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Technology adoption of Indian garment manufacturing firms

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Dedicated to my parents for their unending love and support

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ABSTRACT

Technology adoption has emerged as an important determinant of competitiveness in recent global trade. Gaining competitiveness in the quota free trade became a driving force for the garment firms to adopt technologies. However, there has not been much research focused on technology adoption of a firm, especially in the garment manufacturing industries in developing countries. Very little is known about the status, activities, and organizational factors that affect the scope and the level of technology adoption by garment manufacturers. The purpose of this study is to investigate the status and the effects of organizational factors on the level of technology adoption within the context of the Indian garment industry. Specifically, this study focuses on the effect of firm size, export orientation, top management's commitment, cost of capital, technical skills, and competitive advantage.

A survey methodology was employed to collect data. Garment manufacturing firms located in Tirupur, a town of the Tamil Nadu state in India were chosen as the sample for this study. A random sampling procedure was used to select firms those engaged in the manufacturing and production of garments. Six hypotheses are proposed regarding the effect of organizational factors on technology adoption. An online survey using a structured questionnaire was prepared through an online research service. The data was analyzed using the SPSS (Statistical Package for Social Science) software package, version 14.0. A multiple regression analysis (MRA) was used to test the hypotheses.

The results revealed that firm size positively influences and export orientation negatively influences the technology adoption level of a firm. The effect of competitive advantage was moderately significant. The negative effect of export orientation was unexpected, and a close examination showed that the effect was interrelated with other

organizational variables. On the other hand, the results indicated that the top management commitment, cost of capital, and technical skills did not have significant effects on the technology adoption level. The results are discussed in terms of characteristics of garment manufacturing, organizational behavior, and the trade environment. Suggestions and implications for garment industry practitioners and for future research are also discussed.

CHAPTER 1

INTRODUCTION

In recent world trade, developing countries have gained a significant market share in textiles and apparel exports. In the context of textiles and apparel manufacturing, developing nations have advantages in resources and abilities to produce the goods on a broader scale at low costs and respond quickly to fashion changes. Accordingly, the textiles and apparel export industry has become a major contributor of economic growth for developing countries. The World Trade Organization's (WTO) termination of Multi Fiber Arrangement (MFA) on January 1, 2005, which had limited textiles and apparel trade for decades, has launched a new era of textiles and apparel trade.

Among many developing countries that actively participate in textiles and apparel trade, the Indian garment industry is exhibiting significant growth potential in the global market with its advantages in low production costs, abundant resources of raw material, and skilled labor forces. The textiles and apparel industry is India's second largest industry, and India's largest exporter of manufacturing goods. However, with an increased level of competition from low cost manufacturers around the world, the industry is under tremendous pressure to increase productivity, to improve performance, to improve production quality, and to advance the management systems. Furthermore, competition is much more intense in the textiles and apparel exports business after the quota cancellation (Clark, 2005). Therefore, it became crucial for garment manufacturers to respond to the new challenges with new strategies and solutions.

Given the intensified competition in the global market, it became important for manufacturers in order to thrive, to gain sustainable competitive advantage by innovations in

technology or concepts as well as in production. The garment manufacturing industry is highly labor-intensive and production oriented, and production involves a great deal of manually operated machine work. The main considerations of apparel sourcing and manufacturing decisions are lower costs, high productivity, and better quality. Faced with increasing labor costs, advanced technologies for garment manufacturing processes have been called upon to increase productivity and produce better quality goods, in high volume, in short time cycles, at lower costs. Thus, advanced technologies and conduciveness facing new challenges driven by the intense competition is critical for Indian garment manufacturers to remain competitive and grow.

While technology adoption has emerged as an important determinant of competitiveness in the quota free environment, research in technology adoption of the garment manufacturing firms and the factors that foster the level of technology adoption, especially in developing countries, is scarce. The central research question of this study is which firms are more likely to adopt advanced technology. Very little is known about technology adoption status and activities of the garment manufacturing firms and the influence of organizational factors. The purpose of this study is to investigate the status of technology adoption and organizational factors that affect the level of technology adoption within the context of the Indian garment industry. Specifically, this study focuses on the effects of firm size, export orientation, top management's commitment, cost of capital, technical skills, and competitive advantage on technology adoption.

In an increasingly globalized and knowledge-based world economy, this study contributes to knowledge of technology adoption in developing countries like India by filling the void in the literature on technology adoption of the garment manufacturing industry. This contributes to the development of an advanced, world clothing supply chain and provides new insights into how manufacturers can be receptive to technologies and remain competitive in the

global market. This, in turn, contributes to the economic development of the developing countries. For industry practitioners, this study helps buyers from developed countries understand technology adoption activities of Indian garment manufacturers. It also provides them an opportunity to improve the global industry-wide cooperation and build an efficient supply chain.

CHAPTER 2

LITERATURE REVIEW

This literature review section addresses the following topics: 1) overview of world textile and apparel trade; 2) Indian textile and apparel industry; and 3) technology adoption and the factors that affect a firm's technology adoption of a firm; 4) this review is followed by the relevant hypotheses of this study.

2.1 World Textiles and Apparel Trade

2.1.1 Overview of Textiles and Apparel Trade in World Trade

Accelerated and closer economic relations around the world in recent years have boosted international trade activities and helped developing countries participate in international trade and become more competitive in the world markets. With the concept of globalization and increased trade activities among countries, trade boundaries have slowly been removed. The developing nations, like India, are becoming successful competitors in manufacturing because of their low-cost labor and supplies. The textile and apparel industry has been an important part of economic development of developing countries (Akalin, 2001), and they supply a significant portion of textiles and apparel products.

Since 1960, the textile and apparel production sector has moved to the countries where labor is cheaper and abundant. As a result, developed countries restricted and limited their textile and apparel imports to protect their domestic industries. Such restrictions started in 1961 and were revised in 1976 to become the Multi-Fiber Agreement (MFA), by which developed countries restrict textiles and apparel imports in terms of volume (Akalin, 2001; Richard, 2005). The quotas had been negotiated each year on a country to country basis, assigning the quantities

of specified items which could be exported from a developing country to a developed country. The quota allocations could be changed and revised with bilateral negotiations between countries in conjunction to trade policies and promotions.

Table 1

Annual Percentage Change of Leading Exporters of Textiles in Billion Dollars

Country	1996	1997	1998	1999	2000	2001	2002	2003
China	-13	14	-7	2	24	4	22	31
European Union (15)	4	0	-1	-6	1	3	5	14
Hong Kong, China	2	3	-11	-6	10	-9	1	6
United States	9	15	0	3	15	4	2	2
Korea, Republic of	3	5	-15	3	9	-14	-2	-6
Taipei, Chinese	1	6	-13	-2	9	-17	-4	-2
India	13	6	-13	12	18	-10	12	9
Japan	-3	-3	-12	11	6	-12	-3	7
Pakistan	16	-6	-7	-1	6	0	6	21
Turkey	8	23	6	-2	6	7	8	24
Indonesia	4	-20	5	28	16	-9	-10	1
Canada	21	11	4	6	9	-2	1	4
Thailand	-2	7	-13	3	8	-4	2	12
Mexico	21	23	6	12	12	-19	6	-5
Czech Republic	-26	0	14	-2	11	9	3	21

Source: World Trade Organization.

Tables 1 and 2 show annual percentage changes of major countries textile and apparel exports by value from 1996 to 2003. Since 2001, China, the EU, India, Pakistan, Turkey, Thailand, and the Czech Republic have maintained a steady increase in their exports, while rest of the countries had suffered with the downward trend in their textile exports. In clothing, China, the EU, Turkey, India, Romania, Vietnam, and Pakistan recorded solid growth rates. On the other hand, US textile exports showed a downward trend from 2000 onwards, and clothing exports recorded a decreasing trend from 1999.

Table 2

Annual Percentage Change of Leading Exporters of Clothing in Billion Dollars

Country	1996	1997	1998	1999	2000	2001	2002	2003
China [a]	4	27	-6	0	20	2	13	26
Hong Kong, China	3	5	-4	1	8	-3	-5	4
European Union (15)	10	-4	1	-8	0	7	5	15
Turkey	-1	10	5	-8	0	2	21	23
Mexico [a]	37	50	17	18	11	-7	-3	-5
India [b]	3	3	10	8	20	-11	10	7
United States	13	15	1	-6	4	-19	-14	-8
Bangladesh [b]	13	21	41	-12	25	2	-6	8
Indonesia	6	-19	-9	47	23	-4	-13	4
Romania	15	12	13	3	14	19	17	25
Thailand	-26	-1	-4	-2	9	-5	-6	7
Korea, Republic of [b]	-15	-1	11	5	3	-14	-9	-8
Vietnam [b]	...	...	-6	25	12	3	41	35
Morocco [a, b]	-2	-7	-	-2	-4	-2	4	16
Pakistan	16	-3	2	0	16	0	4	22

Source: World Trade Organization.
Note. a-Or nearest year, b-Includes secretariat estimates.

In 2003, clothing and textile accounted for 3.1 % and 2.3 % of world merchandise trade respectively with annual growth of 10.9 % in textiles and 11.7 % in apparel (WTO, 2004). According to a report by the International Labor Organization (ILO) (2005), textiles and clothing represent about 7 % of total world exports, and individually, clothing represents 57 % of total textile and clothing trade. The average growth rate of clothing trade was 5.9 % between 1997 and 2004, and textiles trade recorded an average growth rate of 3 % (ILO, 2005). Developing countries account for approximately a half of the total world textile exports and almost three-quarters of the total world clothing exports. While developing countries are mainly exporters of textiles and apparel, the US, the EU (European Union), and Japan account for a majority of imports. According to the annual report by National Textile Center (NTC) in 2004, in the US the

total dollar value of textile import has increased from $47.59 billion in 1989 to $100 billion in 2001 respectively (NTC, 2004).

2.1.2 Trade in the Post Quota Environment

On January 1st 2005, the MFA, which had limited the textile and clothing trade for almost 30 years, ended. Consequently, trade experts predicted that China and India would control about 80% of the global textile market in the post quota era (Richard, 2005). The strong growth of Chinese and Indian exports has impacted the pattern of world textiles and apparel trade. A recent study by McKinsey Quarterly suggested that low-cost Chinese manufacturing and Indian services have significantly influenced the prices of traded goods (Lenny, 2005). Thus, Asian countries that have been major exporters of clothing (e.g., Hong Kong, South Korea, Taiwan, and Macao) during the past two decades would no longer be a source of comparative advantages in textile and apparel production (Lenny, 2005). Instead, they became a source of management innovation by providing production services to the foreign buyers and contracting productions in low wage countries.

During the first nine months of 2005, in fact, textiles and apparel exports from Asian economies to the US recorded the biggest drop of 21 %, to $ 5.9 billion, compared to the same period of 2004 (Zarocostas, 2006). This is contributed to their losing competitiveness to lower cost countries such as China and India (Zarocostas, 2006). By the end of November, 2006, India and China recorded strong growth in exports to the US with a percentage change of 14 and 11 respectively, when compared to previous year exports (OTEXA, 2007). At the same time, Bangladesh, Cambodia, Pakistan, and Jordan recorded solid export gains to the US. Other countries that recorded decline in exports to the US since the quota removal included Canada, Mexico, Turkey, the European Union and Sub-Saharan African countries. Furthermore, Central

American Free Trade Agreement (CAFTA) countries (i.e., Costa Rica, the Dominican Republic, El Salvador, Guatemala, Honduras, and Nicaragua) recorded a 2 % decline in exports to $6.9 billion in the first nine months of 2005 (Zarocostas, 2006). By the end of November, 2006, CAFTA recorded a total of 8 % decline in exports to US (OTEXA).

