Profit Optimization of a Textile Industry in Bangladesh Using Linear Programming

By

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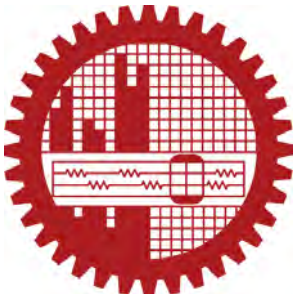
Student I.D. 1015092507 F
Session: October'15

Master of Science
IN
MATHEMATICS



Department of Mathematics

Bangladesh University of Engineering and Technology
Dhaka-1000

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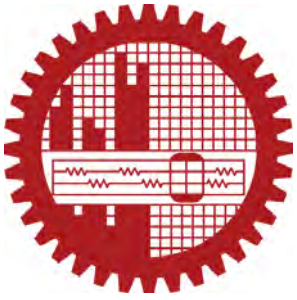

The thesis is submitted for the partial fulfillment of the degree of **Master of Science** in the department of Mathematics, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh.

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The Thesis Title

PROFIT OPTIMIZATION OF A TEXTILE INDUSTRY IN BANGLADESH USING LINEAR PROGRAMMING

Submitted by

NUSRAT JAHAN NISITA

Student ID: 1015092507 F, Session: October/2015 a full-time student of M. Sc. in Mathematics has been accepted as satisfactory in partial fulfillment for the degree of M. Sc. in Mathematics on July 2, 2021.

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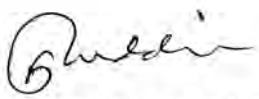
It is our pleasure to certify that the M.Sc. thesis entitled **"Profit Optimization of a Textile Industry in Bangladesh Using Linear Programming "**submitted by Nusrat Jahan Nisita in partial fulfillment of the requirement for the degree of M.Sc. in Mathematics, Bangladesh University of Engineering and Technology, Dhaka, has been completed under my supervision. So, far I know this research work is a novel one and it has not been submitted elsewhere for any kind of degree.

I wish her a bright future and every success in life.



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Candidate's Declaration

I hereby announce that the work which is being presented in this thesis entitled

"Profit Optimization of a Textile Industry in Bangladesh Using Linear programming"

At first I declare that this thesis is solely my original work with close supervision and guidance of my supervisor. In addition to this all source of materials used in the thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment for the requirement of M. Sc degree at Mathematics at Bangladesh University of Engineering and Technology (BUET), Dhaka. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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Dedication

This Thesis is dedicated to my beloved **parents**, **husband** and my lovely daughter **Liyana Fatima** for their patience and sacrifice during my academic study and all aspects of the research.

Acknowledgement

First and foremost, I would like to thank and praise the Almighty, most Merciful and most Gracious, for granting me the wisdom, the perseverance, and the necessary support and resources to navigate the M.Sc. study and finish the dissertation. It is my hope that this dissertation could glorify His name.

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Abstract

The research deals with profit maximization of a Textile Industry by Linear Programming (LP). Linear Programming, an operation research technique is widely used in finding solutions to complex managerial decision problems. In this paper, the Linear Programming model is built by taking considerations on market segmentation, interest of workers, utilizations of machines and other resources, demand of products by forecasting and production capacity of the company. In order to validate and calibrate the model, real data from a textile industry named Rozha Textiles Ltd. have been collected. Textile industry is one of the most feasible business options owing to the straightforward manufacturing process involved starting a cloth manufacturing business in Bangladesh.

In this dissertation, it is considered Linear Programming Model to maximize the profit at level best in the textile industry. This study can optimize profit of several types of cloths. This research used AMPL programming language to maximize profit mathematically using a standard Linear Programming model. Labor cost, machine cost and other cost have also been taken into consideration. Then using these data, a Linear Programming Model is formulated. In this Linear Programming, objective function is to maximize profit. Labor cost, machine cost and other cost are considered as subject to constraints. After that, the Linear Programming is solved by using AMPL. Sensitivity analysis that helps the company to improve their business policy are carried out on cost parameters. The industry will be able to see how any change can affect the profit. From the numerical results, it is clear that fabric cost and machine cost are the most sensitive cost. If the fabric cost and machine cost can be decreased, the profit will also increase. Finally, the result of the optimal solution will be represented in tabular form in addition to the graphs.

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Chapter 1

Introduction

1.1 Introduction

The Textile industry is one of the oldest industries existing until date or most of the recorded history humankind has relied on natural fibers prominent ones being cotton and wool for its textile products. The sector has made significant contributions in terms of foreign earnings and employment and is one of the mainstays of the economy. Bangladesh has been in the midst of a great social, political and economic change ever since reforms were introduced in various spheres of activity. The country has greater confidence to take on the competition from developing countries and has attracted global investors in ever increasing measure. The Bangladeshi textile industry is one of the largest in the world with a massive raw material and textiles manufacturing base. Our economy is largely dependent on the textile manufacturing and trade in addition to other major industries. By 2002 exports of textiles, clothing and ready-made garments (RMG) accounted for 77% of Bangladesh's total merchandise exports. In 1972, the World Bank approximated the gross domestic product (GDP) of Bangladesh at USD 6.29 billion and it grew to USD 173.82 billion by 2014, with USD 31.2 billion of that generated by exports, 82% of which was textile industry. As of 2016 Bangladesh held the 2nd place in producing garments just after China. Bangladesh is the world's second – largest apparel exporter of western fashion brands. 60% of the export contracts of western brands are with European buyers and about 40% with American buyers. Only 5% of textile factories are owned by foreign investors, with most of the production being controlled by local investors. In the financial year 2016-2017 the textile industry generated US $28.14 billion, which was 80.7% of the total export earnings in exports and 12.36% of the GDP; the industry was also taking on green manufacturing practices.

1.2 Definition of Textile Industry

The term 'Textile' is a Latin word originating from the word 'texere' which means 'to weave'. Textile refers to a flexible material comprising of a network of natural or artificial fibers known as yarn. Textiles are formed by weaving knitting crocheting knotting and pressing fibers together. And the textile industry is primarily concerned with the design, production and distribution of yarn, cloth and clothing. The raw material may be natural or synthetic using products of the chemical industry.

1.3 History of Textile Industry

The history of textile is almost as old as that of human civilization and as time moves on the history of textile has further enriched itself. The invention of various raw-materials, development of transportation and communication facilities enriched the industry of textiles day by day. The total history of textiles industry is given below in a short form:

1.3.1 Ancient and Prehistoric (Prehistoric age & 28000BC-600AD)

Spindle was used to create yarn (prehistory). Sewing needles were applied in Russia (28000 BC). Flax cultivation in the near east (8000 BC). Naalebinding technique which uses short separate lengths of thread (6500 BC). Woven textiles used to wrap the dead in Anatolia (6000 BC). Linen cloth production in Ancient Egypt, along with other bast fibers including rush, red, palm and papyrus. (5000BC). Mesolithic examples of Naalebinding in Denmark, marking speed of technology to northern Europe (4200 BC). “Needle Knitting” in Peru, a form of Naalebinding that preceded local contact with the Spanish (200 BC-200 AD). Woodblock printing (flowers in three colors on silk) in China (200 AD). Earliest attestation of a foot-powered loom with a hint the invention arose at Tarsus (298 AD). Spinning wheel in India (500 AD-1000 AD). “Jia xie” method for resist silk dyeing using wood blocks invented in China (500 AD). Oldest samples of cloth printed by woodblock printing from Egypt (600 AD).

1.3.2 Modern History (1600-1799):

Cotton socks made by true knitting using continuous thread appear in Egypt (1000’s AD). A silk burial cushion knit in two colors found in the tomb of Spanish royalty (1275). First example of use of the purl stitch, from a tomb in toledo, Spain which allows knitting of panels of material (1562). William Lee invents stocking frame, the first but hand-operated weft knitting machine (1589).

1.3.3 Cottage Stage

There are some indications that weaving was already known in the Paleolithic. An indistinct textile impression has been found at Pavlov, Moravia. Neolithic textiles are well known from finds in pile dwellings in Switzerland. One extant fragment from the Neolithic was found in Fayum at a site which dates to about 5000 BC. The key British industry at the beginning of the 18th century was the production of textiles made with wool from the large sheep-farming areas in the Midlands and across the country. The export trade in woolen goods accounted for more than a quarter of British exports during most of the 18th century, doubling between 1701 and 1770. Before the 17th century, the manufacture of goods was performed on a limited scale by individual workers. This was usually on their own premises and goods were transported around the country. Clothiers visited the village with their trains of pack-horses. Some of the cloth was made into clothes for people living in the same area, and a large amount of cloth was exported. Rivers navigations were constructed, and some contour-following canals. In the early 18th century, artisans were inventing ways to become more productive. Silk, wool, fustian, and linen were being eclipsed by cotton, which was becoming the most important textile. In Roman times, wool, linen and leather clothed the European population and Silk, imported along the Silk Road from China, was an extravagant luxury. The use of flax fibre in the manufacturing of cloth in Northern Europe dates back to Neolithic times. During the late medieval period, cotton began to be imported into northern Europe. John Mandeville, writing in 1350, stated as fact the now preposterous belief: "There grew in India a wonderful tree which bore tiny lambs on the ends of its branches. These branches were so pliable that they bent down to allow the lambs to feed when they are hungry." This aspect is retained in the name for cotton in many European languages, such as German Baumwolle, which translates as "tree wool". At the end of the 16th century, cotton was cultivated throughout the warmer regions of Asia and the Americas. Spinning evolved from twisting the fibres by hand, to using a drop spindle, to using a spinning wheel. Spindles or parts of them have been found in archaeological sites and may represent one

of the first pieces of technology available. They were invented in India between 500 and 1000 AD.

1.3.4 Industrial Revolution

The textile industry grew out of the industrial revolution in the 18th Century as mass production of yarn and cloth became a mainstream industry. In 1734 in Bury, Lancashire, John Kay invented the flying shuttle one of the first of a series of inventions associated with the cotton industry. The flying shuttle increased the width of cotton cloth and speed of production of a single weaver at a loom.

Figure 1.1: Shuttles

In 1761, the Duke of Bridgewater's canal connected Manchester to the coal fields of Worsley and in 1762, Matthew Boulton opened the Soho Foundry engineering works in Hands worth, Birmingham. His partnership with Scottish engineer James Watt resulted, in 1775, in the commercial production of the more efficient Watt steam engine which used a separate condenser. In 1764, Others credit the original invention to Thomas Highs- Industrial unrest and a failure to patent the invention until 1770 forced Hargreaves from Blackburn, but his lack of protection of the idea allowed the concept to be exploited by others. As a result, there were over 20,000 Spinning Jennies in use by the time of his death. Again in 1764, Thorp Mill, the first water-powered cotton mill in the world was constructed at Royton, Lancashire, England.

1.3.5 19th Century Developments (1801-1899)

Joseph Marie Jacquard invents the Jacquard punched card loom (1801). Pierre Jeandeau patents the first latch needle for using on knitting Machine (1806). Paul Moody of the Boston Manufacturing Company builds the first power loom in the United States; beginnings of the "Waltham System" (1814). East Chelmsford becomes incorporated as the town of Lowell, Massachusetts, the first factory city in the United States (1826). Lancashire Loom developed by Bullough and Kenworthy, a semi-automatic Power loom (1842). William Mason Patents his "Mason self-acting" Mule (1847). Matthew Townsend patents the variant of latch needle which has been the most widely used needle in weft knitting machines (1849). William Henry Perkin invents the first synthetic dye (1856). Redgate invents a warp knitting machine working with vertical position latch needles, called later as "Raschel machine" named after the French actress

Elisabeth Felice Rachel (1856). William Cotton patents the straight bar knitting machine named after him "Cotton machine" (1864). The American Mac Nary patents the circular knitting machine with vertical needles for fabrication of socks and stockings with heel and toe pouches (1866). Northrop Loom: Draper Corporation, first automatic bobbin changing weaving loom placed in production (1889). The Cartwright Loom, the Spinning Mule and the Boulton & Watt steam engine, the pieces were in place to build a mechanized textile industry. Quarry Bank Mill was built on the River Bollin at Styal in Cheshire. It was initially powered by a water wheel, but installed steam engines (1810) Quarry Bank Mill in Cheshire still exists as a well preserved museum, having been in use from its construction in 1784 until 1959. Using an 1822 patent, Richard Roberts manufactured the first loom with a cast iron frame, the Roberts Loom (1830).

