabrics. A chemical process is used to alter the natural casein to form fiber. The casein is separated from defatted milk using acid or rennet, dried, and mixed with other ingredients to produce the desired qualities that make the finished cloth suitible for clothing. Some ingredients used in casein fiber recipes have included linseed oil, acrylic, zinc and beeswax. It is important that any ingredient mixed with the fiber is biodegradable, non toxic, and dyeable with acid (suitable for protein fibers) dyes when considering sustainability. The solution is then forced through spinnerets, set in a precipitating acid bath, and cut into thread lengths for spinning (Whittier & Gould, 1940). Currently milk fiber is in production in China and Germany, but there are no guarantees that the "milk fiber" offered is produced in a sustainable way.

Anke Domaske, a German designer and chemist, has created a casein fiber she calls Qmilch that uses only organic waste milk, little water to produce, (2 gallons to produce 2 pounds of fabric as opposed to 10,000 liters used in cotton) and is biodegradable (Associated Press, 2011). She claims to have created a recipe that uses only natural ingredients to enhance the fabric's qualities in the processing. Her fabric

sets a precedent for a sustainable casein textile and was listed as one of Time magazine's top 50 inventions for 2011 (Time, 2011, p.70). Domaske has not shared her recipe, however, if the formula meets the sustainability standards required by the design of a local, sustainable textile producer, one solution to shortening development time could be to license her recipe.

Qmilch fabric is reported to be costly, at 28 dollars (U.S.) per half pound of finished fabric it is 40% more expensive than the equivalent of organic cotton (Associated Press, 2011). The higher cost of the fabric will be justified for use in a high-end garment, where cost is not as competitive and length of life is generally one or two seasons (Doeringer & Crean 2005). Designers working with local customers can demand a higher price through offering unique and specialized garments. Small numbers of custom-made garments can be produced with a high degree of design input at a higher price point. To reach the economies of scale that would allow the investment in new technological process and return the sizable investment required to create the local textile industry a basic apparel product should be produced, along with high end garments. Basic products (Abernathy, 1995) in garment retailing language are items like socks and underwear representing the largest number of units produced and with the least fashion design input (Doeringer & Crean, 2005). Basic products, are sold through a variety of large retailers, have an "indefinite design life" (p.5) and can be produced for several years without much change to the design or manufacturing method (Doeringer & Crean, 2005). Underwear, hospital gowns and socks are all possibilities as basic garment offerings for local markets as their longevity as products and market potential is great.

Like milk itself, fabric made from casein fiber is reported to have natural, healthy qualities. Anka Domaske claims Qmilch has essential amino acids that are healthy for human skin (Sevcenko, 2011). Further claims include that the material is antibacterial and hypoallergenic, qualities that lend themselves to basic products like infant cloth diapers or undergarments, yet these claims would need to be corroborated through the development processes of the locally produced casein fiber. Designers will be tasked with discovering uses based on the fabric properties developed for their local markets. Although product development is required, generally casein for fiber is time-tested and a legitimate proposition for sustainable textiles for apparel.

Dyes, Toxic Chemicals and Biodegradable Waste Solutions

Dyes must be considered when designing a system for sustainability. Any ingredient used in the casein textile dictates what dye will be used and that in turn determines limitations on colors and processes, as well as end of life cycle options. Sustainable design practice requires accounting for the entire lifecycle of a product by either planning perpetual uses for the materials, or by creating something that can break down through the biodegradation process (McDonnell & Braungart, 2002). The ingredients used in the casein fiber matter because they dictate which dyes may be used, which in turn dictates the properties of the fabrics, as well as the chemical processes required to dye and finish the fabric. For this reason, the milk fiber currently offered by one international supplier, Doshi Group, cannot be considered sustainable, even if waste milk is used, because the fiber is blended with acrylic, a synthetic chemical requiring a dying process potentially harmful to workers (Doshi Group, 2012). A casein/ acrylic blend is more difficult to dye than a natural protein fiber according to Pro Chemical Dye

company expert Nancy Rodriguez because dying acrylics requires auxiliary processes that require ventilation (N. Rodriguez, personal communication, February, 22, 2012). Rodriguez explains that acrylic is often used in fabrics because it is an inexpensive additive. Its use complicates the end of lifecycle considerations, as well as environmental impact of casein fabrics. Locally made dyes for fabric are currently not available in the Kansas City area, but this could be a goal of development. Ideally dye suitable for use with casein fiber would come from the same location as the raw material in a local industry, however these too must be developed with sustainability in mind.