The U.S. textile and apparel imports, during the first nine months of 2005, increased by 8 % compared to the same period of the previous year (Zarocostas, 2006). According to the Office of Textiles and Apparels (OTEXA), during the year of 2005, India's exports to the US grew by 27 % to $4.6 billion (Subramanian, 2006). The EU's imports from India in the beginning of 2005 also showed an increase, with a record of 279.68 million Euros value compared to 246.16 million during the same period in the previous year. For the first nine months of 2005, India's exports to the EU rose 18.1 % to $5.3 billion. Canada imported $133.37 million in January-March 2005, with a marginal growth of 2.39 % compared to the previous year (Banerji, 2005).

In short, textile and apparel production has been moving to developing countries where cheap labor sources are abundant over the last few decades. Since the expiration of the MFA, manufacturers in developing countries have observed a great deal of changes and opportunities; since the changing patterns of trade and increases in textiles and apparel imports by developed countries. There has been a significant increase in exports of low-cost goods from developing countries. Among them, India has been indicated as one of the most promising exporters of textiles and apparel products in the post-quota environment.

2.2 Indian Textile and Apparel Industry

2.2.1 Significance of Indian Textiles and Apparel Industry

India is a developing country, and its textiles and apparel industry constitutes one of the biggest and most important industries for country's exports. The textiles and apparel industry is

one of the India's largest foreign exchange earners and accounts for nearly 16 % of the country's total exports. The textile and apparel industry contributes about 14 % of the total industrial production in India, employing approximately 38 million workers, and accounts for about 27 to 30 % of the country's total exports (Dutta, 2003; Robyn, 2005; Tait, 2001). Thus, the textile and apparel industry is the leading force for the Indian economy.

The Indian textiles and apparel industry has taken a significant share of world trade. During 1980s, the industry showed a significant growth. Exports recorded at a compound growth rate of 22 % annually and it was as high as 32 % during the period of 1985-86 to 1989-90. India's textile exports have also shown a steady increase during 1990s and 2000s, especially to the US (see Figure 1). India exports about US$ 14 billion of textile and apparel products, and experts predicted that this figure would reach over US$ 50 billion by 2010, which is about four times the current figure (Rao, 2005). From 1990 to 2003, the average growth rate of Indian textile and apparel production was 5 %. Furthermore, this figure has been predicted to be as high as 15 % after 2005 (Business India Intelligence, 2005 & Veembur, 2004).

2.2.2 Textiles and Apparel Production and Trade in India

The textiles and apparel industry manufactures and exports fiber, yarn, fabric, and garments made of a wide range of materials and products. It has been estimated that India has approximately 30,000 ready-to-wear garment manufacturing units employing around three million workers. Today, not only is the garment export business in India growing, but also enthusiasm in the minds of the foreign buyers toward Indian garments is at a high. India produces more than 100 garment product categories and is increasingly considered as a major supplier of high quality fashion apparel (Tait, 2001). Especially, Indian companies have a

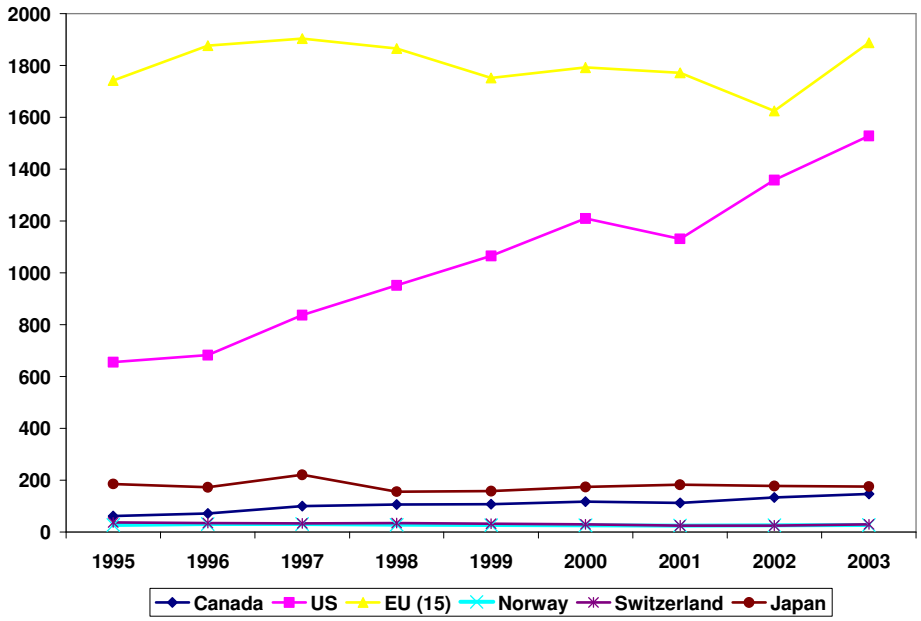

Figure 1. India's textile exports to other countries in million dollars.
Source: World Trade Organization.

significant market share in clothing and house wares made of hand woven, embroidered or embellished fabrics. Traditional Indian apparel has also gained appreciation in major international markets. Importers who produce and source from India express their satisfaction with the Indian manufacturers' handiwork, which they cannot find in China or in any other countries (Williamson, 2005).

India's apparel exports alone account for approximately US$6 billion annually, and India projects to export US$25 billion by 2010 (Tait, 2001). Figures 2 and 3 illustrate India's textile and apparel exports and imports between 1995 and 2005. It is clear that India's textiles and apparel exports figures have steadily increased during last 10 years. Its export figures are significantly larger than imports, which indicates strong export orientation of the Indian textiles and apparel industry.

Figure 4 shows the major importers of India's clothing, and it illustrates steady increases in India's clothing exports to all the regions during the period of 1995 to 2003. A major portion

of Indian garments have been exported to developed countries, especially to the US, the UK, and Germany.

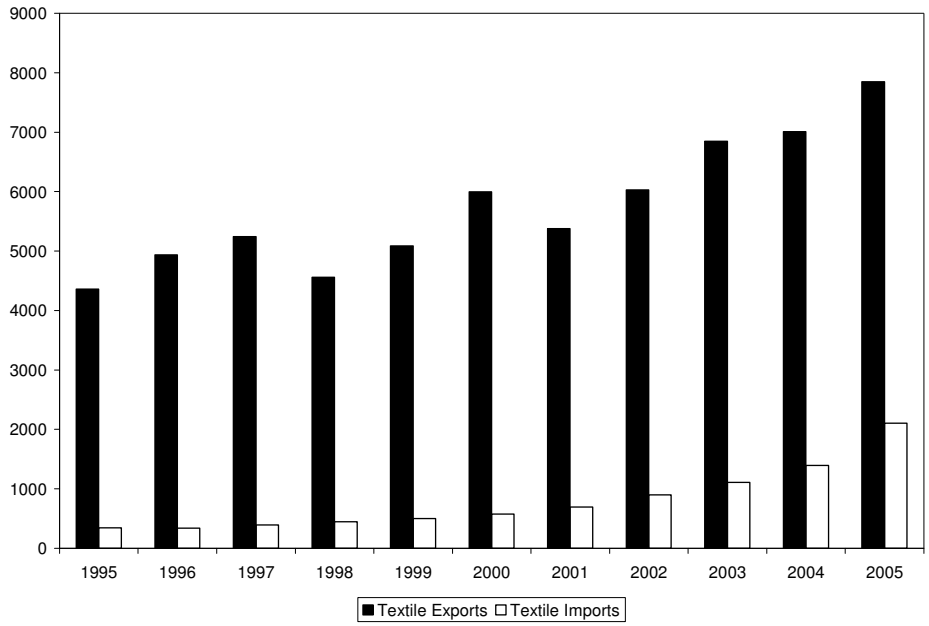

Figure 2. India's textile exports and imports in million dollars (1995-2005).
Source: World Trade Organization.

Since quota cancellation, Indian textiles and apparel firms have increased their export volume dramatically. The Indian textile firms exported at much higher volumes in 2005 at 2,335 million square meters, with a 22 % increase from 2004, compared to the 15 % increase during previous year (Subramanian, 2006). India also sold $2.97 billion worth of apparel with an increased rate of over 34 %, compared with a growth of 10.7 % in 2004 (Subramanian, 2006). Indeed, industry watchers say that total exports of Indian textiles could grow as much as 35 % over the next few years, and its share would double from the current 4 % in five years (Subramanian, 2006).

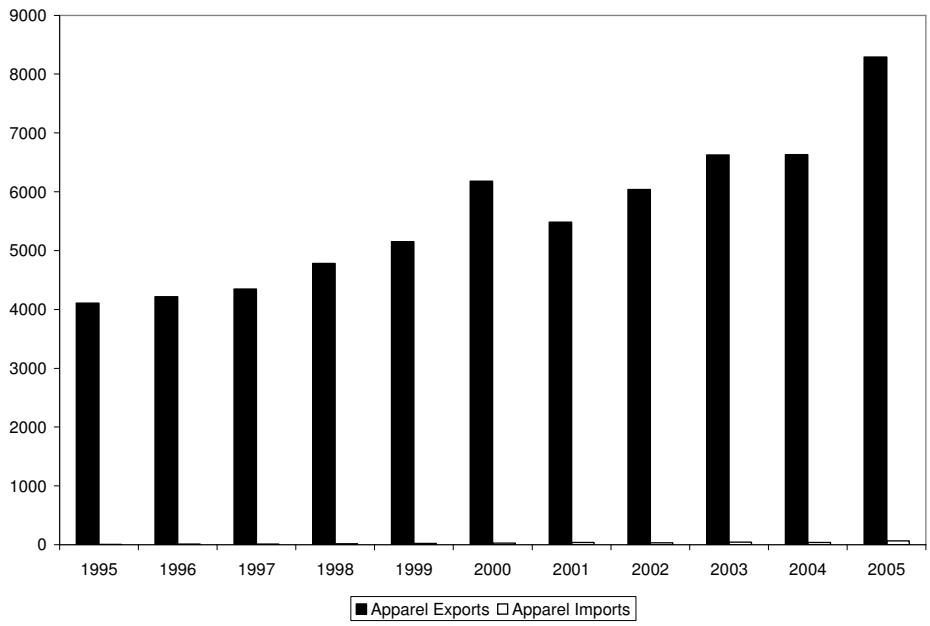

Figure 3. India's apparel exports and imports in million dollars (1995-2005).
Source: World Trade Organization.

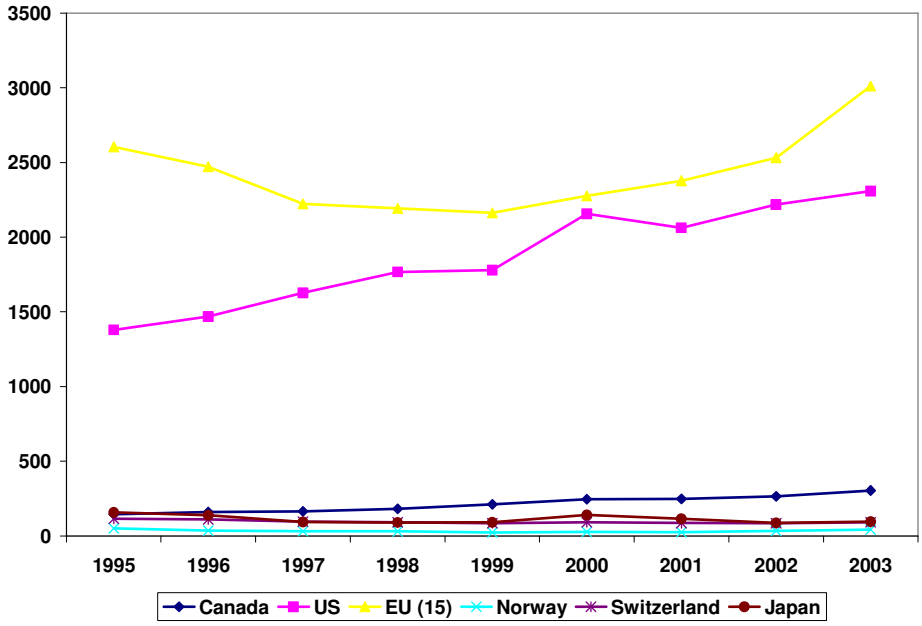

Figure 4. India's apparel exports to other countries in million dollars.
Source: World Trade Organization.