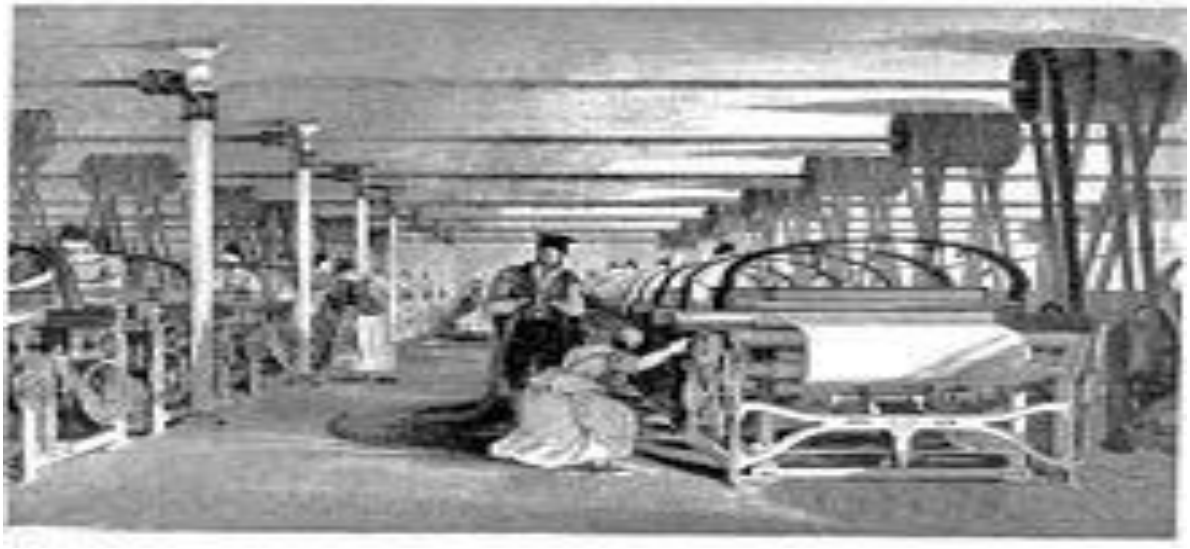

Figure 1.2: A Roberts's loom in a weaving shed in 1835

originally, power looms were shuttle-operated but in the early part of the 20th century the faster and more efficient shuttle less loom came into use. Today, advances in technology have produced a variety of looms designed to maximize production for specific types of material. The most common of these are air-jet looms and water-jet looms. Industrial looms can weave at speeds of six rows per second and faster. The industrial revolution changed the nature of work and society The three key driver's in these changes were

- Textile manufacturing
- Iron founding and
- Steam power

The geographical focus of textile manufacture in Britain was Manchester, England and the small towns of the Pennies and southern Lancashire. Textile production in England peaked in 1926 and as mills were decommissioned, many of the scrapped mules and looms were bought up and reinstated in India. The demographic change made by World War I, had made the labor-intensive industry unprofitable in England, but in India and later China it was an aid to development.

1.3.6 20th Century (1900-1999)

Heinrich Stoll creates the flat bed purl knitting machine (1900). Heinrich Mauersberger invents the sewing-knitting technique and his "Malimo" machine (1949). First commercial polyester

fiber production by DuPont (1953). Fiber reactive dye invented (1954). Major changes came to the textile industry during the 20th century, with continuing Technological innovations in machinery, synthetic fibre, logistics and globalization of the business. Cotton and wool producers were not the only source for fibres, as chemical companies created new synthetic fibres that had superior qualities for many uses, such as rayon, invented in 1910, and DuPont's nylon, invented in 1935 as in inexpensive silk substitute, and used for products ranging from women's stockings to tooth brushes and military parachutes. The variety of synthetic fibres used in manufacturing fibre grew steadily throughout the 20th century. In the 1920s, acetate was invented; in the 1940s, acetate, modacrylic, metal fibres, and saran were developed; acrylic, polyester, and spandex were introduced in the 1950s. Polyester became hugely popular in the apparel market, and by the late 1970s, more polyester was sold in the United States than cotton. By the late 1980s, the apparel segment was no longer the largest market for fibre products, with industrial and home furnishings together representing a larger proportion of the fibre market. Industry integration and global manufacturing led to many small firms closing for good during the 1970s and 1980s in the United States; during those decades, 95 percent of the looms in North Carolina, South Carolina and Georgia shut down and Alabama and Virginia also saw many factories close.

1.3.7 21st Century (2000-present)

- In 2002, textiles and apparel manufacturing accounted for $400 billion in global exports, representing 6% of world trade and 8% of world trade in manufactured goods.
- In the early years of the 21st century, the largest importing and exporting countries were developed countries, including the European Union, the United States, Canada and Japan. The countries with the largest share of their exports being textiles and apparel were as follows (2002):

    - Bangladesh: 85.9%
    - Macau: 84.4%
    - Cambodia: 72.5%
    - Pakistan: 72.1%
    - El Salvador: 60.2%
    - Mauritius: 56.6%
    - Sri Lanka: 54.3%
    - Dominican Republic: 50.9%
    - Nepal: 48.7%
    - Tunisia: 42.4%

1.4 History of Bangladesh's Textile Industry

1.4.1 Early history

Under Mughal rule, Bengal Subah was a midpoint of the worldwide muslin and silk trades during the 16th to 18th centuries. During the Mughal era, the most important center of cotton production was Bengal, particularly around its capital city of Dhaka, leading to muslin being called "daka" in distant markets such as Central Asia. Bengal also exported cotton and silk textiles to markets such as Europe, Indonesia and Japan. Bengal produced more than 50% of textiles and around 80% of silks imported by the Dutch from Asia. Bengal was conquered by

Figure 1.3: A woman in Dhaka clad in Bengali muslin, 18th century

the British East India Company after the Battle of Plassey in 1757 and the Bengal Presidency was founded in 1765. British colonization forced open the Bengali market to British goods, while at the same time Britain implemented protectionist policies such as bans and high tariffs that restricted Bengali imports to Britain. Raw cotton was also imported without taxes or tariffs to British factories, which used them to manufacture textiles, many of which were exported back to Bengal. British economic policies led to deindustrialization in Bengal.

1.4.2 Post-1971

From 1947 to 1971 the textile industry, like most industries in East Pakistan, were largely owned by West Pakistanis. in the 1960s, local Bengali entrepreneurs had set up their own large textile and jute factories. Following its separation from West Pakistan, the newly formed Bangladesh lost access to both capital and technical expertise. Until the liberation of Bangladesh in 1971, the textile sector was primarily part of the process of import substitution industrialization (ISI) to replace imports. After the liberation, Bangladesh adopted export-oriented industrialization (EOI) by focusing on the textile and clothing industry, particularly the readymade garment (RMG) sector. Immediately after the founding of Bangladesh (1971), tea and jute were the most export-oriented sectors. But with the constant threat of flooding, declining jute fiber prices and a significant decrease in world demand, the contribution of the jute sector to the country's economy deteriorated. In 1972 the newly formed government of Sheikh Mujibur Rahman who was also the head of the Awami League, enacted the Bangladesh Industrial Enterprises (Nationalization) Order, taking over privately owned textile factories and creating a state-owned enterprise (SOE) called Bangladesh Textile Mills Corporation (BTMC). President Rahman promoted democracy and a socialist form of capitalism. The BTMC never managed to match the pre-1971 output and in every year after the 1975–1976 fiscal year, lost money. Until the early 1980s the state owned almost all spinning mills in Bangladesh and 85 percent the textile industry's assets (not including small businesses). Under the 1982 New Industrial Policy (NPI) a large number of these assets including jute mills and textile mills were

privatized and returned to their original owners. After the famine in 1974, Bangladeshi government shifted public policy away from its concentration on a socialist economy, and began to denationalize, disinvest and reduce the role of the public sector in the textile industry while encouraging private sector participation. The 1974 New Investment Policy restored the rights to both private and foreign investors. Bangladesh's development model switched from a state-sponsored capitalist mode of industrial development with mainly state-owned enterprises (SOE) to private sector-led industrial growth. Post-liberation war, Bangladesh continued to focus on the agricultural sector to feed its rural and poor masses. Even in 1978, there were only nine "export- oriented" garment manufacturing units. That same year the first direct export of garments, 10,000 shirts to a Parisian firm, was shipped from a Bangladeshi firm. The Bangladeshi government began to realize potential for the industry to flourish and offered development stimulus such as "duty-free import machinery and raw materials, bonded warehouse facilities and cash incentives."

1.4.3 Milestone Years in Bangladesh Textile Industry

- The Textile industry acts as a catalyst for the development of Bangladesh. The "Made in Bangladesh" tag has also brought glory for the country, making it a prestigious brand across the globe. Bangladesh, which was once termed by cynics a "bottomless basket" has now become a "basket full of wonders". The country with its limited resources has been maintaining 6% annual average GDP growth rate and has brought about remarkable social and human development.
- The apparel industry of Bangladesh started its journey in the 1980s and has come to the position it is in Bangladesh. He had a vision of how to transform the country. In 1978, he sent 130 trainees to South Korea where they learned how to produce readymade garments.
- With those trainees, he set up the first factory "Desh Garments" to produce garments for export. At the same time, the late Akhter Mohammad Musa of Bond Garments, the late Mohammad Reazuddin of Reaz Garments, MdHumayun of Paris Garments, Engineer Mohammad Fazlul Azim of Azim Group, Major (Retd) Abdul Mannan of Sunman Group, M Shamsur Rahman of Stylecraft Limited, the first President of BGMEA, AM Subid Ali of Aristocrat Limited also came forward and established some of the first garment factories in Bangladesh.
- RMG industry of Bangladesh can obviously be regarded as the safest industry in the world. The Labor Law has been amended ensuring noticeable improvements in workers' rights and welfare. The industry is making strides in terms of environmental compliance to have a sustainable footing in the global apparel market. Many Textile Industry factories at their own are adopting green technologies and practices. They are using cleaner technologies and producing garments in a caring and responsible way that preserves the environment for future generations. Already a number of RMG factories achieved LEED certification from US Green Building Council (USGBC) for their green practices.

Table 1.1 The Milestones Years of the Bangladesh's Textile Industry

Year	Milestone
1995	Realistic Solution of child labor issue with ILO, UNICEF & US Embassy
2005	Phase out of MFA Quota
2009	Successfully faced Global Recession
2010	Ranked as the 2nd Largest Exporting Country
2013	Ensuring workplace safety

1.5 Segments of Bangladeshi Textile Industry

Bangladeshi Textile Industry can essentially be categorized into two segments:

1. Organized Textile Industry
2. Unorganized Textile Industry

1.5.1 Organized Textile Industry

Organized Textile Industry is a highly organized one with immense importance on capital intensive production process. This sector is characterized by sophisticated mills where technologically advanced machineries are utilized for mass production of textile products.

1.5.2 Unorganized Textile Industry

Unorganized Textile Industry sector is the dominant part in this industry which mainly utilizes the traditional practices woven or spun in cloth production and hence is labour intensive in nature. This industry is characterized by the production of clothes either through weaving or spinning with the help of hands. The decentralized nature is considered as another important feature of the unorganized textile industry in Bangladesh.

1.5.3 Leading Textile Mills in Bangladesh

The importance of the textile industry in the economy of Bangladesh is extremely high for a long time. There are many reasons for its importance. Textile industries are also called backward linkage of RMG industry. There are thousands of textile industries in Bangladesh. Some are members of BTMA (Bangladesh Textile Mills Association). And large number of textile industry is not registered BTMA. In this session, I have tried to make a list of top ten textile industries in Bangladesh. Really it is very tough task to take 10 industry names from more than thousands. In this list I have given priority capacity of production, number of total employees, working environments and overall contribution in economy of Bangladesh.

1. Beximco Textile
2. Square Textile
3. Sinha Group
4. Thermax Group
5. Noman Group
6. DBL Group
7. Fakir Group

8. Viyellatex Group
9. Knit Concern Group
10. Sunman Group

1.6 Uses of Textiles

Textiles have an assortment of uses, the most common of which are for clothing and for containers such as bags and baskets. In the household they are used in carpeting, upholstered furnishings, window shades, towels, coverings for tables, beds and other flat surfaces, and in art. In the workplace they are used in industrial and scientific processes such as filtering. Miscellaneous uses include flags, backpacks, tents, nets, handkerchiefs, cleaning rags, transportation devices such as balloons, kites, sails and parachutes textiles are also used to provide strengthening in composite materials such as fiberglass and industrial geotextiles. Using textiles, children can learn to sew and quilt and to make collages and toys.

