A Study on Green Manufacturing Operations Practices in China

John W K Leung, Spencer Sze, William Yu

Abstract

Many manufacturers are facing the challenge of balancing the environment cost, social cost and production cost with the advent of global sustainability trends. Although China has been considered as the manufacturing center of the world, many operations in China are still struggling to achieve the goals of green operations due to many non-environmental factors, such as pricing and quality issues driven by customers, the uncertain economy, legal compliance and pressure from special interest groups. Furthermore, consumer’s requirements, legal regulations, non-governmental organizations (NGOs), and the brands are pushing hard on the manufacturing plants to solve environmental issues. This paper investigates the green manufacturing operation initiatives of four reputable manufacturers to gain insights into how to maintain the intricate balance between profit, social cost and environment cost in the garment industry in China. The strategies and practices in achieving green manufacturing operation are identified and analyzed. It is envisioned that the strategies and practices identified can be adapted in other industries and can serve as a guideline for other green manufacturing operations to benchmark their green practices.

Keywords: Green operations, Green manufacturing operations, Sustainability

1. Introduction

Over three decades’ development, China not only has become the biggest ‘Manufacturing Center’ in the globe but also the world's biggest garment manufacturer and export country. The garment industry in China has more than 100,000 manufacturers, 30% of the world's raw materials and 10 million workers, among which more than 70% are qualified laborers ([1] and [2]). Despite continuous reforms in related policies, the garment manufacturing industry in China is still under significant and continual pressure to satisfy stakeholder’s requirements for higher environmental standards, ranging from the manufacturing to the consuming process of the apparel products. The consequences for not compiling could be disastrous for environment due to the potential impact brought by the manufacturing process related to intensive energy consumption, use of toxic chemicals, releases of chemicals in waste water and solid waste. From a manufacturer perspective, combining sustainability and manufacturing initiatives could address some incoming environmental regulations and impacts affecting the manufacturing cost structure and corporate image. This paper intends to identify green manufacturing strategies and practices that have been successfully implemented in the garment manufacturing industry in China. With the results, we attempt to provide insights into green manufacturing operations which can be applied not just to the garment industry, but also to other manufacturing industries in China. In this paper, we first identify the motivation for the green operations in garment industry. Then, the strategic role of green operation played in the entire manufacturing process is examined. Finally, this study is intended to shed some lights on the challenges facing four garment manufacturers in adopting green operations.

2. Related studies

A growing concern on a more ethical and transparent business model is forcing many enterprises to become more responsible in their corporate behavior [3]. Now, society values have embedded more elements beyond materialistic ones, and consumer demand is matching with this new change [4]. In this sense, customer satisfaction does not simply end with quality of the goods or services sold. Customers are more willing to buy eco-friendly products and
services from socially responsible companies. Hence, business decision-makers should incorporate social and environmental initiatives into their business strategy, daily operations and manufacturing processes. This is especially true for garment manufacturers in China in terms of the industry’s corporate performance and sustainable development.

Sustainability “means something, but not always the same thing to everybody” [5]. Since 1987, sustainability could be defined as something that “meets the needs of the present without compromising the ability of future generations to meet their own needs” in Our Common Future, also known as The Brundtland Report [6]. Before that, companies could dispose waste water; emit carbon dioxide and greenhouse gases freely from their operations. But now, a company is accountable for every piece of clothing manufactured. This not only adds carbon dioxide to the atmosphere but also intensifies the current water scarcity. Hence, businesses in China have to give some thoughts to meet the needs for the present economic growth without compromising the ability of her future generations (i.e. our children) to meet their own needs. Therefore, environmental programs have been undertaken in many companies within the garment industry.