As the focus shifts to cooperative solutions, it makes sense for a manufacturing facility to be flexible for several reasons. Cagla Dogan and Stuart Walker, both faculty of Environmental Design at the University of Calgary, have suggested a new approach to design methodology to address sustainability in manufacturing. Through their work, they have found that considering 'the local' in product design can help to address issues such as " product end-of-life solutions" (2008, p.277). They assert: "In the transition towards sustainability far greater integration is needed and solutions are required that take into consideration the unique and specific particularities of regions, countries and/or geographically connected counties" (2008, p. 281). According to their analysis, a local system is designed to work with existing systems to integrate sustainability though new business opportunities (Dogan & Walker, 2008, p. 285). They offer a solution in the form of a design method known as "integrated scales of design and production (ISDPS)"which reasons that flexibility in manufacturing as the key to sustainably manufactured product offerings (Dogan & Walker, 2008).

When designing a local system, the first questions to ask are what is needed and what is wanted, and then considerations as to the business aspects of the project must be weighed. The U.S. Bureau of Labor and Statistics estimates textile and apparel manufacturing industry jobs in the U.S. will decline by 48% through 2018, illustrating the devastating effect of the global textile production system on the U.S. industrial manufacturing sector (BLS"Career Guide", 2011, para.41). The city of Kansas City offers two programs to financially support businesses with the training of workers employed in newly created jobs ("Business Solutions", 2007). In the case of apparel manufacturing, the metropolitan area has four institutions of higher education with fashion or textile programs offered[x]. Textile mills could be an extension of one of the fine arts or textile colleges in the area, proving rich resources for learning and discovery. A data base of locally sourced materials can be developed to strengthen the resources for the new sustainable, co-operative industry. Local textile and apparel manufacturing is designed to work in tandem with existing industries that provide needed resources to people, working towards reduced waste, while creating innovative solutions for sustainable products. One example of this business principle in action is Ripple Glass, a recycling company in Kansas City and a successful "green" business operating through joint corporate efforts. The company was able to fund a startup venture through investments from businesses in the area concerned with sustainability. A solid business plan allowed the business to become profitable while providing glass recycling to the metro area, and their corporate partners have enhanced their own reputations as good community members, proving local Kansas City businesses are keen to get involved in

new, sustainable business opportunities (J. Krum, personal communication, March 30, 2011).

Textile mills can work directly with waste managers to design local recycling, repurposing and renewal projects at the design stage based on the specific parameters of the community's needs. Manufacturing outputs from textile production such as fabric scraps, trimmings, and others can be considered in waste management programs along with finished garment life-cycle management plans. If composting is the desired end-of life solution for fabric items, care must also be taking in the design stage to account for all trims, notions, linings and embellishments, included, otherwise, time-consuming deconstruction will be required to separate the biodegradable from the non bio-degradable.

Labor Cost Solutions for Competing in Local Markets

Certainly the global system of mass production based on the principal of economies of scale is efficient and effective in terms of price for U.S. consumers (Doeringer &Crean, 2005). There is no doubt that the reason branded garment retailers produce overseas is because of cost differences for labor. Although labor is a significant factor in the ability of overseas manufacturers to offer low cost items, a study of labor costs by the Worker Rights Consortium entitled "The Impact of Substantial Labor Cost Increases on Apparel Retail Prices" (2005) showed that the labor cost of shirts sewn in Mexico in large scale productions makes up a relatively small percentage of the garment cost if a mid-priced item citing the following information:

> Using data from Mexico's National Economic Census, the study finds that for a men's casual shirt manufactured in Mexico, direct labor is $0.50 – or 11.2% of the factory's overall production costs – for an item that the factory sells for $4.45. The product is sold in the U.S. for a retail price of $32.00. Thus, direct labor accounts for 1.6% of the final retail price. . . . They conclude that doubling the wages of all non-supervisory workers would result in a new retail price of $32.50, which represents a retail price increase of roughly 1.6%. The study finds similar results for other apparel products manufactured in Mexico. (p. 2)

The information in this study suggests that the cost of globally produced garments have many factors in addition to labor, and although the U.S. minimum wage is substantially higher than in many countries, factoring in cost offsets, such as transportation costs, agents fees and paperwork, may allow local manufacturers to compete with products made in the global system at certain price points. U.S. manufacturing companies also often pay social benefits such as health insurance that are provided by governments in other advanced countries, adding significantly to our labor costs. Government sponsored health care as subsidies could provide aid to the manufacturing industry to reduce labor costs for producing clothing in the United States to make products competitive.