Textiles used for industrial purposes and chosen for characteristics other than their appearance are commonly referred to as technical textiles. Technical textiles include textile structures for automotive applications, medical textiles e.g. implants, geotextiles reinforcement of embankments, agro textiles for crop protection, protective clothing e.g. against heat and radiation for fire fighter clothing, against molten metals for welders, stab protection and bullet proof vests. In all these applications stringent performance requirements must be met. Woven of threads coated with zinc oxide nanowires, laboratory fabric has been shown capable of "self-powering nanosystems" using vibrations created by everyday actions like wind or body movements.

1.6.1 Sources and Types of Textiles

Textiles can be made from many materials. These materials come from four main sources:

- animal wool,
- silk,
- plant cotton,
- flax,
- jute,
- mineral asbestos,
- glass fibre and
- synthetic nylon, polyester, acrylic

In the past, all textiles were made from natural fibres, including plant, animal, and mineral sources. In the 20th century, these were supplemented by artificial fibres made from petroleum. Textiles are made in various strengths and degrees of durability, from the finest gossamer to the sturdiest canvas. The relative thickness of fibres in cloth is measured in deniers. Microfibre refers to fibresmade of strands thinner than one denier.

1.6.2 Animal Textiles

Animal textiles are commonly made from hair, fur, skin or silk. Wool refers to the hair of the domestic goat or sheep, which is distinguished from other types of animal hair in that the individual strands are coated with scales and tightly crimped, and the wool as a whole is coated with a wax mixture known as lanolin, which is waterproof and dirtproof. Woollen refers to a bulkier yarn produced from carded, non-parallel fibre, while worsted refers to a finer yarn spun from longer fibres which have been combed to be parallel. Wool is commonly used for warm clothing. Wadmal is a coarse cloth made of wool, produced in Scandinavia, mostly 1000~1500CE. Silk is an animal textile made from the fibres of the cocoon of the Chinese silkworm which is spun into a smooth fabric prized for its softness. There are two main types of the silk: 'mulberry silk' produced by the Bombyx Mori, and 'wild silk' such as Tussah silk. Around four-fifths of the world's silk production consists of cultivated silk

1.6.3 Plant Textiles

Grass, rush, hemp, and sisal are all used in making rope. In the first two, the entire plant is used for this purpose, while in the last two, only fibres from the plant are utilized. Coir coconut fibre is used in making twine and also in floormats, doormats, brushes, mattresses, floor tiles, and sacking.

Figure 1.4: Traditional textile making tools from 14th century Persia

Straw and bamboo are both used to make hats. Straw, a dried form of grass, is also used for stuffing, as is kapok. Fibres from pulpwood trees, cotton, rice, hemp, and nettle are used in making paper. Cotton, flax, jute, hemp, modal and even bamboo fibre are all used in clothing. Pina pineapple fibre and ramie are also fibres used in clothing, generally with a blend of other fibres such as cotton. Nettles have also been used to make a fibre and fabric very similar to hemp or flax. The use of milkweed stalk fibre has also been reported, but it tends to be somewhat weaker than other fibres like hemp or flax. Acetate is used to increase the shininess of certain fabrics such as silks, velvets, and taffetas. Seaweed is used in the production of textiles, a water-soluble fibre known as alginate is produced and is used as a holding fibre, when the cloth is finished, the alginate is dissolved, leaving an open area. Lyocell is a man-made fabric derived from wood pulp. It is often described as a man- made silk equivalent, it is a tough fabric that is

often blended with other fabrics cotton, for example. Fibres from the stalks of plants, such as hemp, flax, and nettles, are also known as 'bast' fibres.

1.6.4 Mineral Textiles

Asbestos and basalt fibre are used for vinyl tiles, sheeting and adhesives, "transite" panels and siding, acoustical ceilings, stage curtains and fire blankets. Glass fibre is used in the production of spacesuits, ironing board and mattress covers, ropes and cables, reinforcement fibre for composite materials, insect netting, flame-retardant and protective fabric, soundproof, fireproof, and insulating fibres. Metal fibre, metal foil, and metal wire have a variety of uses, including the production of cloth-of-gold and jewellery. Hardware cloth US term only is a coarse weave of steel wire, used in construction. It is much like standard window screening, but heavier and with a more open weave. It is sometimes used together with screening on the lower part of screen doors, to resist scratching by dogs.

1.6.5 Synthetic Textiles

Figure 1.5: A variety of contemporary fabrics from the left: even weave cotton, velvet, printed cotton, calico, felt, satin, silk, hessian, polycotton.

Figure 1.6: Woven tartan of Clan Campbell, Scotland

Embroidered skirts by the Alfaro-Nunez family of Cochas, Peru, using traditional Peruvian embroidery methods. All synthetic textiles are used primarily in the production of clothing. Polyester fibre is used in all types of clothing, either alone or blended with fibres such as cotton. Aramid fibre e.g. Twaron is used for flame-retardant clothing, cutprotection, and armor. Acrylic is a fibre used to imitate wools, including cashmere, and is often used in replacement of them. Nylon is a fibre used to imitate silk; it is used in the production of pantyhose. Thicker nylon fibres are used in rope and outdoor clothing. Spandex trade name Lycra is a polyurethane product that can be made tight-fitting without impeding movement. It is used to make activewear, bras, and swimsuits. Olefin fibre is a fibre used in activewear, linings and warm clothing. Olefins are hydrophobic, allowing them to dry quickly. A sintered felt of olefin fibres is sold under the trade name Tyvek. Ingeo is a polylactide fibre blended with other fibres such as cotton and used in clothing. It is more hydrophilic than most other synthetics, allowing it to wick away perspiration. Lurex is a metallic fibre used in clothing embellishment. Milk proteins have also been used to create synthetic fabric. Milk or casein fibre cloth wasy developed during World War I in Germany and further developed in Italy and America during the 1930s. Milk fibre fabric is not very durable and wrinkles easily, but has a pH similar to human skin and possesses anti- bacterial properties. It is marketed as a biodegradable, renewable synthetic fibre. Carbon fibre is mostly used in composite materials, together with resin, such as carbon fibre reinforced plastic. The fibres are made from polymer fibres through carbonization.

1.7 Units of Textile Measurement

Textile yarns are measured in various units, such as: the denier and tex linear mass density of fibres, super S fineness of wool fiber, worsted count, woolen count, cotton count or Number English Ne, Number metric (Nm) and yield the inverse of denier and tex. Yarn is spun thread used for knitting, weaving, or sewing. Thread is a long, thin strand of cotton, nylon or other fibers used in sewing or weaving. Both yarn and thread are measured in terms of cotton count and yarn density. Fabric is cloth, typically produced by weaving or knitting textile fibers and is measured in units such as mommes momme is a number that equals the weight in pounds of a piece of silk if it were sized 45 inches by 100 yards, thread count a measure of the coarseness or fineness of fabric, ends per inch (e.p.i) and picks per inch (p.p.i).

1) Fiber:
    a) Denier
    b) Tex
    c) S or super S number
    d) Worsted count
    e) Yield

2) Yarn and Thread:
    a) Cotton count (yards)
    b) Yarn length (Thread, Bundle, Lea, Denier, Tex)
    c) Thread (cotton yarn measure)

3) Fabric
    a) Mommes (units of weight to measure the surface density of silk)
    b) Thread count
    c) Ends per inch (number of warp threads per inch of woven fabric)

1.8 List of Textile Fibers

Textile fibers can be created from many natural sources animal hair or fur, insect cocoons as with silk worm cocoons, as well as semi synthetic methods that use naturally occurring polymers and synthetic methods that use polymer-based materials, and even minerals such as metals to make foils and wires. The textile industry requires that fibre content be provided on content labels. These labels are used to test textiles under different conditions to meet safety standards and to determine whether or not a textile is machine washable or must be dry-cleaned. Common textile fibers used in global fashion today

Table 1.2: Animal-based Fibers (Protein Fibers)

Fibre	Source	Attribute
Byssus	-	-
Chiengora	-	-
Qiviut	Muskoxen	Softness, warmth
Yak	Yak	-
Rabbit	Rabbits	Softness
Wool	Sheep	Warmth
Lambswool	Lambs	Softness, elasticity, warmth
Cashmere wool	Cashmere goat	Softness
Mohair wool	North African angora goat	Warmth, holds dyes well, lightweight
Camel hair	Arabian Dromedary and Northeast Asian Bactrian Camels	Warmth, lightweight
Alpaca/Vicuna/Guanaco wool	South America camelid varieties	Softness, warmth
Angora wool	Angora rabbit	Softness, blends well with other fibres
Silk	Chinese mulberry silkworm	Smooth fabric finish with high shine

Table 1.3: Plant-based fibers (cellulosic fibers)

Fibre	Source	Attribute
Abaca	-	-
Coir	Coconut	Strength, durability
Cotton	Shrub	Lightweight, absorbent
Flax	Herbaceous plant	Lightweight, absorbent, used to make linen
Jute	Vegetable plant in linden family	Strength, durability
Kapok	-	-
Kenaf	-	-
Raffia	Raffia palm	-
Bamboo	Grass pulp	Lightweight, pliable fibre
Hemp	Cannabis	Strength, durability
Modal	Beech tree	Softness, lightweight
Pina	Pineapple leaf	-

Ramie	Flowering plant in nettle family	-
Sisal	-	Strength, durability
Soy Protein	Tofu- manufacturing waste	-

Table 1.4: Mineral-based fibers

Fibre	Source	Attribute
Asbestos Cloth	Asbestos	Fire-resistance, light weight
Glass, Fibreglass	Mixed silicates	Fire-resistance, futuristic appearance in some products
Metals	Gold, silver and many other minerals	Foil, fibres, wire

Table 1.5: Synthetic fibers

Fibre	Source	Attribute
Rayon (Viscose)	Regenerated cellulose, semi synthetic	Lustrous appearance, absorbent
Acetate	Cellulose, semi synthetic	Lustrous appearance, pliable fabric
Tencel	Wood pulp, semisynthetic	Lightweight
Polyester	Polymer, polyethylene terephthalate	Wrinkle-resistant, easy care
Aramid	Aromatic polyamide	Heat and tear resistant
Acrylic	Acrylonitrile	Imitates wools and cashmeres due to softness
Ingeo	Polylactide	Wicks away persperation(hydrophilic)
Luminex	Fibre optics	Light-emitting
Lurex	Polyamide, polyester	Metallic appearance, sheen
Lyocell	Cellulose	Strong, soft, absorbent, biodegradeable
Nylon	Polyamide	Silk-like appearance
Spandex (Lycra)	Polyurethane	Stretches easily
Olefin	Polyethylene, polypropylene	Wicks away persperation(hydrephilic), lightweight (olefin fibre have the lowest specific gravity of all fibres)
PLA fibre, Polylactide	Polymers, lactic acid	Lightweight, wicks away perspiration (hydrophilic), UV light-resistant

1.9 Export Market Share

The worldwide market for textiles and apparel exports in 2013 according to United Nations Commodity Trade Statistics Database stood at $772 billion.

The largest exporters of textiles in 2013 were China ($274 billion), India ($40 billion), Italy ($36 billion), Germany ($35 billion), Bangladesh ($28 billion) and Pakistan ($27 Billion).

In 2016, the largest apparel exporting nations were China ($161 billion), Bangladesh ($28 billion), Vietnam ($25 billion), India ($18 billion), Hong Kong ($16 billion), Turkey ($15 billion) and Indonesia ($7 billion). So it is seen that Bangladesh is in the competition of world textile industry.

1.10 Commerce and Regulation

The Multi Fibre Arrangement (MFA) governed the world trade in textiles and garments from 1974 through 2004, imposing quotas on the amount developing countries could export to developed countries. It expired on 1 January 2005.

The MFA was introduced in 1974 as a short-term measure intended to allow developed countries to adjust to imports from the developing world. Developing countries have a natural advantage in textile production because it is labor-intensive and they have low labor costs. According to a World Bank/International Monetary Fund (IMF) study, the system has cost the developing world 27 million jobs and $40 billion a year in lost exports.

However, the Arrangement was not negative for all developing countries. For example, the European Union (EU) imposed no restrictions or duties on imports from the very poor countries, such as Bangladesh, leading to a massive expansion of the industry there.

At the General Agreement on Tariffs and Trade (GATT) Uruguay Round, it was decided to bring the textile trade under the jurisdiction of the World Trade Organization (WTO). The WTO Agreement on Textiles and Clothing provided for the gradual dismantling of the quotas that existed under the MFA. This process was completed on 1 January 2005. However, large tariffs remain in place on many textile products.