Environmental responsibility is a necessity due to the constant pressure that many organizations face regarding development of environmentally benign products and use of less harmful operations ([7], [8]). Various schools of thought focusing on the concern for environmental issues in industries operations have emerged in the literature. Dating back from the 1970s’, ecology awareness to the lean and green manufacturing are such examples. Reference [9] stated that “the term green manufacturing was coined to reflect the new manufacturing paradigm that employs various green strategies (objectives and principles) and techniques (technology and innovations) to become more eco-efficient. This includes creating products/systems that consumes less material and energy, substituting input materials (e.g. non-toxic for toxic, renewable for non-renewable), reducing unwanted outputs and converting outputs to inputs (recycling). Thus the word “green” is used to reflect environmental friendly awareness and/or state, when it is added to “manufacturing”, it is used to describe manufacturing approach that is aware of the impact of its production/product on the environment and resources, including impacts on its overall efficiency planning and control.” Reference [10] found empirical support for the assertion that “lean is green.”

Despite the fact that there is no consensus on the definition of ‘sustainability’ and also the uncertainty in financial return derived from environmental initiatives, business cases are still built around with reference to its reduction in costs and risks, reputation and word-of-mouth in community, community expectation of the firm’s social behavior [11]. Reference [12] also suggested that there is an increase in employee motivation and also a possibility in reducing the threat of increased regulation through proactive self-disciplinary actions.

All these allow companies to address sustainability objectives, especially when companies move to an environmental management system, solving future unforeseen green issues along the manufacturing process. For that, green operations practices can be defined as practices that can enhance the operations in terms of environmental performance ([13], [14] and [15]). However, manufacturing efficiency has been considered as a trade-off with environmental operations [15]. Therefore, even environmental performance is considered as a key dimension of operations performance ([16], [17], [18]), manufacturers are reluctant to implement green operations practices [19]. Many researchers have been arguing that new solutions and practices are available to enhance efficiency without sacrificing environmental performance ([20], [15]). However, existing results generally focus on discussing the issues at strategic level and may not fit the manufacturing environment in China. Reference [21] has presented an environmental case in the UK and Reference [22] has benchmarked the green operations initiatives in the automotive industry, mainly based on secondary research. Reference [23, 24, 25, and 26] have studied the green operations in China from a view of supply chain management. Still, there is a lack of research work that discusses the green operations implementation at the practice level especially, in the manufacturing environment of China.

3. Research methodology

To gain insights into successful strategies and practices of green operations in the garment industry, we use a qualitative case study approach [27]. Four manufacturers operating in China
with different profiles (see Table 1) were studied to identify how green operations were successfully implemented. To preserve confidentiality, the four manufacturers are denoted as M1, M2, M3 and M4 respectively. Face-to-face semi-structured interviews at different management levels were conducted in 2011. Based on the interviews, we have identified three major stakeholders, including (i) external technical advisors, (ii) international brands (customers) and (iii) government agency that has significant impact on their green operations. The non-governmental organization (NGO) that provides technical and strategic advice on low carbon manufacturing process were interviewed to understand the role as a technical consultant in developing green operations. The NGO also plays the role of a green marketer that recognizes the company’s achievement of the successful green operations. A major American brand, which is also a key customer of the four manufacturers, was interviewed to gain views and insights from a customer’s perspective. The government agent, who serves as the secretary or coordinator for the garment manufacturers in sharing green practices and knowledge was also interviewed to understand the challenges and the needs of the garment industry.

Site visits in China were conducted to observe and interview the front line staff, regarding their daily operations in how environmental initiatives were implemented. Major communication tools related to the success of the four manufacturer’s green operation initiatives were reviewed. For instance, Global Reporting Initiatives (GRI) and sustainability reports [18] which show the achievement and commitment of the green operations of a company, internal newsletters and posters were also studied to gain insights into how and why their environmental operations have been achieved and recognized both internally and externally.