Another way of getting around labor costs is to not have them. Japanese designer Issey Miyake has been creating software for jacquard weaving machines since 2002 to design his 'a-poc' clothing line and has created garments that require no sewing (Scanlon,

2004). The woven fiber does not ravel or fray when cut and the weave of the jacquard fabric is designed to open between woven layers creating interior spaces as a sewn garment would have. Customers can cut out their own clothing and even adjust lengths and styles based on where they choose to cut the 'a-poc' fabric. This is an innovative and interesting way to avoid the labor market needed for traditional garment manufacturing, and with sewing methods mostly unchanged in modern history (one person, sewing two pieces together on one machine), this type of innovation is well past due. Another designer working with software instead of sewing machines is Dutch fashion designer Iris Van Herpen. Herpen is recognized in Time magazine's Best Inventions of 2011 issue (p.72), along with Anke Domaske for her Qmilch fabric. Van Herpen has produced unique clothing that she designs in Photoshop and is then "printed onto a polymer over the course of a week {using a 3D printer}."(2011). Like Miyake, Van Herpen has found a way to marry fashion and technology to "manufacture" garments in unconventional ways.

Dogan & Walker maintain that flexibility in context is important to success in product development and manufacturing and assert that scales of production are required to address sustainability (2008). Therefore, it is important to keep technology adaptive and current. To succeed, the local textile and apparel system must employ the principles of economies of scale. For this reason, basic products that meet local needs can be produced with costs measured by shortened supply chains and special knowledge of local markets to provide prices close to what customers are used to. Key to the model is that employees have various skill levels in the apparel manufacturing sector to provide skilled and flexible labor for the small high-end and consequently more expensive garments,

thereby enlivening a local fashion culture. The combination of offerings will give the new industry the lasting power and flexibility needed to address the needs as they are in a specific local context (Dogan & Walker, 2008). The less fashion focused basic products can be produced and sold at major national retail stores in the area and through providing locally produced garments, retailers will strengthen the image of their national brands with regard to sustainability , while enhancing their regional identities[xi]. This will ensure the consumers' demands are being met closely and also strengthen the local textile industry by working within a well-established retail system.

The local manufacturing of textiles and apparel must be designed with state of the art considerations in terms of sustainability. The system must have the lowest ecological impact possible with current production methods. Chemicals, though they cannot at this point be entirely eliminated, must meet certain standards with regard to human health. McDonough and Braungart state in their book. *Cradle to Cradle*, chemicals used in products must not be "teratogenic, mutagenic, carcinogenic, or otherwise harmful in direct and obvious ways to human and ecological health" (2002, p.174). The fabric should be biodegradable, dyes, finishes and water need to employ a closed-loop system to avoid contaminating the environment, finishes should be water soluble, energy should be renewable, buildings should be as energy efficient as possible, and most of all, there must be built into the system opportunities for continuous improvements to products and systems. Sustainable energy solutions should be designed into the manufacturing system. Eliminating waste, curbing excess inventory and reducing transportation costs (even within city centers) by co-locating operations will provide opportunities towards sustainable economically viable systems. With these changes, sustainability adopts two

meanings, first, that the business practices will be environmentally friendly, and second, that this business itself will be sustainable by reducing its own expenses through less wasteful practices.

Not only should scales of production (Dogan & Walker, 2008) be available, but scales of retail should be available as well. Designers will have the opportunity to work with city planners, waste management experts, energy companies and other community members to consider the how industrial activities can be sustainable. Incorporating design methods such as bio-mimicry (designing to match biological systems) should be explored. By working together across disciplines and industries within the context of community and sustainability, designers of the new system will develop new ways to grow economically while offering new products and services for the full life of garments, employing local workers from beginning to end.

Design and Development of the Local Textile and Apparel Industry

Design is a process of synthesizing information and ideas from culture, technology, and human desires. In Brian Welch's 2010 book *Beautiful and Abundant*, he states "Every major human realization was assembled from the discoveries of lots of different people, each pursuing an individual vision and building on each other's work."(p.6) Design is a building process and moving design and manufacturing to the local context creates opportunities for new discoveries. Participating in the wellbeing of one's community is, in many ways, the value added proposition companies are looking for. Supporting local culture supports the human interaction aspect of design, and designers must continuously gather knowledge, recognize patterns and interact with culture to turn ideas into applicable solutions.