Bangladesh was expected to suffer the most from the ending of the MFA, as it was expected to face more competition, particularly from China. However, this was not the case. It turns out that even in the face of other economic giants, Bangladesh's labor is "cheaper than anywhere else in the world." While some smaller factories were documented making pay cuts and layoffs, most downsizing was essentially speculative – the orders for goods kept coming even after the MFA expired. In fact, Bangladesh's exports increased in value by about $500 million in 2006.

1.11 Factors Responsible Behind the Growth of Textile Mills in Bangladesh

Some of the major factors responsible behind the growth of textile Mills sector are:

1. An immense demand of Bangladeshi apparels and textiles in the international market.

2. Low custom duties on imported textile machinery.

3. Less tight government restrictions on imported goods Major trading partners regarding import of textile machineries include U.S., Germany, Switzerland and U.K. Bangladesh ranks second in the global textile industry and accounts a major portion to the overall Bangladeshi exports. For the sustenance of this growth and to maintain the competence in the international market, the textile mills in Bangladesh need to be modernized. So that I take this project to optimize the profit ratio in Textile industry.

1.12 Bangladesh's Major Competitors in the World

To understand Bangladesh's position among other textile producing the industry contributes 9% of GDP and 35% of foreign exchange earnings, Bangladesh's share in global exports is only 3% compared to China's 13.75% percent. In addition to China, other developing countries are emerging as serious competitive threats to Bangladesh. Looking at export shares, Korea 6% and Taiwan 5.5% are ahead of Bangladesh, while Turkey 2.9% has already caught up and others like Thailand 2.3% and Indonesia 2% are not much further behind. The reason for this development is the fact that Bangladesh lags behind these countries in investment levels, technology, quality and logistics. If Bangladesh were competitive in some key segments it could serve as a basis for building a modern industry, but there is no evidence of such signs, except to some extent in the spinning industry.

Table 1.6: Bangladesh's Competitive Position in Stages of Textile Manufacture

Process	Determinants of Competitive Advantage	Bangladesh's Competitive position	Emerging Competition
Spinning	Quality, cotton price	Medium	Indonesia, Turkey
Weaving	Technology, automation, Power, finance	Low	India, Vietnam, Philippines
Processing	Scale economy, Technology, Environment Issues, finance	Low	China, Vietnam, Philippines
Garmenting	Labor cost, productivity, Brand fashion design	Medium	India, Srilanka, Morocco, East Europe, Mexico

Table 1.7: The Size of Bangladeshi Textile Industry

Sub- sector	No of units	Installed machine capacity	Production capacity (m)	Manpower
Textile spinning	341	7.20 ml. spld 0.18 ml. rotor	1600 kg	400000
Textile weaving	400	25000 SL/SLL	1600mtr	80000
Specialized textile and power loom	1065	23000SL/SLL	400mtr	43000
Handloom (GF/F)	148342	498000 handloom	837mtr	1020000
Knitting, knit dyeing (GF):				
(a)Export-oriented	800	12000 knit/Dy/M	3600mtr	300000
(b)Local market	2000	5000 knit/M	500mtr	24000
Dyeing and finishing (FF):				
(a)Semi-mechanized	180	-	120mtr	10000
(b)Mechanized	130	-	1600mtr	23000
Export oriented RMG	4500	-	475 doz	2000000
Source: Bangladesh Garment Manufacturers and Exporters Association (BGMEA)				

1.13 Government Policies, Schemes and Corporations for Promoting Textile Industry in Bangladesh

1.13.1 Textile Policy 2017

The new Textile Policy-2017 has been approved by the ministry of Jute and Textiles, GOB at a ministerial meeting held on 13th February, 2017. The vision of the policy is to build a strong and internationally competitive textile and apparel industry. The mission of the policy is stated as productivity improvement, employment generation and surge in export and foreign investment to ensure a safe and eco-friendly textile and apparel sector. The Textile Policy-2017 is to provide proper guideline and security to the textile and apparel industry. The mission and vision of the policy is to build an internationally competitive textile industry that will generate more employment, productivity and more exports.

1.13.2 Ministry of Textiles and Jute

The Ministry of Textiles and Jute is the Bangladeshi government ministry responsible for the promotion, development and regulation of the Bangladesh textile industry, the second largest in

the world. The minister is Golam Dastagir Gazi and ministry executive is Mohammad Abdul Mannan (Secretary)

1.13.3 Bangladesh Textile Mills Corporation (BTMC)

Bangladesh Textile Mills Corporation or BTMC, is a public corporation that owns and manages all government textile mills in Bangladesh and is located in Dhaka. It manages 18 government owned textile factories. The corporation was established on 26 March 1972 through the nationalization of textile mills in Bangladesh. It owns Eagle Textile in Chittagong. The Ministry for Textiles and Jute is responsible for running the corporation. The corporation has the largest liability of any state owned enterprise in Bangladesh with billion takas in loans. Nearly 99% of its loans are in default. Rangamati Textile Mill is also owned by the corporation. It used to manage 86 government owned textile mills which has been reduced to the 18 today.

1.13.4 Ministry of Textile and Jute (MOTJ)

The Jute Ministry was established in 1973 and the Textile Ministry was established in 1977. Now these two ministries are involved as two divisions of industry and commerce ministry. Research and expansionary activities cloth, Silk and Jute industries, as well as an increase in the production sector through the development of export income of the country's internal needs and to achieve economic prosperity through a contribution to public life. Strategy and the work order of the ministry are:

- Textile, silk and jute sector policy development and Expansion, adopted plans, implementation and evaluation,
- Textile, silk and jute goods control, supervise and certify,
- Textile and jute mill, and now-extinct property, with various countries and international organizations of jute and jute goods, silk and textile products sector under the internal and external marketing and export of coordination
- Textile, silk and jute sector development and the attraction of direct foreign investment for foreign nationals Recruitment of the duties and responsibilities,
- Textile, silk, and jute products sector of the Multiplication of activities,
- Textile, silk and jute industry of skilled manpower to take the necessary action.

1.13.5 BTMA, BGMEA, BKMEA

Three independent associations are responsible for the textile sector. These are:

- **Bangladesh Textile Manufacturers Association (BTMA)**- represents spinners, woven, fabric manufacturers
- **Bangladesh Garment Manufacturers and Exporters Association (BGMA)**- represents the RMG sector, primarily the cutting and sewing units
- **Bangladesh Knitwear Manufacturers and Exporters Association (BKMEA)** – represents the knitwear fabric manufacturers, the fabric dyeing units and the knit garment cutting and sewing units.

These three associations work either in collaboration or independently from each other, subject to the agenda they may be forwarding. However, it should be borne in mind that the bulk of

yarn manufactured by BTMA members is consumed by members of the BKMA, which at times leave the two associations at loggerhead opposing sides of an industry issue. The three main government departments that work for apparel sector are the ministry of textile and Jute, the ministry of Finance and the ministry of Commerce.

1.14 Multi Fibre Arrangement (MFA) and DAEWOO

Starting in 1974 the Multi Fibre Arrangement (MFA) in the North American market ensured that trade in textiles and garments remained the most regulated in the world. Among other things the MFA set quotas on garments exports from the newly industrializing countries of Asia, but had exceptions, most notably the state of Bangladesh. Entrepreneurs from quota-restricted countries like South Korea began "quota hopping" seeking quota-free countries that could become quota-free manufacturing sites. The export-oriented readymade garment industry emerged at this time. Daewoo of South Korea was an early entrant in Bangladesh, when it established a joint venture on 27 December 1977 with Desh Garments Ltd. making it the first export oriented ready-made garment industry in Bangladesh. After only one year in which 130 Desh supervisors and managers received free training from Daewoo in production and marketing at Daewoo's state-of-the- art ready-made garment plant in Korea, 115 of the 130 left Desh Garments Ltd. and set up separate private garment export firms or began working for other newly formed export- oriented RMG companies with new garment factories in Bangladesh for much higher salaries than Desh Garments Ltd offered. Global restructuring processes, including two non-market factors, such as quotas under Multi Fibre Arrangement (MFA) (1974–2005) in the North American market and preferential market access to European markets, led to the "emergence of an export-oriented garment industry in Bangladesh in the late 1970s." It was uncertain what the phase out of the MFA meant for the Bangladeshi RMG industry. However, surpassing all doubts, the industry continued to succeed and dominate on a global level

1.15 Export-Import Policy

The government EXIM policy provides for a variety of largely export-related assistance to firms engaged in the manufacture and trade of textile products. This policy includes fiscal and other trade and investment incentives contained in various programs.

1.15.1 Agreement on Textiles and Clothing (ATC)

From 1995 to 2005 the WTO Agreement on Textiles and Clothing (ATC) was in effect, wherein more industrialized countries consented to export fewer textiles while less industrialized countries enjoyed increased quotas for exporting their textiles. Throughout the 10-year agreement, Bangladesh’s economy benefited from quota-free access to European markets and desirable quotas for the American and Canadian markets.

Table 1.8: Market Shares of Bangladeshi Textiles in the USA & EU

export market	USA (textile)	USA (clothing)	EU (textile)	EU (clothing)
market share in 1995	<3%	4%	<3%	3%
market share in 2004	3%	2%	3%	4%

As the above table shows, the market shares for Bangladeshi textiles in the USA and both textiles and clothing in the European Union have changed during the time period of the ATC.

1.15.2 US Tariff Relief Assistance for Developing Economies Act

The United States introduced the Tariff Relief Assistance for Developing Economies Act of 2009 designated Bangladesh as one of the 14 least developed countries (LDC), as defined by the United Nations and the US State Department, eligible for "duty-free access for apparel assembled in those countries and exported to the U.S." from 2009 through 2019. The Bangladesh Garment Manufacturers and Exporters Association (BGMEA), an industry lobby group, claimed that in 2008 alone Bangladesh paid " $USD 576 million as duty against its export of nearly $3 billion' mainly consisting of woven and knitwear. However, this act was temporarily suspended for Bangladesh by President Obama after the Rana Plaza collapse in 2013.

1.16 Role of Bangladeshi Textile Industry in the Economy

Bangladesh's textile industry, which includes knitwear and ready- made garments along with specialized textile products, is the nation's number one export earner, accounting for 80% of Bangladesh's exports of $15.56 billion in 2009. Bangladesh is 3rd in world textile exports behind Turkey, another low volume exporter and China which exported $120.1 billion worth of textiles in 2009. The industry employs nearly 3.5 million workers. Current exports have doubled since 2004. Wages in Bangladesh's textile industry were the lowest in the world as of 2010. The country was considered the most formidable rival to China where wages were rapidly rising and currency was appreciating.

Garments Industry occupies a unique position in the Bangladesh economy. It is the largest exporting industry in Bangladesh, which experienced phenomenal growth during last two decades. By taking advantage of an insulated market under the provision of Multi Fiber Agreement (MFA) of GATT, it attained a high profile in terms of foreign exchange earnings, exports, industrialization and contribution to GDP within a short span of time. The industry plays a key role in employment generation and in the provision of income to the poor. Nearly two million workers one directly and more than ten million inhabitants are indirectly associated with the industry. The sector has also played a significant role in the socio-economic development of the country. In such a context, the trend and growth of garments export and its contribution to total exports and GDP has been examined the following table shows the position

Table 1.9: Growth and Trend of Garments Exports and Contribution to GDP

Year	Garment Export (min USD)	Total Export (min USD)	Share to total Export in %	Share to GDP in %
1984-85	116-	934-	12.42-	-
1989-90	624(40)	1924(16)	32.43(21)	-
1994-95	2228(29)	3473(13)	64.15(15)	5.87-
1999-00	4349(14)	5752(11)	75.61(3)	9.23(9)
2004-05	6418(8)	8655(9)	74.15(-1)	10.63(3)
2005-06	7901(23)	10526(22)	75.06(1)	12.64(2)
Source: Economic review of Bangladesh, BGMEA and Computation made by author. Figures in parentheses indicate compound growth rates (CGR) for the respective periods. (Amounts in million USD)				

It is revealed from the Table 1.8 that the value of garment exports, share of garments export to total exports and contribution to GDP have been increased significantly during the period from 1984-85 to 2005-06. The total garments export in 2005-06 is more than 68 times compared to garments exports in 1984-85 whereas total country's export for the same period has increased by 11 times. In terms of GDP, contribution of garments export is significant; it reaches 12.64 percent of GDP in 2005-06 which was only 5.87 percent in 1989-90. It is a clear indication of the contribution to the overall economy. It also plays a pivotal role to promote the development of linkage small scale industries. For instance, manufacturing of intermediate product such as dyeing, printing, zippers, labels have begun to take a foothold on limited scale and is expected to grow significantly. Moreover, it has helped the business of basling, insurance, shipping, hotel, tourism and transportation. The sector also has created jobs for about two million people of which 70 percent are women who mostly come from rural areas. The sector opened up employment opportunities for many more individuals through direct and indirect economic activities, which eventually helps the country's social development, woman empowerment and poverty alleviation. In such a way the economy of Bangladesh is getting favorably contribution from this industry.