<table>
<thead>
<tr>
<th>Manufacturer 1 (M1)</th>
<th>Manufacturer 2 (M2)</th>
<th>Manufacturer 3 (M3)</th>
<th>Manufacturer 4 (M4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>History</strong></td>
<td>58 years in textiles</td>
<td>63 years in garment supplier business</td>
<td>41 years in garment manufacturing and supplier business</td>
</tr>
<tr>
<td><strong>Ownership</strong></td>
<td>Third-generation family owned</td>
<td>Family owned</td>
<td>Family owned</td>
</tr>
<tr>
<td><strong>Company size</strong></td>
<td>Spinning, weaving and dyeing facilities in Hong Kong and 2 spinning plants in China</td>
<td>10 facilities in 5 Asian countries with over 22,000 employees and annual production around 1 in 6 dress shirts in the US</td>
<td>12 factories 35,000 employees 200M pieces produced per year</td>
</tr>
<tr>
<td><strong>Leader profile</strong></td>
<td>University graduate educated in Canada</td>
<td>CEO and CTO hold doctoral degree from the US</td>
<td>A veteran in the garment industry</td>
</tr>
</tbody>
</table>

4. Findings & results

4.1. Motivation for green operations initiatives

While all the 4 manufacturers agreed that at the outset they are all under considerable pressure to meet environmental standards requested from various sources, such as the local government, the brands (customers) and even the NGOs. To response to that, many manufacturers are reluctant to develop green operations as profit remains the single bottom line for the survival of a company. Though triple bottom lines approach [28] that have been advocated for some time to measure the holistic performance of a company, it is not easy,
especially for small companies, to invest additional resources on green projects. On the other hand, large companies are facing the challenge that they have to change on a gradual basis so as to avoid jeopardizing the morale of the company. M1 is motivated to initiate green operations because the director, who is educated in Canada, believes firmly in the triple bottom lines approach for measuring the success of a company. That is, success of companies must not be measured solely by their profits, but also by their social and environmental costs and performance. As a socially responsible corporation, a company must consider the impact of its current operations brought to the future generations. Members of the top management of M2, mainly educated in the US, believe that the green trend is inevitable and will affect the sustainability a company significantly. M2 takes a rather proactive approach and voluntarily participate in those related green activities, such as setting the international environmental standards for garment manufacturers. In fact, M2 would take advantage of the green movement and differentiate itself from the competitors through aligning its green operations with the green marketing strategies adopted by its customers. The owner of M3 is highly motivated by the book “An inconvenient truth” [29] written by the former vice-president of the US, Al Gore. The owner shares the values of Al Gore and takes the lead in building a green manufacturing environment in his company. Though green operations may incur higher manufacturing costs, for instance, the cost of recycling used cotton may be even higher than the new cotton. the owner believes that a green environment is beneficial to his workers as well as to the community as a whole. In fact, the company’s green operation has aligned with the local government’s green policies, which in turn building a better relationship with the government. M4 considers environmental initiatives a natural belief and had built into her family business core values due to family members’ educational background. M4 also infused the “Reduce, Reuse, and Recycle” principle into her company culture to minimize pollution. So, the real challenge is not about whether green operations should be implemented or not, but the art to optimize the profits and minimize the costs through the operations under the principle of the triple bottom lines.

4.2. Strategic role of green operations initiatives

To balance the triple bottom lines, the managing director of M1 has classified his green operations initiatives into two categories according to their return on investment (ROI). For those initiatives that can have 30% or more ROI, he will recommend them to the board for consideration first. For those that require a longer term or larger capital investment, he looks for other kinds of resources, such as the financial support from the government and other sponsors advocating green practices. Also, M1 jointly develops innovative ideas with its suppliers. For instance, M1 has developed machinery that can separate the water from the dye, based on the engineering concept of separating lubricants. For M1, the green operation initiatives play a dual role. On the one hand, they help to save costs and hence generate higher profits. On the other hand, they can attract other funding for further research and development on more green measures.

The top management of M2 believes that corporate social responsibility (CSR) is critical to sustaining a company. Instead of passively conforming to the green requirements imposed by the stakeholders, members of the top management proactively promote the green garment standards, which can be practically implemented. Moreover, the members advocate building a unified international green standard which is acceptable worldwide. With this approach, the aggregate number of green manufacturing audits requested by various stakeholders can be reduced. Hence, the overall costs due to multiple and duplicated audits can be lowered. Moreover, as a first mover for promoting green practices, M2 believes that they can differentiate from the other competitors through developing a green branding image.