2.2.3 Resources and Competitiveness

The competitiveness of the Indian textile and apparel industry in the world market depends on several factors. One of the most important factors is its comparative advantage gained from its labor abundant economy. Labor costs in India are one of the lowest in the world (Veembur, 2004). India's labor cost in clothing is around 0.33 US$ per hour compared with their major competitor China's 0.73 US$ (ILO, 2001). This provides an advantage to the Indian industry when compared with other major textile and apparel exporting countries (e.g., Taiwan).

Another important factor is the rich supply of raw materials. India is the third largest cotton producer in the world with 25 % of the world cotton area and accounting for 15 % of world cotton output following the US and China (USITC, 2001). India has the highest cotton acreage in the world; it produces 2.7 million tons annually. India is also the second largest producer of silk, the largest producer of jute, and one of the largest production bases for cotton/denims and blends of linen. Along with such abundant cotton fiber supply, India is also a leading cotton yarn manufacturer (Narayanswamy, 2005). There are over 1,500 spinning units (38,000 million spindles and 400,000 rotors) and 280 composite mills that are vertically integrated from spinning to finished fabric. There are also thousands of smaller spinning units, around 200 exclusive weaving units, and an estimated of 1,700,000 power mills in operation (Dutta, 2003).

In addition to the rich supply of natural fibers, India also has a robust production capacity for man-made fibers and has global scale productions (Dutta, 2003). India is one of the top exporters of man-made yarns and fabrics in the world and stands third in the production of filament yarn (USITC, 2001), and its production capacity of man-made fibers and fabrics is growing. India produced a total, of 2072.31 tons of synthetic fiber in 2002-03, compared to

1851.01 tons in 2001-02, which represents a 12 % growth (Asian Chemical News, 2003). Therefore, India is self sufficient in fabric supplies and has little need to import fabrics, both natural and synthetic, for apparel manufacturing.

2.3 Outlook of Indian Textile and Apparel Industry

Because of its advantages gained from abundant raw materials, large and inexpensive labor supply base, availability of local textile production and skilled work force, the Indian textiles and apparel industry has great potential to continue to grow in the world market (Padhi, Pauwels, & Taylor, 2004). Being the world's second most populated country, with 1.09 billion people, India is successfully engaging multinational businesses with low cost and wide production range. Many business professionals and industrialists from other countries favor India's indigenous craftsmanship, wealthy artisanship, strong work ethics, customer friendly attitudes, and beautiful textiles and prints that are rarely found anywhere else in the world. U.S. buyers have pointed out that India is likely to remain as a major supplier with its great design, raw material availability, low-cost labor, and the English language (Haber, 2004).

The growth of textiles and apparel production and trade along with predictions made by experts confirm a positive outlook for the Indian textiles and apparel industry (Padhi et al., 2004). In recent years, the investments in the Indian clothing industry accounted for more than US$ 17 billion (Robyn, 2005). It has been suggested that the quota phase-out has provided incentives to the investors with an emphasis on improving productivity, upgrading technology and expanding capacities (Robyn, 2005). The Indian government has recognized the need for industry development and responded by taking a number of measures to reshape and advance the entire textiles and apparel industry. For example, the Indian government provides special support for textile and fiber producers to boost the country's export market by cutting custom duties to

10 % from 15 % on all polymers, while the duty on intermediates was cut to 5 % from 10 % (Alfred, 2005). The excise duty on polyester filament yarn (PFY) was cut down to 16 % from 24 % (Alfred, 2005). Import duty on textile machinery was also slashed to 5 % from 25 % (Asian Chemical News, 2003).

To further the industry's competitiveness, the Indian government is in the process of establishing Special Economic Zones (SEZ), planning 25 apparel parks by 2008 which will create 500,000 new jobs. Each park, which is maintained as one industrial unit consisting of small producers, will be equipped with shared testing labs, raw material, and warehouses, along with state of art infrastructure (Robyn, 2005). Such government policies and programs will help the firms form an advanced and efficient industry through consolidated operations, vertical integration, and efficient supply-source management (Robyn, 2005).

India's export growth rate of 18 %, next to that of China with 22 % was the second highest among the top 30 leading exporters in world merchandise trade in 2002 (Jaitley, 2003). The end of the quotas is expected to provide a new era of clothing business opportunities for India. Current 4 % global market share is expected to increase to 6.5 % by 2008 which accounts for US$ 248 billion (Williamson, 2005). Although China probably has the most advantages with abundant labor and raw material supply, China is subject to temporary safeguard quotas which could limit specific goods shipment until 2008. This imposes a great deal of risks for the buyers to diversify the sources of goods (Clark, 2005), and this makes India to be the best alternative source to China (Haber, 2004).

In short, since the quota phase-out, competition among the major textile and apparel exporting countries has intensified. India's textiles and apparel industry has witnessed strong growth in textiles and apparel production and trade, and it exhibits positive outlook. Backed by

its raw materials, labor supply, government and industry alliances, the Indian garment industry is likely to become a major apparel supplier with proper strategic responses. Improving in the areas of speed, innovation, and quality are the challenges Indian manufacturers confront in the highly competitive, post MFA environment. As the apparel manufacturing sector is experiencing increasing labor costs, gaining competitiveness depends on productivity, short lead time, and quality through implementation of new technologies.

2.4 Technology Adoption

2.4.1 The Role of Technology in Garment Manufacturing

A firm's quick response to compete in the global market depends on the extent of manufacturing technology adopted and its integration of this technology into business operations (Mechling, et. al, 1995). Constant innovation and adoption of new technology becomes an essential element for competitive advantage in the global market because firms can maintain quick and flexible responses to market demand using the technologies (Cooper, 1996; Mechling et al., 1995; Özçelik & Taymaz, 2004). While developing countries have disadvantages in developing and exporting advanced technologies due to capital intensiveness, adoption of the technologies can increase their manufacturing industries' performances (Kumar & Siddharthan, 1994). A firm may adopt or borrow technology already in use within the industry (Gopalakrishnan & Damanpour, 1994).

There are two groups of technologies in the manufacturing industries (Wiarda, 1987): 1) hardware technology and 2) software technology. Typically, the hardware technologies include: automated identification stations; automated inspection stations; automated material handling devices; computer aided design work stations; computerized numerical control machine tools; numerical control machine tools; programmable production controllers; robots; and shop-floor

control systems (Wiarda, 1987). Example of software technologies include: computer-aided manufacturing; computer-aided engineering; statistical process control; production planning/inventory management software; engineering data management; computer aided process planning; local area networks; and group technology (Wiarda, 1987).

Traditionally, high technology and R&D activities have been less prioritized in the garment manufacturing industry. The industry runs on three basic operations: cutting, stitching, and pressing/finishing. While the typical production is a combined process of various specialized and/or general machines operated by manual/mechanical/electronic devices by skilled and unskilled labor of diversified organizational production activities (Bhavani & Tendulkar, 2001). However, in many instances, the production involves manual operations of machines and materials of automated assembly. Since the material need proper feed through the machines, automation is limited (Bailey, 1993). Therefore, the technology adoption in the industry has primarily been mass-production focused, and technology development and usages have been limited.

In recent days, however, the change in the market trends and fast fashion styles reduced demands for mass production models. It has been reported that apparel executives believe that industry competitiveness depends upon the ability to quickly respond to demand with a variety of practices and better engineering practices (Bailey, 1993). Desired levels of production and quality can be achieved by adoption of newer technologies and techniques. Apparel makers strive to cope with ever-changing fashion styles by reducing the time it takes to design, produce, and deliver the goods (Bailey, 1993). In this environment, technology to support such needs emerged as an important source of competitiveness. Accordingly, the industry began to place

greater emphasis on advanced technologies to fulfill the extended demand for production, speed, and quality requirements for the competitive export market.

Recent technology changes in clothing manufacturing include: development of robotics for automation assembly line for garment making; high-speed sewing machines; new pressing and fusing techniques; computer-aided design; computer-aided manufacturing; and computer-aided marketing. These technologies can be used individually or in combination with other technologies to achieve the desired economies.

The intensified global competition has pushed the firms to meet demands and standards quickly and effectively. Flexibility, quality, inventory reduction, efficient production cycle, and shorter lead time in manufacturing became essential for firms to achieve global competitiveness (Mechling et al., 1995). The adoption of advanced technology is a way to improve these areas and meet the export standards.

2.4.2 Organizational Factors Influencing Technology Adoption of a Firm

Imitation/adoption of the technologies and knowledge widely varies across the countries, industries, and firms (Gopalakrishnan & Damanpour, 1994). At the firm level, it has been suggested that firms differ in technology adoption activities depending on firm's internal capabilities (Gopalakrishnan & Damanpour, 1994). Various organizational factors that may influence the level of technology adoption of a firm and corresponding hypotheses are discussed in the following sections.

- Firm Size. In the literature, the size of a firm has been a conventional factor that determines the innovation and performance level of the firm: firm size positively influences the degree of innovation and technology adoption of a firm. Although small firms have certain advantages over larger firms in terms of flexibility, informality, adoptability, and operational

speed (Fiegenbaun & Karnani, 1991), the size positively affects the technology activities of the firm (Mansfield et al., 1977). Larger firms are more likely to adopt new technology than smaller firms and outrun small companies in technology intensity (Rogers, 1995). Moreover, being highly adoptive of new technologies, large firms are more eagerly engaged in learning and utilizing new technologies than small firms (Fichman & Kemerer, 1997). R&D process is a rare activity in small firms, and thus technology adoption for them remains incremental or often imitative. This has been explained by the fact that large firms have sufficient resources for investing in technologies and are financially stable (Wagner & Hansen, 2005). Therefore, large firms have an advantage over small companies because their financials might allow them to be more capable adopters.

Hypothesis1: The size of a firm positively influences the technology adoption of the firm

● Export Orientation. A desire to leave the highly competitive domestic market, strive to equal or surpass similar companies, improve business opportunities, and achieve economies of scale are the motivational sources for a firm to expand its operations to foreign markets (Moini, 1992). Commitment, international attitude, perception and knowledge of international matters, risks involved, and the opportunities present in foreign markets have been found to be the significant factors that influence a firm's entry into the international market (Aaby & Slater, 1989; Axinn, 1988; Cooper & Kleinschmidt, 1988; Czinkota & Johnston, 1983; Madsen, 1989; Nassimbeni, 2001). Studies have also found that technology activities are an important factor in explaining the export performance of firms in developing countries (Kumar & Siddharthan, 1994). To better assist firms in their internationalization efforts, various technology development and promotion programs have been initiated as a major stimulus for economic growth (Yeoh & Jeong, 1995).

Similarly, a firm's adoption of advanced manufacturing technology is found to be positively correlated with the export orientation of the firm (Mechling et al., 1995). Export orientation can be conceptualized as the extent to which a firm is motivated to export and various export activities are undertaken. Firms differ in their objectives (i.e., flexibility, competition, cost savings, etc.) depending on whether they are engaged in the global and/or domestic markets, and thus differ in adoption of advanced technologies to compete effectively in their respective markets (Mechling et al., 1995). Thus, a firm's export orientation may influence adoption of technologies. It seems that technology adoption has become an essential of export orientation for a firm. Accordingly, that export orientation is hypothesized to positively affect the level of technology adoption in a firm.