1.17 The Current Position of the Textile Industry

Today, the textile industry in Bangladesh can be divided into three major categories: the public sector, handloom sector and the organized private sector. Each of these sectors has its advantages and disadvantages. Currently, the organized private sector dominates and is also expanding at the fastest rate.

1.17.1 Public Sector

The public sector is that portion of the industry controlled by organizations that are part of the government. The factories in the public sector enjoy certain privileges such as government funding. However, in Bangladesh factories in the public sector are not well supervised. There are frequent changes in officers and many of these officials do not have a personal interest in the factory for which they are responsible. In addition, the equipment in this sector is not well maintained, as much of the money allocated for this purpose is not spent as planned, but is wasted through corruption and poor accounting.

1.17.2 Handloom Sector

The rural group of textile producers includes operators of handlooms and a number of organizations which employ rural women, such as BRAC, or the Bangladesh Rural Advancement Committee. The Handloom industry provides employment for a large segment of the population of Bangladesh. The industry also supplies a large portion of the fabric required by the local market. Factories in this sector are usually well looked after by the owners and are quite productive, considering the equipment available. However, the inferiority of their machinery, mostly due to their narrow width, means that the fabric production is slow, and usually falls short of the quality needed for export.

1.17.3 Private Sector

The most productive of the three categories is the private sector. This, as the term suggests, is made up of those factories owned by companies or entrepreneurs. Since the owners of such factories are directly affected by their performance, they take an active part in planning, decision making, and management. Most of these factories also have machinery that is superior to those in the two other sectors because the owners are well aware of the connection between their equipment and their profits.

1.17.4 Effects on Exports

Bangladesh ranked as the second leading exporter in the world after China in 2015 according to an estimate by Khurram Shahzad who applied data derived from the World Trade Organization to Balassa's RCA index. Shazad found that Bangladesh fell between Pakistan and India in regards to comparative advantages in textiles, but held the highest RCA for clothing. Private actors maintain a positive outlook on the industry, as the clothing sector has seen a positive growth in terms of RCA.

1.17.5 McKinsey report (2011): Bangladesh as next hot spot, next China

As of 2011 Bangladesh was second largest ready-made garments (RMG) manufacturer after China, by the next five years Bangladesh will become the largest ready-made garments manufacturer. Bangladesh was the sixth largest exporter of apparel in the world after China, the EU, Hong Kong, Turkey and India in 2006. In 2006 Bangladesh's share in the world apparel exports was 2.8%. The US was the largest single market with US$3.23 billion in exports, a 30% share in 2007. Today, the US remains the largest market for Bangladesh's woven garments taking US$2.42 billion, a 47% share of Bangladesh's total woven exports. The European Union remains the largest regional destination - Bangladesh exported US$5.36 billion in apparel; 50% of their total apparel exports. The EU took a 61% share of Bangladeshi knitwear with US$3.36 billion exports.

According to a 2011 report by international consulting firm McKinsey & Company, 80 percent of American and European clothing companies planned to move their outsourcing from China, where wages had risen, and were considering Bangladesh as the "next hot spot" making it the

"next China" offering 'the lowest price possible' known as the China Price, the hallmark of China's incredibly cheap, ubiquitous manufacturers, much "dreaded by competitors."

1.18 Challenges of Textiles Industry

Textile supply chains compete on low cost, high quality, accurate delivery and flexibility in variety and volume. Several challenges stand in the way of Bangladeshi firms before they can own a larger share of the global market:

1.18.1 Scale

Except for spinning, all other sectors suffer from the problem of scale. Bangladeshi firms are typically smaller than their Chinese or Thai counterparts and there are fewer large firms in Bangladesh. Some of the Chinese large firms have 1.5 times higher spinning capacity, 1.25 times denim and 2 times gray fabric capacity and about 6 times more revenue in garment than their counterparts in Bangladesh thereby affecting the cost structure as well as ability to attract customers with large orders. The central tendency is to add capacity once the order has been won rather than ahead of the demand. Customers go where they see both capacity and capabilities. Large capacity typically goes with standardized products. These firms need to develop the managerial capabilities required to manage large work force and design an appropriate supply chain. For the size of the Bangladeshi economy, it will have to have bigger firms producing standard products in large volumes as well as small and mid- size firms producing large variety in small to mid-size. Then there is the need for emergence of specialist firms that will consolidate orders, book capacities, manage warehouses and logistics of order delivery.

1.18.2 Skills

Three issues must be mentioned here:

- There is a paucity of technical manpower there exist barely 30 programmers at graduate engineering levels graduating about 1000 students this is insufficient for bringing about technological change in the sector.
- Bangladeshi firms invest very little in training its existing workforce and the skills are limited to existing processes.
- There is an acute shortage of trained operators and supervisors in Bangladesh. It is expected that Bangladeshi firms will have to invest close to taka 1400 bn by year 2010 to increase its global trade to $ 50 bn. This kind of investment would require, by our calculations, about 70,000 supervisors and 1.05mn operators in the textile sector and at least 112,000 supervisors and 2.8mn operators in the apparel sector assuming an 80:20 ratio of investment between textiles and apparel. The real bottleneck to growth is going to be availability of skilled manpower.

1.18.3 Cycle Time

Cycle time is the key to competitiveness of a firm as it affects both price and delivery schedule. Cycle time reduction is strongly correlated with high first pass yield, high throughput times and low variability in process times, low WIP and consequently cost. Bangladeshi firms have to dramatically reduce cycle times across the entire supply chains which are currently quite high.

Customs must provide a turnaround time of ½ day for an order before Bangladeshi firms can they expect to become part of larger global supply chains. Bangladeshi firms need a strong deployment of industrial engineering with particular emphasis on cellular manufacturing, JIT and statistical process control to reduce lead times on shop floors. Penetration of IT for improving productivity is particularly low in this sector.

1.18.4 Innovation & Technology

A review of the products imported from China to USA during January–April 2005 reveals that the top three products in terms of percentage increase in imports were Tire Cords & Tire Fabrics 843.4% increase over the previous year, Non-woven fabrics 284.1% increase and Textile Fabric Finishing Mill Products 197.2% increase FICCI, 2005. None of these items, however, figure in the list of imports from Bangladesh that have gained in these early days of post-MFA. Entry into newer application domains of industrial textiles, Nano textiles, home furnishings etc. becomes imperative if we are to grow beyond 5–6% of global market share as these are areas that are projected to grow significantly. Synthetic textiles comprise about 50 per cent of the global textile market. Bangladeshi synthetic industry, however, is not well entrenched. The Technology Upgradation Fund of the government is being used to stimulate investment in new processes.

1.18.5 Domestic Market

The Bangladeshi domestic market for all textile and apparel products is estimated at $26 bn and growing. While the market is very competitive at the low end of the value chain, the mid or higher ranges are overpriced i.e., 'dollar pricing'. Firms are not taking advantage of the large domestic market in generating economies of scale to deliver cost advantage in export markets. The Free Trade Agreement with Singapore and Thailand will allow overseas producers to meet the aspirations of domestic buyers with quality and prices that are competitive in the domestic market. Ignoring the domestic market, in the long run, will peril the export markets for domestic producers. In addition, high retail property prices and high channel margins in Bangladesh will restrict growth of this market. Firms need to make their supply chain leaner in order to overcome these disadvantages.

1.18.6 Institutional Support

Textile policy has come long ways in reducing impediments for the industry sometimes driven by global competition and at other times, by international trade regulations.
However, few areas of policy weakness stand out labor reforms, power availability and its quality, customs clearance and shipment operations from ports, credit for large scale investments that are needed for upgradation of technology and development of
manpower for the industry. These are problems facing several sectors of industry in Bangladesh and not by this sector alone.

1.19 Problems Faced by The Textile Industry in Bangladesh

Some problems we face in textile industry which are given below:

1.19.1 Lack of Research and Development (R and D) in Cotton Sector

The lack of research and development (R and D) in the many sectors especially in cotton sector of Bangladesh has resulted in low quality of cotton in comparison to rest of Asia. Because of the subsequent low profitability in cotton crops, farmers are shifting to other cash crops, such as sugar cane. It is the lack of proper R and D that has led to such a state. They further accuse cartels, especially the pesticide sector, for hindering proper R and D. The pesticide sector stands to benefit from stunting local R and D as higher yield cotton is more pesticide resistant.

1.19.2 Lack of Modernize Equipment

Moreover, critics argue that the textile industry has obsolete equipment and machinery. The inability to timely modernize the equipment and machinery has led to the decline of Bangladesh textile competitiveness6. Due to obsolete technology the cost of production is higher in Bangladesh as compared to other countries like India, Pakistan and china.

1.19.3 Finance Bill to Burden Industry Further

All Bangladeshi Textile Mills Corporation has told that government's actions are not matching according to its expectations for the textile industry and its smooth growth. According to him, reintroduction of minimum tax on domestic sales would invite unavoidable liquidity problem, which is already reached to the alarming level. Also the textile industry was facing negative generation of funds due to unaffordable markup rate on the one hand and acute shortage of energy supply and unimaginable power tariff for industry.

1.19.4 Increasing Cost of Production

The cost of production of textile rises due to many reasons like increasing interest rate, double digit inflation and decreasing value of Bangladeshi Taka. The above all reason increased the cost of production of textile industry which create problem for a textile industry to compete in international market.

1.19.5 Internal Issues Pose a Larger Threat for Bangladesh's Textile Industry

Bangladesh's textile industry is going through one of the toughest period in decades. The global recession which has hit the global textile really hard is not the only cause for concern. The high cost of production resulting from an instant rise in the energy costs has been the primary cause of concern for the industry. Depreciation of Bangladeshi Taka during last few years raised the cost of imported inputs. In addition, double digit inflation and high cost of financing has seriously affected the growth in the textile industry. Bangladesh textile exports have gone through challenges during last three years as exporters cannot effectively market their products since buyers are not enough visiting Bangladesh due to adverse travel advisory and it is getting more and more difficult for the exporters to travel abroad. Additionally, he stressed that government should take immediate measures to remove slowdown in the textile sector. High cost of doing business is because of intensive increase in the rate of interest which has increased the problems of the industry. Also loans availed crisis by the industry, hence, the volume of non-performing loans has reached to an alarming situation. Moreover, power shut downs may result in massive

unemployment resulting in law and order situation.

1.19.6 Energy Crisis (Electricity Crisis)

As a consequence of load shedding the textile production capacity of various sub-sectors has been reduced by up to 30 per cent. Many joint meeting of organization were held at different times to formulate a joint strategy to address the alarming electricity crisis being faced by the textile industry. The meeting unanimously decided to constitute a joint working group of electricity management for the textile industry in the larger interests of the value chain of the textile industry10. The joint working group will meet shortly to design a detailed plan to pursue the following goals; immediate total exemption from Electricity load shedding for the textile industry value chain; Rationalization and reduction of electricity tariff. The load-shedding of electricity cause a rapid decrease in production which also reduced the export order. The cost of production has risen due to instant increase in electricity tariff. Due to load shedding some mill owner uses alternative source of energy like generator which increase their cost of production further. Due to such dramatic situation the capability of competitiveness of this industry in international market effected badly.

1.19.7 Gas Shortage

Gas load-shedding continues in textile industries despite a significant increase in temperature. A Spokesman for the Bangladesh Textile Mills Corporation (BTMC) claimed that 60 to 70 per cent of the industry had been affected and was unable to accept export orders coming in from around the globe. Continuous gas disconnection over months, causing huge production losses are badly affecting the capability of the industry. In the larger interest of the economy and exports, the government should “ensure utility companies provide smooth electricity and gas supply to the textile industry”.

1.19.8 Tight Monetary Policy

The continuity of tight monetary policy causes an intensive increase in cost of production. Due to high interest rate financing cost increases which cause a severe effect on production. The withholding tax of 1% also effects the production badly. The high cost of doing business is because of intensive increase in the rate of interest which has increased the problems of the industry. The government should take immediate measures to remove slowdown in the textile sector.