For M3, the owner takes the lead to implement green operation initiatives. Instead of just sharing the environmental concepts, he motivates all his workers to involve in green activities. For instance, he has organized activities for all employees to plant trees for the community so as to arouse their environmental awareness as well as strengthening their commitment to building a green work environment. A green gallery is specially built at the headquarters of the company to acknowledge and showcase the success of their green projects. Instead of solely measuring the tangible ROI, the owner M3 focuses on long term non-monetary achievements which cannot
be measured quantitatively. This can be demonstrated from the enhancement of relationship built with major stakeholders through efforts in saving resources, which can ultimately bring benefit for both society and the company. Again, it is believed that green efforts will be recognized and finally turned into business opportunities.

Generations of M4 consider environmental initiatives are an on-going business strategy that they do not need to be driven by other stakeholders. In fact, when the business director, also the Head of Sustainability, is on board, he tried to trim down unwanted business and only focused on business with high profit margin. Those businesses involve new and innovative technology with embedded green manufacturing operations and in collaboration strategically with upstream and downstream with an aim to co-develop new and greener products.

4.3. Challenges and Constraints

4.3.1. Motivating the workers

Though the top management can envision the importance of green operation initiatives, employees at different levels may have diversified attitudes towards them. So, one major challenge of green operations is to motivate workers to involve in green activities voluntarily. Instead of convincing the frontline workers to apply the green philosophy and the ethical values, the director of green operations of M1 shares with them how green activities can be beneficial to their children and family members. The director points out that all the green operation initiatives are not only important to the company, but also important to the future generations given the critical situation that natural resources are depleting rapidly. Influenced by this argument, workers understand better that all these green operations are strongly linked with the welfare of their family members and hence develop a strong passion for them.

For the workers of M2, they can be classified into two groups depending on the units that they belong to. The units that have been certified by ISO14000 [30] are relatively more receptive to the green operation initiatives, as they have a better understanding about what to expect from the implementation. For the non-certified units, they are not reluctant to adopt the green operation initiatives as long as there is not too much disturbance made to their work. Therefore, green activities, such as replacing traditional light bulbs by the energy saving ones are well received by the workers. However, if operations may be disturbed, it is essential to communicate with the workers through different channels before the green operations are implemented. The advantage of M2 is that different units can benchmark each other’s green practices and speed up the learning curve. To ensure that the green performance targets are reasonable and acceptable to the workers, the top management asks all units to set their own targets based on their manufacturing capacity and constraints.

The receptiveness to green operations at M3 varies between management and frontline workers. While top management can see the long term values behind the green operations, frontline workers who are recruited from all over China have diversified attitudes towards green concepts. Workers from the local province usually have more concerns to protect the local environment as the living standard of their families can be directly affected. However, workers from other provinces tend to care less about the environment, as they just work there for a short period of time and will return to their hometown ultimately. Therefore, M3 has spent lots of efforts to make sure that workers are well treated and considered as a family member of M3. A green garden, built on the top of the headquarters, is open to all the workers. So, all workers can enjoy their lunch in a green environment and can mix together irrespective of their hierarchy.

Since the workers in M4 have been adapting to the green manufacturing processes and ideas, therefore it is not surprising that they follow the lead from the top without any hesitation. Moreover, M4 has started a train-the-trainer program to promote sustainable office internally in order to maximize energy efficiency.
4.3.2. Acquiring and applying the “right” green knowledge