> Hypothesis 2: The degree of a firm's orientation to export positively influences technology adoption of the firm

- Top Management's Commitment. Top management has overall responsibility for a firm beyond production management. The role of a firm's top management also includes management of external relations and continuous development and improvement of the firm (Carpenter et al., 2004). Most of the strategic decisions on design and development, planning and production, innovation and exporting are likely to be made by managerial and professional workers of the firm. The decisions and actions made by the top-managements are likely to have an impact on the organizational change, growth, and development because those at the higher management levels have greater influence upon decisions and the decisions are strategic in nature (Carpenter et al., 2004). Useem (1993) found that top management's vision for the use of these technologies determines the level of support for the innovation adoption. Thus, top-management commitment's to technology is likely to shape the firm's technology adoption activities/policies and influences its level of technology adoption. Top-management's

commitment to technology is defined as 'the degree to which the values and perceptions of the management are in favor of and open to technology adoption' (Useem, 1993, p.422). Hence, the technology adoption level is expected to be higher in those firms with top management commitment to technology than in those without.

> Hypothesis 3: Top management's commitment to technology positively influences the technology adoption of the firm

● Cost of Capital. A firm's success significantly depends on its innovative efforts and the quality of its capital stock (Sterlacchini, 1990). Technology adoption highly depends upon the amount of planned capital expenditure and the firm's ability to secure capital for technology adoption. Thus, while capital is likely to provide opportunities for technology adoption activities in the firm, cost of capital is a major concern that prohibits the firms from making technology investment decisions and developing adoption activities. The cost of capital refers to 'the general cost-related problems associated with advanced technology adoption, the cost of technology acquisition, equipment purchase, and development and maintenance expenses' (Baldwin & Lin 2002, p.6). Accordingly, a relevant hypothesis is proposed as follows:

> Hypothesis 4: The managerial perception of cost of capital negatively influences the technology adoption of the firm

● Technical Skills. Scholars have stressed the importance of human resources for generating diversity and innovation (Co et al., 1998; Holt, 1993). Likewise, the advancement and adoption of technology increase the need for human support. Appropriate and effective employee skills and practices are increasingly important in today's technology-based manufacturing. Many forms of technological implementation, especially adoptions of new manufacturing technologies, need to be accompanied by changes in skill requirements (Doms et al., 1997). Even when the technology activities of a firm are limited to an adoption of existing technologies, they require

the services of highly qualified engineers and technicians in order to identify and make use of relevant information (Mason & Wagner, 1994). A lack of skills inhibits installation of newer equipments due to poor understanding of the technical nature, potential of the equipment, and usage (Steedman & Wagner, 1989).

It has been found that skilled labor has been one of the most important strategies that contribute to the growth of small and medium-sized firms, and it is likely to be a facilitator of technology adoption (Baldwin et al., 1994). Therefore, firms that have a skilled labor forces to support advanced technology are more likely to be proactive in adopting technologies because of the availability of technical skills.

> Hypothesis 5: Availability of technical skills positively influences the firm's technology adoption

● Competitive Advantage. Competition and environmental change may force companies to seek new technologies. In a highly competitive industry, there is a constant need for firms to evaluate advances in technology and adopt them to gain competitive advantage. Competition is one of the environmental variables that affect a firm's strategy, and competitive advantage has been found to be the most significant motivator that determines the level of technology adoption and implementation in a firm (Premkumar, 2003). According to the previous studies (Grover, 1993; Premkumar & Rammurthy, 1995), if the firms perceive that gaining competitive advantage from using the technologies is feasible, they are more likely to adopt new technologies.

The nature of advanced technology adoption depends on the firm's goal. The first and most obvious reason for adopting new technologies is to better satisfy the firm's needs and wants. Specific production problems, or the need to enhance the general product and process flexibility, may further encourage technical change in a firm. The ultimate goal of advanced technologies seems to be producing better products and services at lower prices, which results in

gaining a competitive edge. Firms can gain competitive advantage and grow as a result of technology adoption and implementation. Thus, garment manufacturing firms are likely to adopt advanced technologies to gain or maintain competitive advantage.

> Hypothesis 6: The need for technology as a source of a firm's competitive advantage positively influences the technology adoption of the firm.

CHAPTER 3

METHOD

The purpose of this study was to investigate the status of technology adoption and examine organizational factors that facilitate technology adoption in the garment manufacturing firms in India. To test the hypotheses, primary data for this study was collected through an on-line survey using a self-administered questionnaire. This method was chosen because 1) all the businesses that are involved in international trade use electronic communication method (i.e., e-mail), and 2) it reduces the cost of mailing and incidents in which international mail get lost. This method also saves time in sending mail, receiving responses, and makes organizing and coding the data for analysis easier.

3.1 Sample and Procedure

3.1.1 Sample

Individual firms were treated as the unit of analysis. The responses from the firms that are highly engaged in garment manufacturing and exporting a considerable portion of their total output were deemed appropriate. Garment manufacturing firms located in Tirupur, of the Tamil Nadu state in India, were chosen as the sample for this study. A random sampling procedure was used to select 500 firms from the business directory of apparel exporters of Apparel Export Promotion Council (AEPC), India.

Tirupur is an important part of Coimbatore District in Tamil Nadu State, South India. Tirupur is the biggest supplier of knitted garments in India and a leading source of casual garments and sportswear as well. A total of 56 % of India's knitwear exports come from Tirupur. The reasons for the success of Tirupur are: 1) easy availability of hosiery yarn, 2) availability of

cheap/rural labor, and 3) entrepreneurs' flexible attitudes in meeting the buyers' demands (AEPC). Tirupur is also known as Dollar City, Knit City, Cotton City and mainly "Hosiery Centre".

Buyers from 35 countries frequently visit Tirupur for business. Firms in Tirupur can deliver customized products or garment samples in less than 12 hours, and half a million pieces in a matter of days. Strong entrepreneurial and personalized management facilitates efficient negotiations and cost effectiveness through direct control of operations. Quick delivery and quality products are added benefits of Tirupur as a centre of outsourcing for buyers from all around the world.

According to the Apparel Export Promotion Council of India, Tirupur is one of the largest foreign exchange earners of the nation, earning US$ 1.12 billion and providing employment opportunities to 600,000 people. Tirupur exported 370.4 million pieces in 2003. Tirupur consists of 2500 knitting and/or stitching units, 750 dyeing and/or bleaching units, 300 printing units, 100 embroidery units, and 200 other units (compacting, raising, calendaring). Besides knitwear units in Tirupur, there are a large number of other ancillary industrial units that manufacture elastic tapes, cartons, name tags, printed labels, polythene bags and other packing materials. Since the establishment of the town, a large number of sophisticated computerized machines, full fledged processing units, individual machines, and compacting machines have also been implemented (AEPC).

3.1.2 Instrument

To increase the validity of the instrument and to pretest the data collection procedure, a pilot study was conducted. E-mails were sent to industry professionals in India and faculty members in the Textiles and Apparel field. They were asked to answer the questionnaire and

provide their comments regarding the content and readability of the survey. After the pilot study, further refinement was made according to the comments received to prepare the final questionnaire for the survey. This procedure was performed to achieve content validity and to reduce confusion and misunderstanding by the respondents answering the survey.

Appendix A shows the items included in the questionnaire. The first section of the questionnaire was designed to assess the degree of a firm's adoption of various technologies. Table 3 shows the technologies included in this study and their descriptions. Respondents were presented each technology along with its description and asked to indicate adoption status of the technology by the firm (i.e., adopted, in process of adoption, under consideration for future adoption, not applicable). Respondents were also asked to indicate the frequency of use of that technology if they had adopted it. Section two included questions related to the organizational factors (i.e., firm size, export orientation, top management commitment, cost of capital, technical skills, and competitive advantage). Section three included questions related to the demographic information of the firm and the respondent.

Table 3

Technologies Considered in This Study

Variable	Technology	Description
CAD	Computer aided design	Any design activity that involves the effective use of computers for drawing and designing parts or products for analysis and testing of designed parts and products
AIN	Automated inspection	Parts presentation and inspection are both performed automatically
AMHD	Automated material handling devices	systems capable of automatically loading, unloading, or sorting unit loads; parts feeding and delivery devices

Table 3 (Continued)

Variable	Technology	Description
NC	Numerical control machine tools	A form of programmable automation in which the processing equipment is controlled by means of numbers, letters, or other symbols
SPC	Statistical process control	Mathematical techniques used to control control manufacturing processes within specified limits to ensure that the process is conforming to the desired standards
PPIC	Production planning/ inventory management software	A computerized production planning system whose function is master production scheduling, material requirements planning and capacity planning
LAN	Local area networks	Communication system that permits various devices connected to the network to communicate with each other over distance of several feet to several miles
PPR	Pick/place robots	A simple robot with 1-3^0 of freedom, which transfer items from place to place
OR	Other robots	A reprogrammable, multifunctional manipulator designed for automation assembly line for garment making, move materials, parts, tools, or specialized devices
HSSM	High speed sewing machines	Sewing machines run on high speed with fully/semi automated operation, digital panel and control systems
MFPM	Modern fusing and pressing machine	Fusing machines used to fuse the materials which runs on controlled temperature and speed adjustments and the steam pressing machines with air suction systems
CUFF	Computers used on factory floor	Computers used solely for data acquisition or monitoring daily data, but which are capable of being reprogrammed for other functions
IT	Internet	Usage of internet for web hosting, email, online communication, and to search
CM	Communication	Usage of cell phone, pagers, and Fax

Note. Adopted from Mechling, G. W. et al., (1995) and Dunne, T. (1994).

3.1.3 Measurements

Each variable was measured by multi-item indicators. All the items, except firm size, used a 5-point, Likert-type scale ranging from *strongly disagree* (1) to *strongly agree* (5). The export orientation scale, consisting of four items, was adapted from Francis and Collins-Dodd's (2000) study and assessed a firm's commitment and openness towards exports. The Cronbach's alpha (reliability coefficient) reported for this scale was .82 (Francis & Collins-Dodd, 2000), which is considered highly reliable. Top management commitment was measured by three items that were designed to assess the degree to which top-management is committed to technology adoption. Cost of capital was measured by two items that assessed the degree to which cost constraint interferes with adopting technologies in the firm. Competitive advantage was measured by three items and assessed the need for advanced technologies to compete in the market. The top management's commitment, cost of capital, and competitive advantage scales were adapted from Premkumar's (2003) study that investigated information technology in small businesses. In his study, the three scales established reliabilities (α) of .70, .75, and .64, respectively. Four items for technical skill were adapted form Igbaria et al.'s (1997) study that reported composite reliability of the scale as .92. The technical skills scale was used to assess the availability of technical support by specialists, in terms of technical assistance and specialization. The Size of the firm was measured by the number of employees.

3.1.4 Procedure

This study used an electronic mailing method to communicate and collect the data through an online survey. Participation in the study was voluntary and participants were assured that their responses would be confidential. An electronic mailing system was established, by which an e-mail invitation was sent to the appropriate individual from each selected firm. Each

e-mail was individualized to the receiver (e.g., name and company) and provided the necessary information about the survey. It contained a web link to direct the receiver to the online questionnaire. One week after the initial e-mailing a first reminder email was sent. Two weeks after the initial e-mailing, a final reminder e-mail was sent. The reminder e-mails also contained the link to the questionnaire. This procedure was expected to maximize the response rate.

3.2 Sample Description

Among 500 firms that were sent e-mails, 332 were successfully delivered. A total of 114 completed responses were received, resulting in a response rate of 34.3 %. After careful review of the returned responses, three responses were determined unusable because of a significant number of missing values. Therefore, a total of 111 responses were deemed usable and were included in the analysis.