1.19.9 Removal of Subsidy on Textile Sector

The provisions of Finance Bill 2012-2013 are not textile industry friendly at all. Provisions like reintroduction of 0.5% minimum tax on domestic sales, withholding tax on import of textile and articles etc., are nothing but last strick on industry’s back. Reintroduction of minimum tax on domestic sales would invite unavoidable liquidity problem, which is already reached to the alarming level. The textile industry was facing negative generation of funds due to unaffordable markup rate.

1.19.10 Lack of New Investment

Bangladesh textile industry is facing problem of Low productivity due to its obsolete textile machineries. To overcome this problem and to stand in competition, Bangladesh Textile Industry will require high investments. There is a continuous trend of investing in spinning since many years. Bangladesh is facing externally as well as internally problems which restrict the new investment. The unpredictable internal condition of Bangladesh causes a rapid decrease in foreign investment that affected all industries but especially textile industry.

1.19.11 The 2005 Challenge

In the year 2005, some of the international policies regarding the export of textiles and garments will change, which may present the Bangladeshi textile industry the greatest challenges it has had to face so far. There is much speculation at present about the situation of the RMG exporters in the post-MFA period, when the World Trade Organization or WTO, instead of GATT will control the sector. Under the WTO all quotas will be removed, resulting in a free market worldwide. Bangladesh's garment and textile manufacturers will have to face steep competition from countries such as India, Pakistan, China, and Thailand, from whom the country now imports fabric to meet the demands of its RMG sector. When the WTO free market is established, all these countries will be able to expand their RMG exports, now limited by Quotas. As a result, these countries will be able to utilize more of their locally produced yarn and fabrics internally, resulting in the rise of prices for these in the export market, putting pressure on the industries of countries such as Bangladesh.

1.19.12 United States and EU Cuts Imports of Textile from Bangladesh

United States cancels huge of textile orders of Bangladesh. US also impose a high duty on the import of textile of Bangladesh which affects the export in a bad manner. US and EU are the major importer of Bangladesh textile which creates a huge difference in export of Bangladesh textile after imposing a restriction on import of Bangladeshi textile goods.

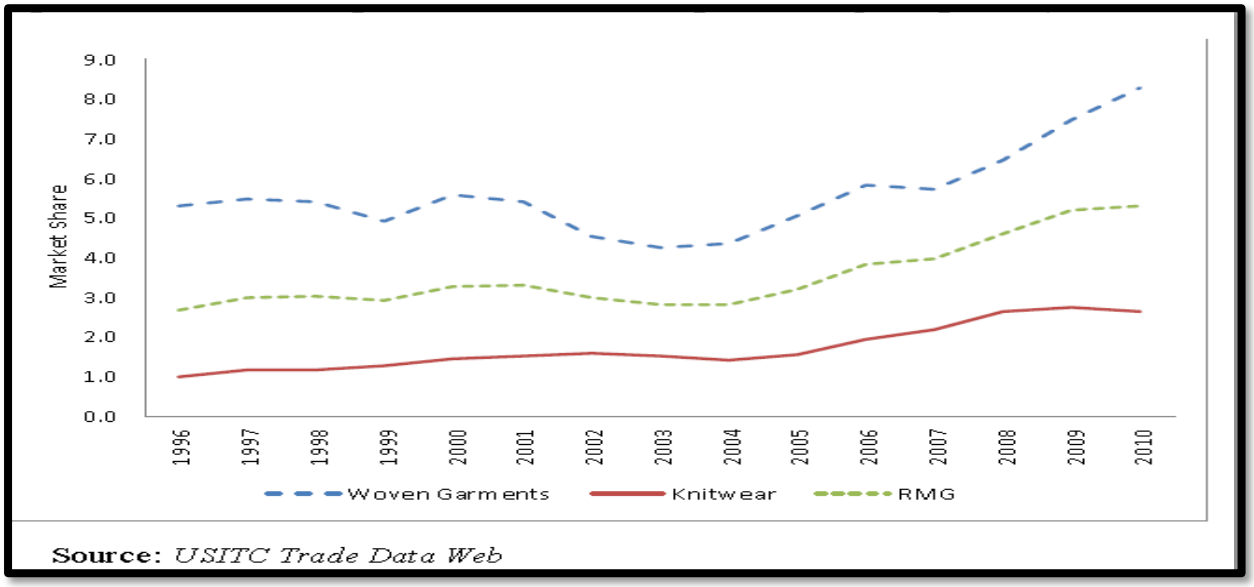

Figure 1.7: Share of Bangladesh in the total EU and US garment import (percent) Raw material prices

Prices of cotton and other raw material used in textile industry fluctuate rapidly in Bangladesh. The rapid increase in the price raw material affects the cost of production badly. The increase in raw material prices fluctuates rapidly due to double digit inflation and instable internal condition of Bangladesh. Due to increase in the cost of production the demand for export and home as well decreased which result in terms of downsizing of a firm. Hence the unemployment level will also increase. Govt should step to survive the textile industry. In order to decrease the price raw material for textile we need to increase our production capability. Simultaneously, the government should make arrangement for introducing international system of Cotton Standardization in Bangladesh to enhance quality and value of Bangladesh lint cotton by utilizing the technical services of Bangladesh Cotton Standard Institute.

1.19.13 Demand Supply Gap

The phenomenal expansion of the RMG industry in Bangladesh and the dramatic increase in the population in addition to an increased standard of living in the country has led to a large demand-supply gap as shown by the following table. Only 21% of the total demand for yarn is met locally in Bangladesh The figures for grey are not much better as only 28% of the total demand is met locally sub-sector currently is able to process all of the locally produced grey, but will need to expand at as with the weaving and knitting sub-sectors. All sectors of the textile industry of the same challenges. These problems include lack of power, obsolete technology, low capacity utilization, lack of machinery maintenance, a workforce that is not adequately trained, problems with labor unrest and militancy, political unrest causing disruption such as hartals and a lack of working capital. The problems with electricity were evident to me on my visit to the Sinha Textile Mills; I was told that it is more efficient to power the factory continuously by a generator, instead of production be hampered by power failures.

1.19.14 Export Performance of the Textile Sector

Although the export performance of textiles sector in Bangladesh lies in a satisfactory level but still a great concern to Bangladesh due to high cost of production, power shortage and stiff competition with regional players and others issues. Minister's on Textile, Abdul Latif Siddique said that high cost of doing business, power shortage, poor industrial infrastructure and slow external demand are some major factors contributing to the more challenges in textile and it smooth export.

1.19.15 The Effect of Global Recession on Textile Industry

In economics, the term ‘recession’ means “The reduction of a country’s Gross Domestic Product (GDP) for at least two quarters or in normal terms, it is a period of reduced economic activity.” Bangladesh is developing economy in the world and one of the lowest in terms of the dollar. It is sad to see our economy like this now. Bangladesh is actually a very economically diverse country with boasting industries of textiles, agriculture etc. The main reason for this slump largely been the political instability over the past few years; no proper economic policies were implemented; at least none that succeeded. This caused a very high rate of inflation, the prices of commodities soared through the roof, the number of people living below poverty line increased from 60 million to 77 million and consequently, the working class layman became virtually deprived from basic necessities like water, wheat electricity, natural gas, and cooking oil; add to all this, the preposterous amounts of load-shedding, and what we get is a nation in shambles12. The

above all situation of the economy badly affected the textile industry also. The demand for textile product cut down locally and internationally as well. The export order reduced due to unpredictable conditions of Bangladesh and political instability. The cut down in the production of textile cause further unemployment level which decrease the living standard of peoples.

1.19.16 Effect of Inflation

Inflation rate is measured as the change in consumer price index (CPI). Inflation is basically in the price level. It is decline in the real value of money. Inflation can have adverse effect on economy. Bangladesh is one of prey of inflation. It still faces high double digit inflation. The increase in inflation causes the increase in production of textile good which return in downsizing. The double digit inflation causes reduction in exports of textiles.

1.20 Retrospective Studies on Textile Industry

This thesis paper is about a case study of a firm in Narayanganj. Narayanganj has very renowned heritage regarding manufacturing of fine cloths, a competitive attraction in terms of communications for entrepreneurs. Development of knitwear production in Bangladesh is showed here by various valuable data, tables and statistics from renowned sources. Different types of issues about knitwear like capacity of firms, actual production, number of establishments, employment, firms size in the knitwear sector, organization of production at large, medium and small firms, product varieties, raw materials, enterprise formation, entrepreneurial growth, status of firms at the initial and milestone years of business, sources of finance, employment pattern and wage structure, competitiveness and efficiency perceived by firms, rise and fall of the knitwear manufacturing firms in Bangladesh were discussed by Yunus [1]

This study was about the development of linear programming model for Almeda Private Limited, Ethiopian Textile Industry as a case study. Loose of profit of a company, that was expected to gain, was the result of poor profit planning way or limitation of modern profit planning tools which subjects the company to promote more expenses rather than revenue. Linear Programming (LP) is a linear programming model in which there a particular function to be maximized or minimized subject to several constraints and in this case it was to maximize profit. So, in pursuit of maximizing profit or minimizing production cost, the linear programming model was developed. The model was developed by taking considerations on market segmentation, interest of workers, utilization of machines and other resources, demand of products by forecasting, and production capacity of the company. To develop the model, data were collected from primary and secondary sources. This study was supported through accessing available and related literatures, company survey and software and analyzed the information collected using main principles of linear programming technique. All major products and constraints with their values were identified and used for developing the model. The main objective of that study was to increase profit by using linear programming technique and reduce production cost. As a result, the linear programming model was developed which maximized profit from around 44.46 million ETB to 53.77 million ETB. This was achieved by applying proper product mix strategy as production of 0.25 unit of yarn, 0.25 unit of fabric, 0.76 unit of CM, 8.5 units of knit garment, and 0.25 unit of woven garment product. Increasing profitability and decreasing cost of production was the main challenges of many industries in our country Ethiopia, particularly this affects textile industry. The main cause of these problems was lack of a quantitative technique which enables them to minimize cost of production within the production system was discussed by

Eshetie Kassegn et al. [2]

This thesis paper was written about optimization of man - machine ratio for garment industry. Effective use of machines and manpower was essential in manufacturing of apparel products for ensuring high productivity investment from available resources in today's competitive business environment. It was crucial to establish optimal man-machine ratio to gain high resource utilization and profitable output. So Ambika B and Joseph Regy tried to achieve high productivity investment from available resources, to gain high resource utilization and profitable output. They also analyzed the requirement of the garment industry and suggest the best possible infrastructure in terms of machineries and manpower keeping the productivity in mind, so that the proponent got the best man – machine ratio. Therefore, it had a very good scope of setting up a plant of apparel industry with appropriate man machine ratio. [3]

An accelerating increase in linear programming applications to industrial problems had made it virtually impossible to keep abreast of them, not only because of their number and diversity but also because of the conditions under which many were carried out. Industrial and governmental secrecy was often present. Other conditions also bar access to ascertainment and assessment of the pattern of applications. Lack of a tradition for publication was one. Failure to ascertain the general significance of particular findings was another, as was discouragement arising from the fact that similar applications had previously been published by others. Immediate remedies were not available for these difficulties. Presumably conventions such as this will help, over a period of time, by encouraging informal contacts between interested persons. A talk on "industrial applications of linear programming" must be altered to suit these circumstances. In place of a survey or evaluation of industrial studies, two broad issues which are relevant to all such applications will be discussed. These are, one use of linear programming models as guides to data collection and two analysis and prognosis of fruitful areas of additional research, especially those which appear to have been opened by industrial applications –which were observed by A. Charnes and W.W. Cooper in their thesis paper ''Management Models and Industrial Applications of Linear Programming''. [4]

The considerable interest in the prediction of business failures was reflected in the large number of studies presented in the literature. Various methods had been used to construct prediction models. This paper provided a review of the literature and a framework for the presentation of this information. Articles could be classified according to the country, industrial sector and period of data, as well as the financial ratios and models or methods employed. Relationships and research trends in the prediction of business failure were discussed by Dimitras et al. in their thesis paper "A survey of business failures with an emphasis on prediction methods and industrial applications, European Journal of Operation Research (EJOR)". [5]

The basic concept of Textile Industry was explained broadly in this paper. The history of textile industry was also discussed elaborately here. The Indian Textile Industry's overview, milestone years of Textiles, segments, types, classifications, units of textile measurement, textiles fibers etc. had showed here so nicely so that anybody could imagine the full concept of Indian Textile Industry smoothly. The growth and structure of Indian textile industry were also explained here. Role of Indian Textile industry in the economy, challenges of textile industry, problems faced by Indian Textile industry and its solutions were shown here broadly. [7]