Another challenge in implementing the green operation initiatives is selecting the right technical solutions for the right initiatives. For M1, the managing director well realizes that it is important to acquire the latest environment-related technology. While he can hire external technical consultants for help, the question is how to select the right consultant. M2 believes that using energy-saving light bulbs should be cost-saving and environmentally friendly. However, it ends up that M2 has tried quite a number of energy saving light bulbs before the “right” kind of light bulbs are identified even though a technical consultant has been hired to take up the project. But for M4, the company only replaces faulty T8 lamps with T5 lamps but not in one go. To identify the “right” kind of green practices to be applied in the garment industry, M1 took the initiative to form an alliance with other garment manufacturers for sharing related experience. However, due to conflicting interests among the other garment manufacturers, the alliance was not successfully formed at the beginning. The response to the alliance was lukewarm and only staff from middle management were involved. To overcome this challenge, M1 has requested a government agent to serve as the secretary of the alliance. With this arrangement, an alliance comprising 37 garment manufacturers is formed and it has become an important source for sharing and promoting green practices and knowledge. To acquire technical advice, NGOs promoting green operations are also a good source of acquiring the latest knowledge. For instance, all four manufacturers in our study have significantly reduced their carbon footprint through participating in a Low Carbon Manufacturing Program (LCMP) [31] developed by an NGO and its technical partners as shown in Table 3. Based on the interview with a major NGO, many corporations are reluctant to start their green operations because they have no technical competence to measure or predict the performance resulted from the green operation initiatives. Through the exchange in experiences between this NGO and Universities, opportunities have been opened up to enrich and update the latest green knowledge continually. According to M1, once a manufacturer has started the green operation initiatives, it may gain support from different sources. The managing director of M1 was amazed in the late stage that his green initiatives were recognized and became a source for benchmarking in the industry. On the other hand, the business director of M4 is a frequent speaker at many apparel and sustainable forums and helps in setting up a guidebook for SMEs to achieve triple-bottom-line through the global reporting initiatives (GRI) reporting. Detailed knowledge sharing activities are shown in Table 2.

Table 2. Summary of findings

<table>
<thead>
<tr>
<th>Manufacturer 1 (M1)</th>
<th>Manufacturer 2 (M2)</th>
<th>Manufacturer 3 (M3)</th>
<th>Manufacturer 4 (M4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leadership</strong> (Motivation)</td>
<td>The Director on the Board who cares about environmental issues</td>
<td>Board’s visionary concept on environmental initiatives</td>
<td>Chairman’s passion and vision inspired by Al Gore</td>
</tr>
<tr>
<td><strong>Strategic Planning</strong></td>
<td>Vision on environmental projects that benefit the next generation and society; Start with small projects to evaluate ROI</td>
<td>Vision; Positioning environmental initiatives as a competitive advantage; Engage employee in the program</td>
<td>Experience gained from the model factory will be applied to other sister factories</td>
</tr>
<tr>
<td><strong>Customer Focus</strong> (Link green operations with profit)</td>
<td>Customers’ major concern on price and quality. Green recognitions will create good will for the company that customers treasure</td>
<td>Market differentiator in the long run</td>
<td>The gallery and roof garden in the office sending a strong Corporate Social Responsibility (CSR) message to both customers and staff</td>
</tr>
</tbody>
</table>
Knowledge acquiring and sharing

- Introduce an innovative technology for conserving water and dye
- Measure and reduce footprint of water and energy to achieve savings
- Use newsletter and focus group for internal communication whilst CSR report for external communication
- Measure the savings in energy, oil, electricity and water
- Internal newsletter for promotion
- Measure savings in energy and water consumption
- Internal newsletters and GRI report
- Great challenges received from workers of different origins, hence it is necessary to educate them; moreover the factory layout was designed to make the workers feel like home hence they are willing to learn & participate voluntarily as if it is their home
- Maximizes efficiency by implementing train-the-trainer program to promote sustainable office practice internally
- User Endorsed Solutions Sharing Day (by SFBC*) - to share sustainable practice among the industry
- Jointly publish guidebooks with the government through piloting sustainable initiatives such as GRI, LCMP, and the Eco Index

Workforce Focus

- To educate staff and also need to seek help from external consultants
- No interference on core manufacturing operations