Table 4 summarizes the demographic profile of the respondents. Among 108 respondents, 16 (15%) were female and 92 (85%) were male. The average work experience (tenure) of the respondents at their current firms was 6 years. Most of the respondents held a management position at the firm level (e.g., the owner or a senior officer). Table 4 also provides information regarding the characteristics of the firms included in the analysis. The average annual sales volume of the firms was US$ 4 million. Other sample characteristics include: the average age of a firm is 11.8 years old, the average number of employees was 273.6 employees, and the average revenue from exports was 60 %.

3.3 Analysis

The data were analyzed by using the SPSS (Statistical Package for Social Science) software package version 14.0. SPSS is widely used for various statistics and data management. SPSS is a software package used for conducting statistical analyses, manipulating data, and

Table 4

Characteristics of the Respondents

Variable	Description	Frequency	Percent
Sex	Female	16	15
	Male	92	85
	Total	108	100
Age	0-25	0	0
	26-31	6	6
	32-37	35	32
	38-43	44	40
	44-49	19	17
	50-55	3	3
	56-60	2	2
	61 and above	0	0
	Total	109	100
Title	General Manager	5	4.5
	Business Owner/Partner	28	25.6
	CEO	12	11.0
	Director	21	19.2
	Export Manager	3	2.7
	Factory In charge/Manager	19	17.4
	Merchandiser	8	7.3
	Production Manager	7	6.4
	Quality Assurance Officer	6	5.5
	Marketing Manager	1	0.9
	Total	109	100
Ownership	Public/Government	0	0
	Privately Owned	102	94
	Joint ownership of government and private parties	5	5
	Joint ownership with foreign companies	1	1
	Total	108	100
Annual sales	Less than or equal to 1 million	40	39.6
	More than 1 to 5 million	27	26.7
	More than 5 million	34	33.7
	Total	101	100

Table 4 (Continued)

Variable	Description	Frequency	Percent
Product	Woven shirts	31	28
	Knit shirts	73	66
	Trousers	30	27
	Ladies blouses	31	28
	Skirts	33	30
	Suits	6	5
	Coats	7	6
	Sweaters	13	11
	Robes	20	18
	Dressing gowns	21	19
	Babies garments	49	44
	Breeches and shorts	27	24
	Nightwear and pajamas	54	49
	Underwear	36	33
	Accessories	11	10
	Other	5	4

generating tables and graphs that summarize data. Regression analysis, as well as descriptive statistics such as means and frequencies, were used in this study.

A multiple regression analysis (MRA) was used to test the hypotheses. MRA allows researchers to test the relationship between multiple independent (or predictor) variables and a dependent (or criterion) variable. Using multiple regressions, one can establish a set of independent variables, assess the proportion of variance in a dependent variable explained by the independent variables (by R^2), and establish the relative predictive importance of the independent variables (by comparing beta coefficients). A multiple regression equation takes the form of $Y = b_1 * x_1 + b_2 * x_2 + \ldots\ldots + c + e$, where Y is the dependent variable, the b_1, b_2… are the regression coefficients for the corresponding x (independent) variables, c is the constant, and e is the error term reflected in the residuals. Thus, MRA was determined to be the appropriate data analysis

technique to test the hypotheses of this study. In this study, technology adoption was a dependent variable and organizational factors were independent variables.

CHAPTER 4

ANALYSIS AND RESULTS

This chapter reports the preliminary data analysis including reliabilities and validities of the measurements, descriptive statistics, and regression analysis to test the hypotheses.

4.1 Reliabilities of the Constructs

The reliabilities of the constructs used in this study were assessed using Cronbach's alpha coefficients. The results indicated (see Table 5) that four of the five variables achieved an alpha value greater than the suggested cutoff value of 0.7 (Premkumar, 2003). The Cronbach's alpha for cost of capital is .66, which was slightly lower than the cutoff. This variable was measured using two items, and the low coefficient can be attributed to the fact that the Cronbach's alpha tends to be low for constructs with few items and usually the values which are above .6 are considered to be acceptable (Premkumar, 2003). The scores of the items for each construct were summed to represent the extent of the construct, and the summed score was used as a dependent variable. Means and standard deviations of the constructs are reported in Table 6.

Table 5

Variable Statistics

Variable	M	SD	Reliability α
Export orientation(EO)	15.3	2.8	.81
Top management commitment(TPM)	10.5	2.4	.80
Cost of capital(CC)	7.9	1.5	.72
Technical skills(TS)	13.8	2.8	.78
Competitive advantage(CA)	11.2	2.0	.66

Note. Number of items for each construct: EO-4, TPM-3, CC-2, TS-4, and CA-3.

4.2 Technology Adoption by the Firms

Table 6 shows the descriptive statistics of technology adoption. The most frequently adopted technology was internet-IT, which exhibits 100 % adoption status by the firms. The next frequently adopted technologies were as follows in the order of frequency: local area network-LAN, high speed sewing machines-HSSM, modern fusing and pressing machines-MFPM, computers on factory floor-CFF, production planning and inventory management-PPIM, computer aided design-CAD, statistical process control-SPC, automated material handling devices-AMHD, pick up and place robots-PPR, numeric controls-NC, and automated inspection-AIN. The least frequently adopted technology was other robots-OR (1%).

Table 6

Manufacturing Technologies Adoption Status by the Firms

Technology	Valid N	Mean	SD	Number of Firms adopted	Percent
CAD	111	.68	.46	76	68.5
HSSM	111	.92	.25	103	92.8
AIN	111	.10	.31	12	10.8
AMHD	111	.18	.39	21	18.9
MFPM	111	.91	.27	102	91.9
CFF	111	.90	.30	100	90.1
NC	110	.12	.33	14	12.7
SPC	110	.25	.43	28	25.4
PPIM	109	.72	.44	79	72.4
LAN	109	.93	.24	102	93.5
PPR	109	.13	.34	15	13.7
OR	109	.00	.09	1	0.91
IT	109	1.00	.00	109	100

The dependant variable for this study was the composite level of technology adoption. Technology adoption has been described as the adoption or acceptance of a new equipment or

innovation activities of the firm. The technology adoption level of a firm was determined by the product of installation status of the various technologies along with the usage level of each technology installed. The following illustrates the mathematical formula that was used to calculate the dependent variable, technology adoption:

$$\text{Technology Adoption} = \sum_{i=1}^{n} (T_i \times TU_i)$$

Where:

T = Technology installation status (1: installed; 0 uninstalled)

TU= Technology usage level (5: frequently; 4: often; 3: sometime; 2: rarely; 1: never)

i = technology (n = 14)

For technology installation status, the weight was given as 1 if the selected technology was installed. If not installed, the weight was zero. The extent of usage was measured by five levels [i.e., frequently (5), often (4), sometimes (3), rarely (2), never (1)], and each level was quantified ranging from 1-5 with 5 being the highest in usage level. For example, when a respondent indicated that they installed a selected technology and use it frequently, the score of technology adoption for that technology is 5 (i.e., 1 multiplied by 5). If the technology is rarely used, the score is 2 (i.e., 1 multiplied by 2). If the technology was not installed, the technology adoption will be zero. The sum of the technology adoption levels of all 14 technologies included in this study was coded and used as the dependent variable in the regression analysis. Thus, the level of technology adoption reflected the number of technologies a firm installed and the extent of their usages. The dependent variable mean was 29 with a standard deviation of 8.29.

4.3 The Effect of Organizational Factors on Technology Adoption

Table 7 provides the correlation coefficients among the dependent and independent variables. All variables exhibited high correlations with other variables except cost of capital with export orientation, top management commitment, technical skills, and technology adoption. A multiple regression analysis was performed to examine the significance and relationships between organizational factors and the level of technology adoption. The dependent variable was the level of technology adoption, and the independent variables were export orientation, top management commitment, cost of capital, technical skills, competitive advantage, and firm size.

Table 7

Correlations of the Variables

Variables	EO	TMC	CC	TS	CA	FM
Export Orientation (EO)	1.000					
Top management commitment (TMC)	.797**					
Cost of capital (CC)	-.039	-.012				
Technical skills (TS)	.641**	.686**	-.029			
Competitive advantage (CA)	.671**	.716**	.013	.602**		
Firm size (FM)	.222*	.265**	.147	.285**	.187	
Technology adoption (TA)	.160	.284**	-.007	.309**	.268**	.512**

Note. ** Correlation is significant at 0.01 level (2-tailed).
* Correlation is significant at 0.05 level (2-tailed).

The regression analysis (see Table 8) revealed the level of a firm's technology adoption was significantly related to its export orientation and firm size and was moderately related to competitive advantage. The effects of firm size and competitive advantage were positive, and the effect of export orientation was negative. Thus, hypothesis 1 was supported, and hypothesis 6 was moderately supported. The result implies that larger and less export oriented firms tend to install technologies more extensively and use them more frequently than smaller and more

export oriented firms. It also indicates that the firms with a higher level of competitive pressure tend to adopt technology more often than those with a lower level of competitive pressure. The effects of top management commitment, cost of capital, and technical skills were not significant where other independent variables were present in the model, although the technical skills variable was highly correlated with the technology adoption (see Table 7). The regression model explained a total of 32.3% variance with an F value of 8.39 [6,87] which was statistically significant.

Table 8

Results of the Multiple Regression Analysis on Technology Adoption

Independent Variable	**B**	**SE**	**B**
Export orientation	-.860	.419	-.305*
Top management commitment	.232	.529	.070
Cost of capital	-.566	.451	-.109
Technical skills	.491	.343	.175
Competitive advantage	1.025	.522	.258†
Firm size	.024	.005	.486**

Note. R^2 = .366, † P<0.10; * P<0.05; ** P<0.01

CHAPTER 5

DISCUSSION

The purpose of this study was to investigate the technology adoption status of Indian garment manufacturing firms and to examine the effects of organizational variables on the level of technology adoption in the post-quota environment. The organizational variables that were examined include firm size, export orientation, top management commitment, cost of capital, technical skills, and competitive advantage. This chapter discusses the results of the study, contribution and limitations of the study, and implications for future research.

5.1 Findings & Implications

It was found that the most frequently adopted technology was internet-IT, which was adopted by all the firms. This indicated a high level of advanced information and communication technology (ICT) usage by Indian garment manufacturing firms. Adoption of the internet generally helps to reduce cost and time of communication, and the internet now provides a powerful tool for apparel manufacturers to market their products by presenting their firm profiles on a global scale. This enhances the competitiveness of the garment firms. The internet also creates an opportunity for a manufacturer to become a retailer of their own goods by directly reaching target consumers. Further, the ICT continues to evolve as an important tool for implementation of online solutions and to access global market information any time, anywhere. The least frequently adopted technologies found in this study include automated inspection, numeric control, pick-up and place robots, and other robots.

This study also revealed the relative significance of the proposed factors in predicting the level of a firm's technology adoption and supported that some organizational factors significantly predict firm's technology adoption activities. The technology adoption level of a

firm was found to be positively related to the firm size and negatively related to export orientation. The effect of competitive advantage was moderately significant. These findings indicate that larger firms are more likely to adopt advanced technologies than smaller firms. Technology adoption seems to be more important to the firms that are less export focused and large in size. Export orientation alone was not correlated with the level of technology adoption but it was significant when other organizational variables were present, indicating that the effect of export orientation is interactive with other factors investigated.