The importance of the textile industry in the economy of Bangladesh is very high. The garments manufacturing sector earned $19 billion in the year to June 2012, one of the impoverished

nation's biggest industries. Currently this industry is facing great challenges in its growth rate. The major reasons for these challenges can be the global recession, unfavorable trade policies, internal security concerns, the high cost of production due to increase in the energy costs, different safety issues specially fire, etc. Depreciation of Bangladeshi Taka that significantly raised the cost of imported inputs, rise in inflation rate, and high cost of financing had also effected seriously the growth in the textile industry. As a result, neither the buyers were able to visit frequently Bangladesh nor were the exporters able to travel abroad for effectively marketing their products. With an in-depth investigation it was found that the Bangladesh textile industry could be brought on top winning track if government and others individuals took serious actions in removing or normalizing the above mentioned hurdles. Additionally, the government should provide subsidy to the textile industry, minimize the internal dispute among the exporters, withdraw the withholding and sales taxes etc. Purchasing new machinery or enhancing the quality of the existing machinery and introducing new technology could also be very useful in increasing the research and development (R and D) related activities that in the modern era were very important for increasing the industrial growth of a country was observed by Mazedul Islam et al. [8]

Textiles have been an extremely important part of Bangladesh's economy. This industry is concerned with meeting the demand for clothing, which is a basic necessity of life. Growth of Garment factories in Bangladesh, number of machines, contribution of Textile Industry to the economy, Growth and trend of Garments Exports and contribution to GDP were discussed here according to annual report of BGMEA. There was a clean picture of present situation of Textile Industry and future of the Textile Industry in Bangladesh were also elaborately explained here by Rumman Sajib et al. [9]

An In-house Dialogue on the theme of Textile and Clothing Industry of Bangladesh: In a Changing World Economy was held at the Centre for Policy Dialogue on August 12, 1999. Dr. Sadequl Islam, Professor of Economics at the Laurentian University, Canada and Visiting Fellow, CPD performed the keynote presentation while the CPD Chairman, Professor Rehman Sobhan chaired the dialogue. Professor Islam in his presentation observed that textiles and clothing account for about 85% of total export earnings of Bangladesh. Bangladesh, being a labour-abundant country, started the process of industrialization by concentrating on labor-intensive products such as textiles and clothing. Several factors however, generate uncertainty and present challenges for Bangladesh: trade diversion induced by regional trade blocs, special trade relationships between trade blocs and some non-member countries, safeguard mechanisms and stringent "rules of origin" introduced by developed countries, China's accession to the World Trade Organization in the near future, greater competition from major developing countries such as China and India which have a well-integrated textiles and clothing industry. Developing countries including Bangladesh, which are at a stage of low industrial development, face many questions and dilemmas: **1**. Should such countries exploit its comparative advantage in labor-intensive clothing rather than develop textiles industries with government support, if necessary? **2**. Should Bangladesh concentrate on augmenting human capital and acquire comparative advantage in high-value added clothing? **3**. Does it make sense for Bangladesh to diversify its exports from textiles and clothing toward some high-tech products such as electronics? The above questions and apparent dilemmas needed to be addressed in the context of a changing world economy and supply constraints in the Bangladesh economy. This paper analyzed textiles and clothing exports from Bangladesh in the context of globalization of the world economy and liberalization of world trade. The main objectives of the paper were: **1)** To present an overview of international trade in textiles and clothing. **2)** To examine the impact of the Uruguay Round period on the textiles

and clothing industry in different regions based on an applied general equilibrium model, the Global Trade Analysis Project(GTAP) model. **3)** To examine the competitive positions of Bangladesh and selected developing countries which are competitors of Bangladesh in textiles and clothing. **4)** To explore the rational for selection of optimal trade and industry policy instruments for the textile and clothing industry in the short-run and long-run. [10]

History of textile production in Bangladesh, Readymade Garment Industry (RMG)'s world markets, Mckinsey report, some important trade agreements, Employments, worker's health, factory crisis, Education in textile sector etc. were well described in this website (textile industry in Bangladesh) [12]

On time delivery with quality and quantity is important for any manufacturing industry. Lead time was decreasing day by day and customer requirements also continuously changing. To fulfill customer demand whole production system should be more capable and efficient. For this reason, productivity was important for manufacturing industries. Productivity could be defined as a ratio between output and input. Manufacturing industries were always having lots of production processes for desired products. Out of these processes some were not essential and did not add any value to the product. If we observed a garments production line, we will see that there were lots of In-process inventories and waiting time between almost every sequential operation. No strict and precise work distribution was followed by many workers. Material's used to travel large distance from input receiving to needle check and cartooning. Many of these movements and handlings were totally unnecessary. Sometimes reworks were increasing the total completion time. As a result, the productivity was hampered. So, a smooth, streamlined and continuous flow was really necessary to avoid all such unexpected occurrence. The objective of value stream mapping was to identify value-added activities and non-value-added activities. Value stream maps should reflect what actually happens rather than what was supposed to happen so that opportunities for improvement could be identified. Value Stream Mapping was often used in process cycle-time improvement projects since it demonstrated exactly how a process operated with detailed timing of step-by-step activities. The study focused on improving the overall productivity of cutting, sewing and finishing sections through value stream mapping (VSM). Different techniques like process integration, job sharing, multitasking etc. implemented to improve the current state situation. Three different product lines (Jacket, Polo shirt, and tee shirt) were considered to implement this study, and the productivity as well as line efficiency compared before and after implementing the technique were observed by Moin Uddin. [13]

This manuscript aspired toward appraise the notion of Supply Chain Management (SCM) concerning Bangladesh Garment Industry. Managing and Scheming the Bangladesh Garment Industry Supply Chain (SC) is one of the fundamentals for international business and augments export. The distinctive tribulations facing with Garment and Textile Supply Chain (SC) were petite product rotation for Global Critique, extensive manufacturing lead- time and forecasting blunders for Garments substance. The premeditated necessities of Bangladesh garment business resolved the extent, distinctiveness strategic route of the supply chain (SC). Some dealings were only involved with intercontinental maneuver to secure a supply of resources and mechanism; promotion was domestic.

Generally, Supply Chain Management (SCM) is exceedingly multifaceted. In the RMG sector the Supply Chain Management (SCM) is more complex owing to characteristics of global Supply Chain (SC). In the global chain, crossing borders nearby supply with a multiplicity of general

obstructions to intercontinental business; tariffs, nontariff obstructions, switch over rates and differences in product necessities, consumer savors and business observes. Borders also present some impediments in transportation services, which are very common for RMG sector in Bangladesh. Different stages of supply chain had conflicting goals and objectives. Carefully using the available information and integration of supply chain could reduce the cost of conflicting goals and objectives. The approach was to compile the Supply Chain Management for the Bangladesh Garment Industry seriously. This was the right time to think and re-think for the decision Makers and the Planers of Bangladesh (Government and Non- government) about the SCM issue to implement in Bangladesh Garment Industry with the inspiration and keenness to sustain in near next into the Global Garment Market with the highly competitiveness, efficiency and productivity. This was the main part of the thesis paper written by Saiful Islam Tanvir and Noorul Muqaddim. [14]

This paper examined the role of textile and clothing (T&C) industries in growth and development strategies in developing countries. It suggested that textiles and clothing industries are important in economic and social terms, in the short-run by providing incomes, jobs, especially for women, and foreign currency receipts and in the long-run by providing countries the opportunity for sustained economic development in those countries with appropriate policies and institutions to enhance the dynamic effects of textiles and clothing. The potential of the textile and clothing industries to contribute to long-run growth and development will depend not only on the attributes (desirable or otherwise) of the investors, but also on the quality and effectiveness of government policies and institutions in developing countries to build on this investment which was discussed by Jodie Keane and Dirk Willem. [15]

INDR 262 Optimization Models and Mathematical Programming [16] showed the Linear Programming Model definition, a Linear Programming (LP) Model origins, standard form of LP model, and variations in LP model, terminology for solutions of LP Model, solving some examples of LP model geometrically, algorithms and applications of LP model.

Manik Shankar Mandol explained the status of cotton in Bangladesh in his thesis paper [17]. Cotton is one of the important cash crops in Bangladesh. It is the main raw materials of textile industry. Annual requirement of raw cotton for textile industry of Bangladesh is estimated around 2.5 million bales. Here, appropriate geography and climate for cotton cultivation was described. Acreage, production and yield of Upland Cotton, hill cotton were also classified here. Performance of American cotton and hill cotton varieties which are available in Bangladesh were also shown here. The cotton Development Board (CDB) has four main activities which are

i) Research on cotton
ii) Extension Service including technology transfer, training & demonstration
iii) Seed Production & distribution and
iv)Marketing and other institutional support, were well focused in this thesis paper.

The country's total cotton assumption, cotton market, cotton seed industry, ginning industry and capacity, fiber industry, textile and confection industry and problems associated with cotton production in Bangladesh, cotton related future steps all were explained finely here which makes us more conscious about a valuable asset of our country, cotton.

Data Collection

2.1 Introduction

Data collection is the process of gathering and measuring information on targeted variables in an established system, which then enables one to answer relevant questions and evaluate outcomes. Data collection is a research component in all study fields, including physical and social sciences, humanities and business. Interviews, Questionnaires and surveys, Observations, Documents and records, Focus groups, Oral histories are some data collection methods. The basic principles of data collection include keeping things as simple as possible; planning the entire process of data selection, collection, analysis and use from the start; and ensuring that any data collected is valid, reliable and credible. It is also important that ethical issues are considered.

2.2 Source of Data

For this study both primary and secondary data sources are used. Primary data is collected by means of a questionnaire survey and interview with the director, manager, engineer, laborers of the Rozha textiles industry. Questions has asked to know the production cost and profit margin. For the first time the members of the mill have given their valuable data which help to complete the study. The study is largely based on information from secondary sources such as garments censuses and the WTO yearbook, different issues of pocket book, Bangladesh bureau of statistics. Such information is supplemented by primary data generated from field surveys. In particular, the data on the current textile production system, generated by the field surveys, have been used. The following information collected from a textile industry named **ROZHA TEXTILES LIMITED,** Narshindi.

2.2.1 Primary Data

The primary data has collected from manager, director, machine operator, sweeper and other market participants involve in the production and marketing of cloths sub sector. The information includes the overall socioeconomic characteristics of machines operator and mechanical assistant involve in this business using structured questionnaires designed for this study. During visit to the industry by observations, the primary data like products process sequence, machines used for particular operation, number of machines, number of operator, skill matrix, learning performance are carried out by using through observation, recording and collections.

2.2.2 Secondary Data

The primary data has supplemented by a spate of secondary sources of data. Secondary data pertaining to the study has gathered from the records published by various textiles industries. Latest information has gathered from well-equipped libraries in Bangladesh University of

Engineering & Technology, Dhaka, and some journal's and Internet web resources. Further, the secondary data has collected from various leading journals inclusive and exclusive of textile industry. A number of standard texts has studied to obtain pertinent literature on clothing shipment.
A structured questionnaire has designed to collect information on cloth management procedures used on spinning, yarn dyeing, knitting, confection of knits and sizing, finishing of cloths. Some industry in Narshindi are even fully vertically integrated (spinning to finishing). But ROZHA mill doesn't do all the parts of shipment. They manage only spinning that means converting yarn to cloth, then the cloths are sent to many mills to coloring, dyeing, sizing. Here they spend some money to complete these task and they also maintain some transportation costs for this which has shown as some tables and graphs. This study has some related data from some books, magazines and various publications of the central, state & local governments. I also observed reports & publications of various associations connected with business which I mentioned later. I compare data which I collected from industry with the standard manuals. A statistical analysis through tables, graphs, bar charts, pie charts of profit optimization of cloth production for industry will show on another chapter.

The approximate gross value addition for different steps within the textile and garment production in Bangladesh is listed below:

- Spinning 17%
- Weaving 15%
- Knitting 18%
- Dyeing / finishing 15%
- Finished Garments 28%

(Source: Corporate Solution, Bad Nauheim 2005)

2.3 Survey Instrument

An unstructured questionnaire has used to collect data. The questionnaire consists of different parts to gather information on the different key factors of the industry under considerations. The unstructured questionnaire is the best instrument for the survey in this case because for a comparative study every response of the sample is important and interviews has the better chance to explain their opinion that help in evaluating them. It gives more time to the respondents to think and then give the answers. As the sample size is small it has the best opportunity to bring out every possible answer with the unstructured questionnaire. As in-depth interview is the way of conducting the survey and it is qualitative in nature an unstructured questionnaire is the best way to conduct the survey. With this, no responses of the respondents can be missed out.