Table 3. Summary of the green achievement of the 4 manufacturers

<table>
<thead>
<tr>
<th></th>
<th>Manufacturer 1 (M1)</th>
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<th>Manufacturer 3 (M3)</th>
<th>Manufacturer 4 (M4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water</strong></td>
<td>70% of water can be reusable in the dye process</td>
<td>Pre-heat water for domestic use</td>
<td>80% recycled</td>
<td>Recipitation system to reuse industrial water</td>
</tr>
<tr>
<td><strong>Energy</strong></td>
<td>4% increase in boiler efficiency</td>
<td>Reuse dissipation heat from steam system</td>
<td>Heat exchanger</td>
<td>8% saved</td>
</tr>
<tr>
<td><strong>Electricity Savings</strong></td>
<td>5% savings</td>
<td>Reduce power distribution loss</td>
<td>Lighting: 30% Utilities: 30% Cooling: 80% Recovery: 60% Renewable energy: 70%</td>
<td>Replacing faulty T8 lamps with T5 lamps phase by phase</td>
</tr>
<tr>
<td><strong>Waste treatment</strong></td>
<td>100% of Indigo dye stuff was separated out</td>
<td>Reduce toxicity of exhaust by scrubber system</td>
<td>Reduce toxicity of waste water discharge by AABC water treatment plants</td>
<td>Paper-less systems Lego-like furniture</td>
</tr>
</tbody>
</table>

*SFBC: Sustainable Clothing Business Consortium*
remnants thru. application of computer-aided marker systems

<table>
<thead>
<tr>
<th>Raw material</th>
<th>100% of indigo dye stuff reused</th>
<th>Cut &amp; Sew Waste Recycling</th>
<th>Employed recycled fibers into new products</th>
</tr>
</thead>
</table>

**Recognition**
- Awards for Sustainability Reporting
  - Gold Label Class of LCMP, WWF-Hong Kong
- Gold Label Class & Silver Label Class of LCMP, WWF-Hong Kong
- 940,578 trees planted
  - Platinum Label Class, Gold Label Class & Silver Label Class of LCMP, WWF-Hong Kong
- Silver Label Class of LCMP, WWF-Hong Kong

4.3.3. Linking green operations with profit

As mentioned before, a manufacturer needs to manage the social, economic and environmental costs and benefits in achieving the triple bottom lines. Therefore, a critical question is whether more profits can be generated after all the green operations have been implemented. Or, one may ask if these green operation efforts can impress the customers (brands) and bring in more business. The managing director of M1 has frankly told us that it does not appear to have a direct correlation between green operation efforts and sales figures. His sales team mentioned to him that customers only look at two major aspects, namely, quality and price. However, M2 believes that all the green efforts can lead to better corporate brand image and eventually becomes a competitive advantage over other competitors. M3 believes that it has the obligation to protect the environment for the next generation and this in turn will enhance the relationship with major stakeholders, which can not be measured in monetary term. Meanwhile, M4 believes that implementing the green initiatives is not only the family core value but also the business core value. Since M4 tends to adopt the high margin business approach, therefore, doing green manufacturing turns out to have direct links with better profit. M4 also observes that there is a growing demand from the brands for eco-friendly products to replace conventional ones. The brands are also pressurized by the consumers to choose greener suppliers to manufacture their products. Thus, green operations could bring in both tangible and intangible profits which will lead to more business directly or indirectly.

When we interview an international brand, it considers that green manufacturing is not an option, it must be fully implemented as brands are now monitored by the NGOs, media and the community. It may cost the brands heavily if they have been found to hire a supplier who does not comply with the green requirements legally or ethically. Therefore, to ensure that their suppliers are conforming to green regulations, environmental-related audits have to be conducted on a regular basis by the brands. However, to ensure that there is an impact brought by the audit reports, the audit team must team up with the procurement teams in presenting the results. The intention behind is to send a signal to the suppliers that their purchase orders may be linked with their green performance. So, it is envisioned that for those suppliers who do not conform to the green requirements will be left behind in competing for more sales among other manufacturers.