The significant influence of the firm size indicates that a considerable difference exists in the level of technology adoption between small and large garment manufacturing firms. This is supported by a previous study that found larger firms in the industry, where a large number of small businesses are dominant, have a great propensity to adopt advanced technologies (Premkumar et al., 1997). Similarly, the Indian garment industry is characterized by a large number of relatively small firms, and this may have limited their technology expertise. The resources required to implement adoption are probably the reason why large firms are more likely to adopt technologies than small firms. In contrast, smaller firms may be constrained by available resources that can be allocated to adoption of advanced technologies. The result warns that small sized firms may have limitation in responding to global competition through technology adoption and need supports from the government and industry. These firms also need to realize the benefits and strategic implications of the technologies for surviving the competition.

The influence of export orientation on technology adoption found in this study was significant, but the effect was negative. This is inconsistent with previous studies where a firm's adoption of advanced manufacturing technology was found to be positively related to export

orientation of the firm (e.g., Mechling et al., 1995). Nassimbeni (2001) also claimed that the most successful firms in export manufacturing business are more proactive in adoption of technologies. Accordingly, in this study, it was predicted that those who have the desire to be international suppliers may have high motivations to adopt new and advanced technologies, given the recently increased level of free trade opportunities in the apparel industry. However, the negative effect of export orientation found in this study implies that Indian firms may have become less adoptive of technologies because of the intensified price competition and downward pressure of cost in the freer trade environment. It may be that the customers who source from India are mainly focusing on labor intensive products with fewer requirements for technology. The relationship between export orientation and price orientation, and their effects on technology adoption are to be explored in future research.

The moderate significance of the competitive advantage influence indicated that the competitive advantage gained through technology adoption may be a determinant in technology adoption. Competition and environmental changes and the competitive pressure from them may force the firms to seek new technologies. It may be that a firm chooses to adopt advanced technologies simply because of a fear of losing business in competition (Premkumar & Ramamurthy, 1995). Recent study on information technology implementation in small businesses by Premkumar(2003) emphasized gaining competitive advantage as an important motivational source of technology implementation. In the same study, competitive pressure has been described as one of the most significant environmental variables that influence technology adoption of a firm. Even small firms may adopt technologies if their suppliers insist on using advanced technologies for doing business with them. Future research needs to confirm the relationship between competitive advantage and technology adoption.

On the other hand, the results indicated that the top management's commitment, cost of capital, and technical skills did not have significant effects on the technology adoption level. It may be that the effects of these variables become lesser when the firms are large in size. The correlations, in contrast, between most of the organizational variables examined and technology adoption were high. These imply that the insignificant variables resulted from the firm size is relatively more influential than other organizational variables.

Cost of capital had an insignificant effect on technology adoption. Ungan (2005) noted that firms were ready to adopt the best practices in technology as long as they had adequate resources apart from cost. However, firms included in this study indicated that cost may not be a significant constraint of technology adoption. It may be that the cost of establishing and maintenance for these technologies for garment manufacturing is actually low, and thus an insignificant factor in adoption decision.

Top management's support was not significant in influencing a firm's technology adoption, although most prior studies on technology adoption found it significant (Igbaria, 1997; Premkumar et al., 1997; Premkumar, 2003). In many firms, the primary decision-maker in areas like technology adoption is the owner or top management of the business (Carpenter et al., 2004; Premkumar, 2003), and his or her vision for the use of these technologies determines the level of support for the innovation adoption (Useem, 1993). The contrasting result in this study may be due to the environmental characteristics of apparel business. The traditional innovation adoption studies emphasized the support/commitment of adopter as a primary force of adoption, while recent scholars emphasize the importance of external factors rather than internal commitment. One possible explanation for the insignificant result of top-management commitment is that most of the firms adopting the technologies are influenced by variables that are relevant to the current

business environment rather than by the internal decision makers' perspective. The recent free trade trends in the industry may have created an environment where exporting opportunities and competitive pressure are primary motivations. Such new opportunities made them consider external forces and industry demands more intensively than the internal, the managerial factor of adoption. It is also possible that Indian managers are reluctant to implement technology adoption unless they are convinced the technology has to be adopted to meet the new trade requirement and enhances overall firm performance. To take advantage of gained operational benefits, management may support a practice that will significantly improve performance even though it does not have a high compatibility with the existing systems of the company (Ungan, 2005).

The relationship between availability of technical skills and technology adoption was also found to be insignificant. The typical production in the apparel manufacturing process still involves a great deal of manual operations of the machines and automated assembly. Garment manufacturing still remains highly labor intensive rather than technology intensive, and thus the need for technical support may be inconsequential for apparel manufacturing technologies. Noori (1997) claimed that there is little need for additional technical support unless manufacturing technologies become more advanced and sophisticated. It is possible the garment manufacturing technologies are not complex enough to require technical support and thus may not need high skilled human resources.

5.2 Contribution of the Study

This study provides information on the status of technology adoption by Indian garment manufacturing firms in the present context of globalization. The study also explored the effect of organizational factors on technology adoption and suggested what contributes to the higher level

of technology adoption and what types of firms are more likely to adopt new and advanced technologies. This study was an exploratory study and adopted various manufacturing technologies from other fields to explain the influencing factors of technology adoption in the garment manufacturing industry. The findings contribute to the field of textiles and apparel by initiating garment manufacturing technologies research and reporting the level of adoption status of Indian garment firms. In accordance with the increased level of globalization, the field is also needs to further the knowledge on the global level. This study provides insights regarding technology adoption in a case of India. The case deepens knowledge and initiates further research of technology adoption in the global industry.

The concept of technology adoption has traditionally been treated as innovation in business. Among the frequently cited benefits of innovation include reduced direct labor costs, reduced production costs, reduced product development time, reduced inventory, more efficient layout and use of technology, better quality, less waste, improved productivity, shorter manufacturing lead time, and quicker response to market shifts (Bailey, 1993; Bleaney & Wakelin, 2002; Damanpour, 1996; Gopalakrishnan & Damanpour, 1994; Kleinschmidt & Cooper, 1988; Lenny, 2005; Mahemba & De Bruijn, 2003; Mason & Wagner, 1994; Roper & Love, 2002; Soni et al., 1993; Wagner & Hansen, 2005). The results this study provide information that contributes to the development of advanced and efficient garment manufacturing and supply chain by identifying influencing factors of technology adoption. The information is especially valuable because technology adoption is a challenge for the garment manufacturing firms in developing countries to achieve competitiveness. Since developing countries are in a disadvantageous position in the development of high technologies (Kumar & Siddharthan, 1994), adoption is an alternative for these countries to gain a competitive edge. The

results of this study provide the industry with valuable, practical implications for organizational directions that may encourage technology adoption practices. This contributes to the economic development and trade participation for developing nations.

5.3 Limitations and Future Research

Various technologies included in this study were identified from literature in small and medium sized firm's innovation adoption, technology and manufacturing management. Some technologies were found to be scarcely used by the firms studied. Future research may focus on those used more frequently and may expand each technology into more extensive sub-categories. A longitudinal approach to study adoption of technologies would be also valuable to investigate technology adoption over time and determine influential factors as well as the impact of adoption on firm financial performance. As advanced technologies become more critical in the garment industry, it would be essential to examine the financial performance as a result of technology adoption.

Although the results provide insight into technology adoption of firms, they may have limited generalizability. First, firms that received the survey were limited to those who have web access services (internet connection). Another issue related to the respondents is that the survey was sent to the high ranking executives of the firms who were familiar with their overall company operations because the subject of the survey was a managerial issue. Thus, results may not truly reflect all the employees' opinions. Second, because the garment industry is labor intensive, the study's findings may not be applicable to other industries. The study may have sample influence, because the sample was garment manufacturing firms restricted by geographical location in one industrial city and the size of the sample was limited.

Results related to the variables have been inconsistent with traditional technology adoption research. Further research needs to be done on the variables that were found to be insignificant in this study by using different instruments or measurements to confirm the findings of this study. While the managerial force examined in this study was not significant, it is possible that some other internal force such as goals or other managerial characteristics may influence. For example, while some firms act promptly and effectively to maintain or improve competitive advantages from the adoptions, others may wait until they become standards (Premkumar et al., 1997).

Firms' needs for advanced technology adoption may depend upon the environment or contextual conditions. This study found that competitive pressure may have played a significant role in technology adoption. To gain competitive advantage, there is a constant need for firms to observe advances in technology and adopt them (Premkumar et al., 1997). External, environmental variables may be investigated further to better understand firm's technology adoption activities. Further research may explore the relationship between environmental scanning and technology adoption. In addition, goals the firms pursue may also be further explored. This study found that export orientation was not a positive predictor of technology adoption, and thus further research may examine various, different goals of firms on their technology adoption, along with price competition interrelationships.

With the emphasis on technology and the trend toward broader technology adoption, this study can be extended to other industries with a wider range of factors that include environmental, organizational, technology related variables, and supply chain characteristics. For example, an interesting environmental variable is external support/pressure for adopting these technologies. These factors may influence technology adoption or moderate the relationships

between organizational factors and technology adoption. Motivational factors can be internal, supportive, or externally pressured. Further investigations of such factors along with the findings in this study will not only deepen the understanding of motivators and facilitators of technology adoption but also provide more detailed directions for future research. By including the extensive factors and their relationships, a comprehensive framework of technology adoption and its rigor can be built.

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APPENDIX A

HUMAN SUBJECT EXEMPTION FORM

IRB #: 3369 LSU Proposal #:_____ **Revised:** 05/12/2006

LSU INSTITUTIONAL REVIEW BOARD (IRB) for HUMAN RESEARCH SUBJECT PROTECTION

578-8692 FAX 6792
Office:203 B-1 David Boyd Hall

APPLICATION FOR EXEMPTION FROM INSTITUTIONAL OVERSIGHT

Unless they are qualified as meeting the specific criteria for exemption from Institutional Review Board (IRB) oversight, ALL LSU research/projects using living humans as subjects, or samples or data obtained from humans, directly or indirectly, with or without their consent, must be approved or exempted in advance by the LSU IRB. This Form helps the PI determine if a project may be exempted, and is used to request an exemption.

Instructions: Complete this form.

Exemption Applicant: If it appears that your study qualifies for exemption send:

(A) Two copies of this completed form,
(B) a brief project description (adequate to evaluate risks to subjects and to explain your responses to Parts A & B),
(C) copies of all instruments to be used. If this proposal is part of a grant proposal include a copy of the proposal and all recruitment material.
(D) the consent form that you will use in the study. **A Waiver of Written Informed Consent is attached and must be completed only if you do not intend to have a signed consent form.**
(E) Certificate of Completion of Human Subjects Protection Training for all personnel involved in the project (including students who are involved with testing or handling data) at http://cme.cancer.gov/clinicaltrials/learning/humanparticipant-protections.asp. (Unless already on file with the IRB.)

to: ONE screening committee member (listed at the end of this form)in the most closely related department/discipline or to IRB office.

If exemption seems likely, submit it. If not, submit regular IRB application. Help is available from Dr. Robert Mathews, 578-8692, irb@lsu.edu or any screening committee member.

Principal Investigator Venu Varukolu **Student?** (Y)N

Ph: 225-288-3812 **E-mail** VVaruk1@lsu.edu **Dept/Unit** Human Ecology

If Student, name supervising professor Dr. Park Ph: 8-0883
Mailing Address_____ Ph_____
Project Title A study of Technology Adoption of Indian Garment Firms

Agency expected to fund project_____
Subject pool (e.g. Psychology Students) Industry persons
Circle any **"vulnerable populations" to be used**: (children <18, the mentally impaired, pregnant women, the aged, other). Projects with incarcerated persons cannot be exempted.
I certify my responses are accurate and complete. If the project scope or design is later changed I will resubmit for review. I will obtain written approval from the Authorized Representative of all non-LSU institutions in which the study is conducted.