Development of the local textile and apparel system requires analysis of machinery and labor considerations. The proposed manufacturing business requires technology that is in step with the times. The system is designed to work as a complementary system to global production, with the most important differentiating factors being sustainability and the unique local designs the industry will inspire. Ancillary jobs will be created as the system expands. Large organizations can participate by focusing attention on smaller markets and regional cultures. By offering locally manufactured products, while providing a model of sustainability for their own brands across product offerings, retailers can strengthen their brand image. Branded garment retailers have the added advantage of their large organizational power to support innovation through investment, a situation not available to the small cottage industry. Linking the textile industry to the food industry and thus linking it to the needs of a growing population offers the opportunity to work in tandem with important industries with similar goals to maximize network efficiencies.

It is the designer's job to create something desirable within the constraints of what is available and possible, keeping business strategy at the forefront. Designers generally like constraints, as they offer new opportunities for creativity. They have the unique ability to synthesize cultural information with needs and style, and translate it into products that are right for consumers. New materials offer opportunities for designers to create new products. Producing casein fiber locally offers possibilities for new expressions by designers as they discover the qualities of the casein materials. A unique garment, expertly designed with the customer in mind, will be preferred by many to the mass-produced garments currently available.

Conclusion

The local textile and apparel industry will combine consumers, designers and pertinent industries (energy, waste, dairy) into a networked, flexible system. By forming cooperative ventures with strong food and retail industries, organizations can share responsibilities for people, business, and the environment in the context of a community or place. Considering context may be the only effective way companies will incorporate sustainability into their bottom line. Scales of production and scales of product offering allow the flexibility that is necessary to consider sustainability for product development (Dogan & Walker, 2008). Highly skilled workers supported by good communication and transportation infrastructure are a competitive and differentiating factor in manufacturing. Coordination between producers of textile and apparel is enhanced when they are located together.

If the United States is not participating in the innovations necessary to clothe a growing population sustainably, while considering the food needs and natural health of the world, we will not participate in generating solutions to the world's biggest problems and U.S consumers will continue to be passive players in the global chain. Casein fiber and the local textile industry model will require continued development. Like companies everywhere, local textiles will have to plan for future conditions. Hemp, soy, corn, and other fabrics made from locally sourced raw materials will also be developed. "Green" garment criteria will require designs to align with waste management plans. It is the designer's job to consider the constraints, and devise the solutions. As the world population grows, so do the challenges to meet its needs sustainably. If designers do not meet this challenge, they will be "marginalized as secondary actors in the development of

more sustainable strategies" (Morelli, 2011 pg. 90). Though the options may not look perfect now, designers will find ways to solve problems.

[i] In the context of business, sustainability describes profitable business practices that do not harm natural environments or people.

[ii] The term "super wicked problem" is a reference to and an enhancement of the term "wicked problem" characterized by Rittel and Horst in their 1973 work "Dilemmas in a general theory of planning" (Rittel, Horst W (1973): 155-69).

[iii] Information from *Swicofil's yarn manual – Hierarchy of most important textile fibers*. Accessed from the Web. 11 Nov. 2011. <http://www.swicofil.com/>.

[iv] Information retrieved from the *United States Department of Agriculture, Agricultural Marketing Service*. "As of mid-2011, there were 7,175 farmers markets operating throughout the U.S. This is a 17 percent increase from 2010 ('Farmers Markets", 2010)

[v] Gathered from my own travels in Hong Kong in 1992, and personal conversations with Sean McKenna about his observations while living in Singapore, from 2001-2003.

[vi] Missouri is one of 17 U.S. states that produce cotton. (USDA 2010).

[vii] "Milk fiber" is a term for fiber with a casein base, however other ingredients are used in milk fibers and even though they are called "milk fiber" the formulas and therefore fabric properties can vary.

[viii] This information was confirmed at the following Kansas City Metropolitan retail locations: Wal-Mart store # 2490, Marsh's Sunfresh, Price Chopper store #154, Nature's Own Health Food Market.

[ixix] Shatto Milk Company is interested in alternative methods of handling milk waste as per my phone conversation with Matt Shatto, in August of 2011.

[x] The four Kansas City metropolitan area colleges with textile or apparel programs are: the University of Kansas, the Kansas City Art Institute, Johnson County Community College and Penn Valley Community College.

[xi] Retailers already tailor their product offerings according to regional tastes, but fall short of offering locally produced items.

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