In other words, while green operations may not be directly linked to the current profits, it is a hidden imperative for manufacturers, especially the demand for green operations are driven by more and more stakeholders. In the long run, those manufacturers that can perform well in green measurements will be winners and harvest from their green efforts.

4.4. Opportunities from the green operations

Though benefits generated from green operations may be intangible at the moment, it is clear that there are opportunities for saving significant costs through green operations. Savings can be generated from operations related to core production process, such as material recycling and waste treatment. To see the results more readily and with fewer disturbances, savings can be gained through other sources, such water, energy and electricity savings, which may not be
directly related to the manufacturing process. For instance, M3 has successfully applied the solar energy technology at the dormitory of the workers, in heating up water and the period of return on investment is just eight months. In fact, it is believed that non-production-related green actions can be widely used in China independent of the nature of the company. Table 3 summarized the actual performance of the projects.

5. Conclusion

At this stage, all four manufacturers have shown their passions for our next generation and have made significant achievements in their green initiatives. However, the green operation initiative is a ‘hygiene factor’ in their operation and relationship with brands. It appears that they still cannot use these green initiatives and goodwill to attract additional sales, as customers are still looking for better prices and supreme quality. However, the four manufacturers all believe that they will have the first-mover advantage in the near future when the entire new markets, services and offerings are opening up for the next generation kids.

It has drawn to our attention that factory with ISO14001 in place have a much shorter time frame to implement new green initiatives than those who do not. Therefore internal communication is a most important tool to communicate with workers, especially those workers from other provinces, as they don't have a sense of belonging or ownership of the manufacturing operations.

In our interview with a major brand, we felt that many multinationals are constantly seeking ways to manage their indirect environmental and social impacts accordingly. Hence, this imposes an increasing pressure on China’s garment manufacturers. Proactive action seems to be a logical course of action for the manufacturers.

With reference to Table 2 & Table 3 above, it is found that by deploying carbon footprint calculations in the Product-Life-Cycle throughout the manufacturing process, these four manufacturers do have significant reduction in their water and energy consumption. As a result, all four manufacturers have gained a significant reduction in their operational costs. In fact, it is not easy for the management to realize the business case behind these environmental initiatives. Hence M1 took a longer path to achieve the result, whilst M2 and M3 are not lacking of resources to back up all the environmental projects. Because M4’s core value is to develop recycled products without sacrificing quality, they are moving towards high-value added business. The patents they developed as well as the innovative manufacturing processes have already moved them towards another stage of green manufacturing.

For garment manufacturers in China, not only could they do well economically, socially and environmentally, they could also achieve competitive advantages for their business. It is most important for the China’s garment industry to understand its role in the world, being the largest apparel exporter in the world, and to realize also its impetus for future development. A simple carbon footprint calculation could help in major energy saving and hence a reduction in production cost. On the other hand, environmental issues may originate from different sources [27]. As a result, manufacturing processes potentially could lead to an initial cost and process reengineering. Therefore, research of this kind is vital to the healthy growth of the garment industry in China.

6. Future research

China has been known for her fast economic growth and her increasing emission of CO2. Due to the garment industry’s nature in consuming water, producing polluted water and other wastes, there is a need to gain insights through the studies of manufacturers in order to find out how they are facing the challenges of these environmental issues. In this paper, insights are generated through qualitative studies of 4 manufacturers, 1 NGO and 1 major brand. More stakeholders outside the manufacturers, such as the suppliers and consumers should also be interviewed. To gain further insights, more manufacturers from various industries should be benchmarked. The authors are expanding their studies which include manufacturers from different industries and more stakeholders. It is expected that the “best” practice identified
from the ongoing studies can generate a more comprehensive blueprint and to become a model for the garment industry and other manufacturers.

7. Acknowledgment

The authors thank all the manufacturers, NGO and brand for their valuable time and information provided during the interviews. The authors also appreciate M3’s great logistics arrangement during the site-visit.

8. References