PI Signature _____ **Date** July 18, 2006 (no per signatures)

==========

reening Committee Action: Exempted ✓ Not Exempted ___ Category/Paragraph ___

Reviewer Michael Keenan Signature Michael Keenan Date 8-2-06

Study exempted by
Louisiana State University
Institutional Review Board
203 B-1 David Boyd Hall
225-578-8692
Robert C. Mathews, Chair

Institutional Review Board
203 B-1 David Boyd Hall
Louisiana State University and A&M College
Baton Rouge LA 70803

LSU IRB
REQUEST FOR WAIVER OF SIGNED INFORMED CONSENT

***** A copy of the script you will use for oral consent should be included with this form. This script should contain the necessary elements for written informed consent (see http://appl003.lsu.edu/osp/osp.nsf/$content/LSU%20IRB%20Documents/$File/chklist.txt)**

FROM: Name: Venu Varukolu

Department Human Ecology

TO: Robert C. Mathews, Chairman
Institutional Review Board for Research with Human Subjects

DATE: July 18, 2006

RE: **IRB#** _____

TITLE: A study of Technology Adoption of Indian Garment Firms

☐ **Requesting waiver of signed Informed Consent because:**

(a) The consent document would create the ***principal risk*** of participating in the study.

Or

☑

(b) The research presents ***no more than minimal risk*** of harm to subjects and involves no procedures for which written consent is normally required.

APPENDIX B
SAMPLE LETTER

Dear Practitioners,

This email is sent to you as a friendly reminder of a study on 'Technology Adoption of Indian Garment Manufacturing Firms'.

The purpose of this survey is to investigate the level of technology adoption and organizational factors that foster the level of technology adoption in the context of Indian clothing industry in the post-quota environment. Your contribution in this study is vital to understand the technology adoption activities throughout the industry.

Please do completely finish the survey, if you partially done so the results may not be useful for review work. It takes about 10 minutes to finish and we heartily welcome any suggestions and comments!

Your responses are completely confidential and your participation is voluntary. Please contact us if you have any questions.

Please visit the link below to access the survey

http://www.zoomerang.com/survey.zgi?p=WEB225HCZGQAKW

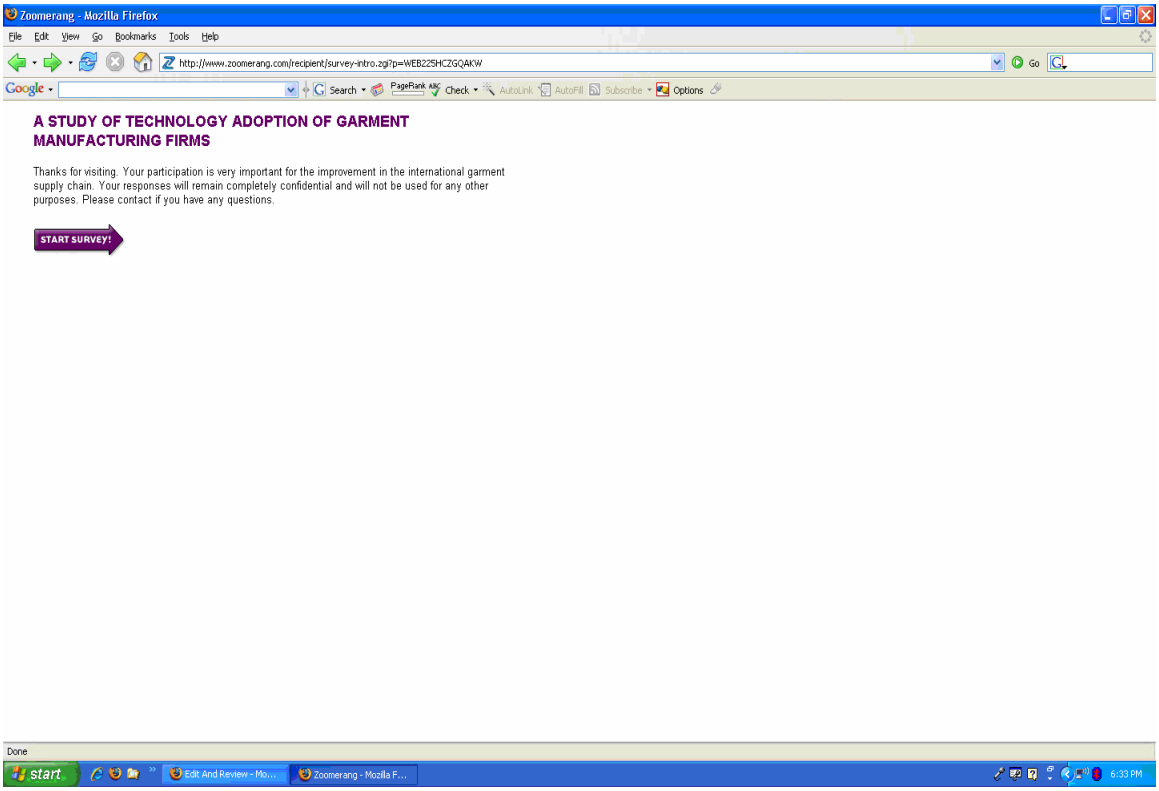
Investigators:
Venu Varukolu, MS candidate
Haesun Park, Assistant Professor
School of Human Ecology
Louisiana State University, USA
Ph: 225-578-1723
Fax: 225-578-2697
Email: vvaruk1@lsu.edu, hpark@lsu.edu

This study has been approved by the Louisiana State University Institutional Review Board. If you have any questions about participants rights you can contact Dr. Robert Mathews at 225-578-8692.

Thank you in advance for your survey participation and feedback

APPENDIX C

ONLINE QUESTIONNAIRE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A STUDY OF TECHNOLOGY ADOPTION OF GARMENT MANUFACTURING FIRMS
Thanks for visiting. Your participation is very important for the improvement in the international garment supply chain. Your responses will remain completely confidential and will not be used for any other purposes. Please contact if you have any questions.
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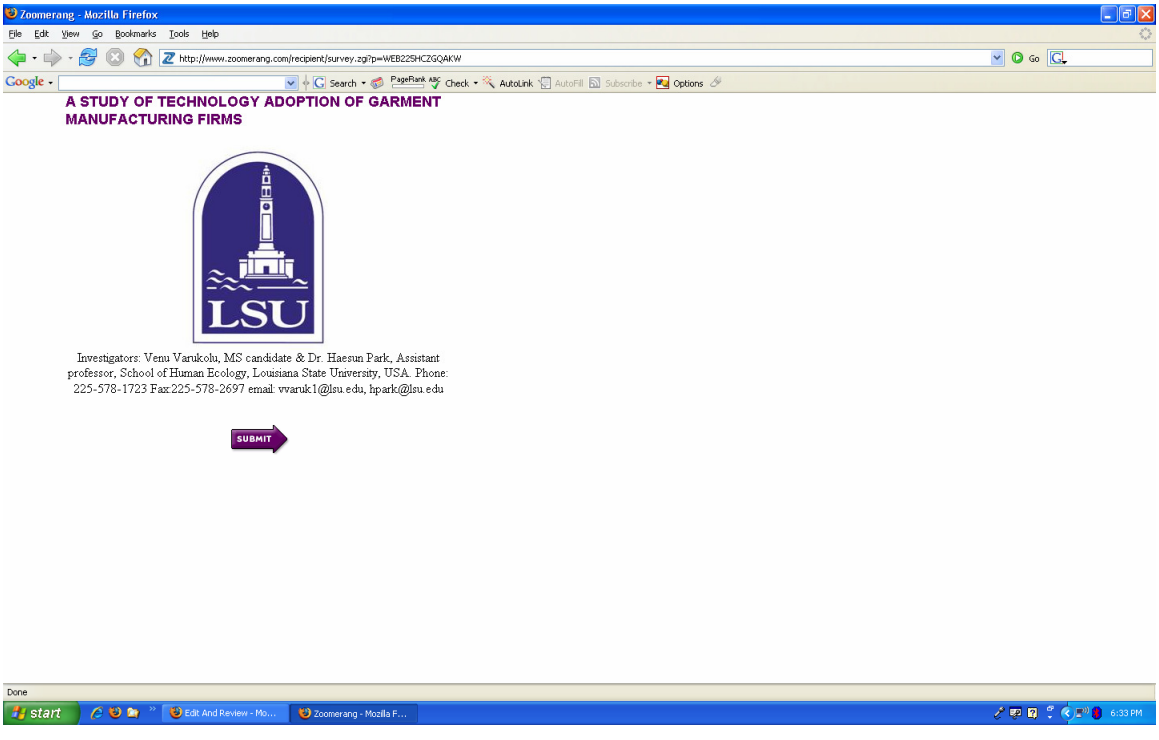
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A STUDY OF TECHNOLOGY ADOPTION OF GARMENT MANUFACTURING FIRMS
LSU
Investigators: Venu Varukolu, MS candidate & Dr. Haesun Park, Assistant professor, School of Human Ecology, Louisiana State University, USA. Phone: 225-578-1723 Fax:225-578-2697 email: vvaruk1@lsu.edu, hpark@lsu.edu
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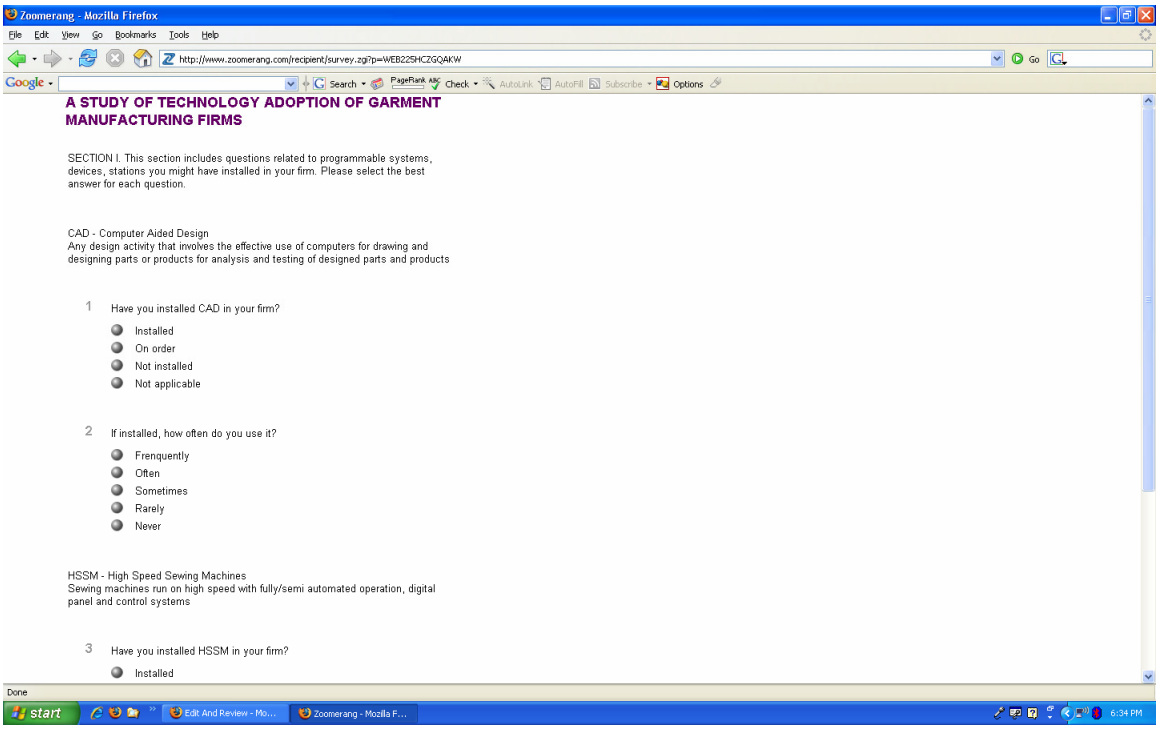
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A STUDY OF TECHNOLOGY ADOPTION OF GARMENT MANUFACTURING FIRMS
SECTION I. This section includes questions related to programmable systems, devices, stations you might have installed in your firm. Please select the best answer for each question.
CAD - Computer Aided Design
Any design activity that involves the effective use of computers for drawing and designing parts or products for analysis and testing of designed parts and products
1 Have you installed CAD in your firm?
Installed
On order
Not installed
Not applicable
2 If installed, how often do you use it?
Frenquently
Often
Sometimes
Rarely
Never
HSSM - High Speed Sewing Machines
Sewing machines run on high speed with fully/semi automated operation, digital panel and control systems
3 Have you installed HSSM in your firm?
Installed
Done
start
Edit And Review - Mo...
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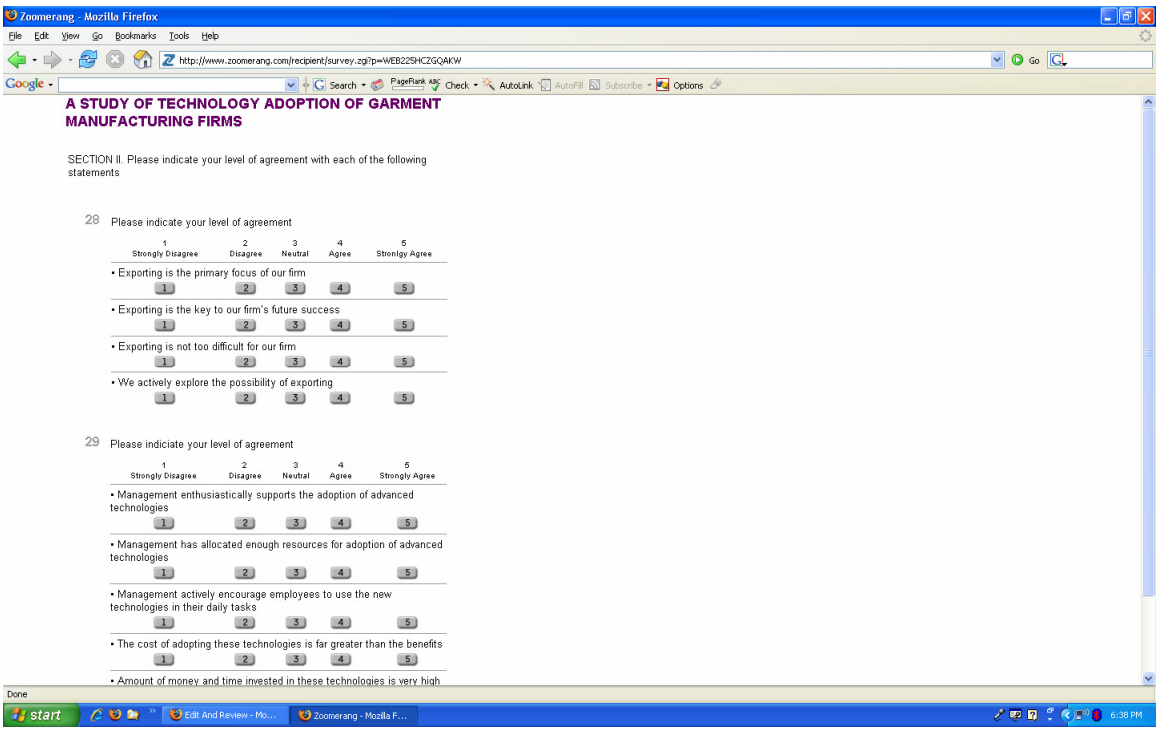
6:34 PM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http://www.zoomerang.com/recipient/survey.zgi?p=WEB22SHCZGQAKW
A STUDY OF TECHNOLOGY ADOPTION OF GARMENT MANUFACTURING FIRMS
SECTION II. Please indicate your level of agreement with each of the following statements
28 Please indicate your level of agreement
1 Strongly Disagree
2 Disagree
3 Neutral
4 Agree
5 Strongly Agree
• Exporting is the primary focus of our firm
• Exporting is the key to our firm's future success
• Exporting is not too difficult for our firm
• We actively explore the possibility of exporting
29 Please indicate your level of agreement
1 Strongly Disagree
2 Disagree
3 Neutral
4 Agree
5 Strongly Agree
• Management enthusiastically supports the adoption of advanced technologies
• Management has allocated enough resources for adoption of advanced technologies
• Management actively encourage employees to use the new technologies in their daily tasks
• The cost of adopting these technologies is far greater than the benefits
• Amount of money and time invested in these technologies is very high
Done
start
Edit And Review - Mo...
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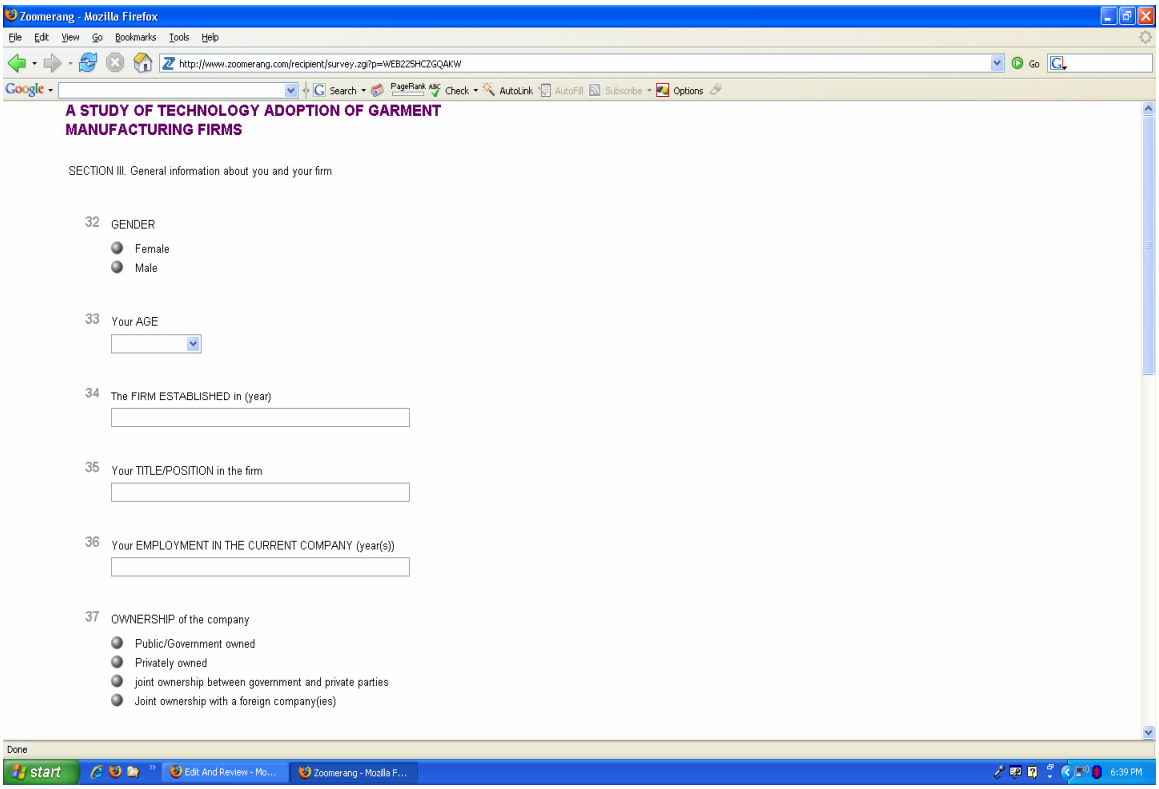
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Google Search PageRank Check AutoLink AutoFill Subscribe Options
A STUDY OF TECHNOLOGY ADOPTION OF GARMENT MANUFACTURING FIRMS
SECTION III. General information about you and your firm
32 GENDER
Female
Male
33 Your AGE
34 The FIRM ESTABLISHED in (year)
35 Your TITLE/POSITION in the firm
36 Your EMPLOYMENT IN THE CURRENT COMPANY (year(s))
37 OWNERSHIP of the company
Public/Government owned
Privately owned
joint ownership between government and private parties
Joint ownership with a foreign company(ies)
Done
start
Edit And Review - Mo...
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APPENDIX D
CONTENTS OF THE QUESTIONNAIRE

SECTION I.
Please check one of the options for each of the following programmable systems, devices, stations, etc. which you have already installed in your plant , on order for your plant, and have thought to install in future. (If none please enter zero)

CAD	Computer aided design	___Installed	___On order	___Install in future
AIN	Automated inspection	___Installed	___On order	___Install in future
AMHD	Automated material handling devices	___Installed	___On order	___Install in future
NC	Numerical control machine tools	___Installed	___On order	___Install in future
SPC	Statistical process control	___Installed	___On order	___Install in future
PPIC	Production planning and/or inventory management software	___Installed	___On order	___Install in future
LAN	Local area networks	___Installed	___On order	___Install in future
PPR	Pick/place robots	___Installed	___On order	___Install in future
OR	Other robots	___Installed	___On order	___Install in future
HSSM	High speed sewing machines	___Installed	___On order	___Install in future
MFPM	Modern fusing and pressing Machine	___Installed	___On order	___Install in future
CUFF	Computers used on factory floor	___Installed	___On order	___Install in future
IT	Internet	___Installed	___On order	___Install in future
CM	Communication (Telephone, cell phone, pagers, and fax)	___Installed	___On order	___Install in future

SECTION II
Export orientation:

- Exporting is the primary focus of our firm
- Exporting is the key to our firm's future success
- Exporting is not too difficult for our firm
- We actively explore the possibility of exporting

Top management commitment:

- Management enthusiastically supports the adoption of advanced technologies
- Management has allocated enough resources for adoption of advanced technologies
- Management actively encourage employees to use the new technologies in their daily tasks

Cost of capital:

- The cost of adopting these technologies is far greater than the benefits
- Amount of money and time invested in these technologies is very high

Technical skills:

- A specialist is available for assistance with hardware difficulties
- A specialist person is available for assistance with software difficulties
- Specialized instructions and education for new technologies are available to employees
- Technical guidance is available in the selection of hardware, software, printers, and other equipment

Competitive advantage:

- We will lose customers to our competitors if we do not adopt these new technologies
- It is a strategic necessity to use advanced technologies to compete in the marketplace
- Our customers require the use of these technologies for doing business with them

SECTION III
General information about you and your firm

1. GENDER: Female _____ Male _____

2. YOUR AGE: _____

4. Your FIRM ESTABLISHED in _____ (year)

5. YOUR TITLE/POSITION in the firm _____

6. Your EMPLOYMENT IN THE CURRENT COMPANY _____ year(s)

7. OWNERSHIP of your company:
- Public/Government owner _____
- Privately owned _____
- Joint ownership between government and private parties_____
- Joint ownership with a foreign company (ies)_____

8. Approximate NUMBER OF EMPLOYEES _____

9. Approximate ANNUAL SALES _____

10. YOUR PRODUCTS (Check appropriate category (ies))
- Woven shirts
- Knit shirts
- Trousers
- Ladies blouses
- Skirts
- Suits
- Coats
- Sweaters
- Robes
- Dressing gowns
- Babies garments
- Breeches and shorts
- Nightwear and pajamas
- Underwear
- Accessories
- Other

11. Please write any concerns and comments related to technology adoption related issues.

VITA

Venu Varukolu was born in Karimnagar, India, on April 1st, 1981. He received his bachelor of technology degree in textile technology from University College of Technology, Osmania University, India, in 2003. He is currently a master's student in the School of Human Ecology at Louisiana State University. He expects to receive the degree of Master of Science in spring 2007.