2.4 The Company Profile

The textiles industries overview, machine's outline, labor schedule, salary, bonus, cloths costs distribution, various selling price and profit's outline, productivity analysis, main cost that means yarn cost analysis as tables and graphs, shipment history etc. these data has collected in December, 2015. The collection of data has done through direct interview and telephonic conversation with the concerned people.

Table 2.1: Textile Profile

Industry	Rozha Textiles Limited
Type	Cotton Shipment (Manufacturing & exporting)
Specialization	Woven' s cloth
Established	2008
Employees	21+
Machine	24

2.5 Volume of Production

The ROZHA Textiles Ltd mainly takes order as cycles or period system. They generally produce one type of cloth at a time at all machines. Then they processed the cloths by dyeing, sizing, printing after all ready to sell. The mill pays salary to its workers weekly. Sometimes the machine operators do overtime at all over night to complete the orders schedule. Normally the mill can produce 15000 gauzes of cloths weekly. So that the owner of the mill can take an order of 60000 gauzes.

2.6 Mill's Place, Area and Rent cost

The mill is situated at Algei in Narshindi which is also known as "The Manchester of the east". The area of the mill is one bigha. So the mill is small in size. There has an office room of director and manager. Clients and guests are welcomed here to visit. Half of the area is used for machine purpose. Yarn's collection is placed here also at one corner. Some female workers are seen here busy to prepare the cloths to send these to different textile companies to dye, size, and print. I observed full area of the mill. The place of mill is so nice. The place is rented by one lac and fifty thousand takas. The manager and director were so helpful and cordial to give me all types of information related to my thesis work. They didn't give like such interview before it. I also communicate with the manager during the whole session of my thesis work. I am so pleased with their behavior, hospitality and co-operation. After completing my thesis work, I will definitely advise them about their profit maximization process to develop their production shipment.

Figure 2.1: My visit at Rojha Textiles Ltd.

2.7 Shift Work

The mill maintains shifting rules. Twelve hour of working schedule per shift. Twelve workers work daily per shift. Two shifts are continuing daily. These are day shift and night shift. Day shift continues from 6 am to 6 pm and night shift continues from 6 pm to 6 am. The mill is closed from 8 am to 8 pm on Friday. But when delivery has to maintain within a very short time, all staffs have to do overtime. The members of the company are very promising. So their client's satisfaction is very high and they give delivery frequently to keep a healthy relationship among them.

2.8 Types of Cloths

Generally, the mill takes order of six types of cloths. They also take some seasonal cloths in winter and summer. The names of cloths are given below:

a) Shifting
b) Biscos
c) Heringon
d) Tisi
e) Shirting
f) Twin
g) Denim – D
h) Shirton

Table 2.2: Comparison of Cost and Selling Price of Various Types of Cloths

No	Cloths name	Cost (tk)	Selling Price (tk)	Profit range (tk)
01	Shiting	34	37	3
02	Biscos	90	100	10
03	Heringon	56	60	4
04	Tisi	24	26	2
05	Shirting	110	120	10
06	Twin	50	55	5
07	Denim-D	80	90	10
08	Shirton	110	125	15

2.9 Machine's name, price and numbers

The brand name of each Machine's is **SHINKWANG.** Every Machine's price is 7 lakhs. There are 24 machines in the mill. Machines are imported from Korea.

Figure 2.2: Shinkwang machine for producing cloth from yarn.

2.10 Working Process of the Textile Company

Full process of delivery is completed by some phases. The mill maintains the process step by step so smoothly within the fixed schedule. So clients are satisfied to them. The process is given below:

- Buying yarn for cloths.
- Spinning yarns
- Starching, dyeing cloths
- Seizing for sewing.

- Cutting cloths.
- Printing cloths
- Finishing cloths.

Figure 2.3: A Laborer is spinning machine to produce cloth

Figure 2.4 A woman is sizing & folding cloths

2.11 Some Mills and Industries to Dye, Print and Starch Cloths

The textile company only processed yarns to cloths but not sizing, dyeing etc. The mill generally sends all cloths to different industries to size, dye, starch. The mill always maintains a friendly relation with these companies. Names of some companies are given below:

- Thithi textiles ltd
- Tharmex group of industries and ltd
- Maskina textiles ltd.

2.12 Salary Structure

The mill gives its employees handsome salary according to their designation. All employees are satisfied with their payment. I discussed with all types of employees of the mill about their salary and working environment. They reported me with their satisfaction. The structure of employee's salary is given below:

Table 2.3: Salary Structure of Employees of the Company

Designation	No. of employees	Salary per person per month
Mechanical Engineer	1	32,000
Manager	2	12,000
Mechanical Assistant	3	16,000
Electrician	1	22,000
Fueler	3	9,500
Sweeper	1	7,000
Machine Operator	12	12,000
Gate keeper	1	7000

Figure 2.5: Manager is observing the spinning process

Figure 2.6: Checking time before shipment

2.13 Machine Cost

All machines are imported from Korea. Each machines cost is seven lacks which is fixed cost. Due to working shifting rules, sometimes machines can't take rest. So some technical problems are arisen. There are some costs to run the machines smoothly. I use these machines costs to implement the model and then solve the problem to maximize the profit using AMPL programming.

Table 2.4: Machinery Cost (monthly)

Purpose	Cost (tk)
Oil	32,000
Tools	32,000
Purse (1Set)	1500
Bell (30 Piece)	6000
Electric Motor (3 Piece)	9000
Total	**51,700**

2.14 Order Duration

Rozha Textiles Ltd takes order frequently. They have some regular clients. They always deliver order within one month or one and half months. The company maintains order as cycling system.

2.15 Festival Bonus

The company gives its staffs two bonuses. Bonuses are given in two EID. One bonus is 50% of gross salary. But if any worker faces problem then the company always helps him economically.

2.16 Electricity Bill

As the mill has to run twenty-four high voltage machines so that the company has to pay a huge amount of money to pay electricity bill every month. The cost is around one lac and fifty thousand takas. The cost of per unit bill is nine takas. This cost is also included in the LP model.

Figure 2.7: Manager, director & some clients discussed with me about my thesis at office room.

2.17 Foreign Order

The mill also got foreign orders. The orders duration was from eight to ten months per year. The orders were come from U.S.A., Canada, Italy and Brazil. But during the last four years' company didn't get any foreign order. The manager thought that lacking of well-developed technology to produce cloths is the main reason for not getting foreign orders.

2.18 Local Order

Maximum production goes to the largest cloth market that is Islampur cloth market, Dhaka. Besides this, some orders come from Narshindi Market also.

2.19 Profit (per cycle)

The textiles mill got profit of two or three lacks taka per cycle. But they are now in loss project. Every year company has to pay some unexpected loss so that the profit amount becomes so poor. My motto is to cover their loss, profit maximization. Through my thesis, I will give them a solution of profit maximization to overcome the unexpected loss.

2.20 Production Quality Per Year

This is the target production quantity per year when product specified in produce drawing is manufactured in accordance with the condition mentioned in this document.

2.21 Working Days Per Year

Three hundred days are set for working days per year.

2.22 Production Quantity per shift

The production quantity per line × the number of lines ×1 shift = the production quantity per shift.

Formula 1

The production quantity per shift $= \frac{working\ time\ \ per\ shift \times the\ number\ of\ worker}{standard\ total\ operation\ time}$

2.23 Number of (Production) Line

Production line is divided into three sections. These are:

2.23.1 Cutting Section

This is the line where the cutting carries out, where the number of people required cutting for a particular portion and the target production is calculated.

2.23.2 Sewing Section

This is the line where actual sewing operation is made. The number of lines varies depending on item. This calculates an appropriate number of persons per line and indicates the required number of lines for target production quantity. When there are multiple lines, another could be considered, namely automatic machines, fusing press machines, special equipment etc. are treated as common equipment will increase the operation rare of each equipment. This is judged from an appropriate production quantity of each equipment.

2.23.3 Finishing Section

This is the line finished products by sewing section are complemented and reformed by supplementary works (removal of thread fray, hand stitching of buttons, hemming…), inspection, off-press, iron etc.

When there are multiple sewing lines, off-press machines and special equipment are common equipment and finished products may be intensively processed.

2.24 Number of Worker

The number of persons required in spinning sections is twelve, mechanical engineer is one, number of electric engineer is one, manager and director are two, fueling members are three,

gate keeper is one and the number of sweeper is one. The indirect persons such as supervisors, persons for transportation are not included. The number of persons listed here is calculated subject to the workers who are highly qualified in each work of operation flow.

From (Formula 1) **Formula 2**

$$\text{The number of workers} = \frac{production\ quantity\ per\ shift \times standard\ total\ operation\ time}{workinh\ time\ per\ shift}$$

2.25 Operation Time

This is the required total operation time for completing a garment spent in sections in sewing line and finishing line. This time includes time allowances, not including the time of ALT or VAR. TIME ALLOWANCE… This is the time irregularly spent for the incidents against the regular time spent for product operation during working time, such as arrangement of products, thread change, transportation (transfer) of products, discussion for work, restroom, negligence etc. Unit is minute.

2.26 Daily Productivity (sewing section only)

This is the daily productivity by direct sewing operation per worker. In case the design changes, operation time in operation flow varies. The productivity changes accordingly.

$$\text{Daily productivity} = \frac{production\ quantity\ per\ shift}{number\ of\ sewing\ (section's) worker}$$

2.27 Some Cloths of Foreign Brands

The mill sometimes produces some foreign brand's cloths which are given below:

Table 2.5: Cloths of Foreign Brands

Country	Brand
Japan	Toyota, Sutegana
Italy	Barmatex
China	Shirt's loam

2.28 Transportation System

The company has to send cloths to different mills to dye, print, starch. So they maintain some transportation systems. Most of the mills of these purposes are in the Narshindi area. So they are not so much worried about transportation problem. They have some hiring cover vans, pick-ups, small trucks etc. to manage these works. And at the time of main delivery the clients manage and pay cost for the transportation systems.

2.29 Inner Cost of Each Type of Cloth

Here I show each and every inner costs like yarn, dying, sizing, printing etc. of each cloth of the company by tables and graphs

Table 2.6: Inner Cost and Selling Price of Shiting cloth

Particulars	Rate (BDT)	Volume	Cost	Selling Price
Yarn cost (pound)	9	60,000 gauzes	34 taka/gauzes	37 taka/gauzes
Sizing cost	5			
Dying cost	10			
Printing cost	10			
Total	34			

Figure 2.6: Showing various cost of Shiting cloth by a pie chart

Table 2.7: Inner Cost and Selling Price of Biscos Cloth

Particulars	Rate BDT	Volume	Cost	Selling price
Yarn cost (pound)	75	50,000 gauzes	90 taka/gauzes	100 taka/gauzes
Sizing cost	-			
Dying cost	15			
Printing cost	-			
Total	90			

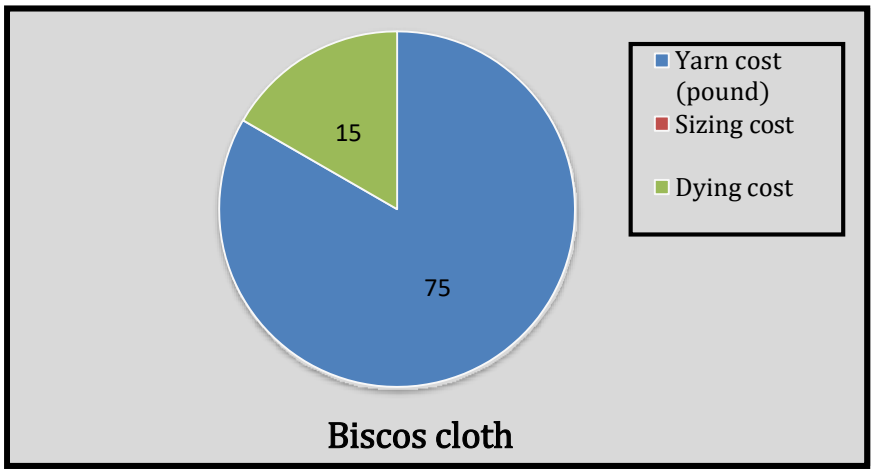

Figure 2.7: Showing various cost of Biscos cloth by a pie chart.

Table 2.8: Inner Cost and Selling Price of Heringon Cloth

Particulars	Rate BDT	Volume	Cost	Selling price
Yarn cost (pound)	46	70,000 gauzes	56 taka/gauzes	60 taka/gauzes
Sizing cost	10			
Dying cost	-			
Printing cost	-			
Total	56			

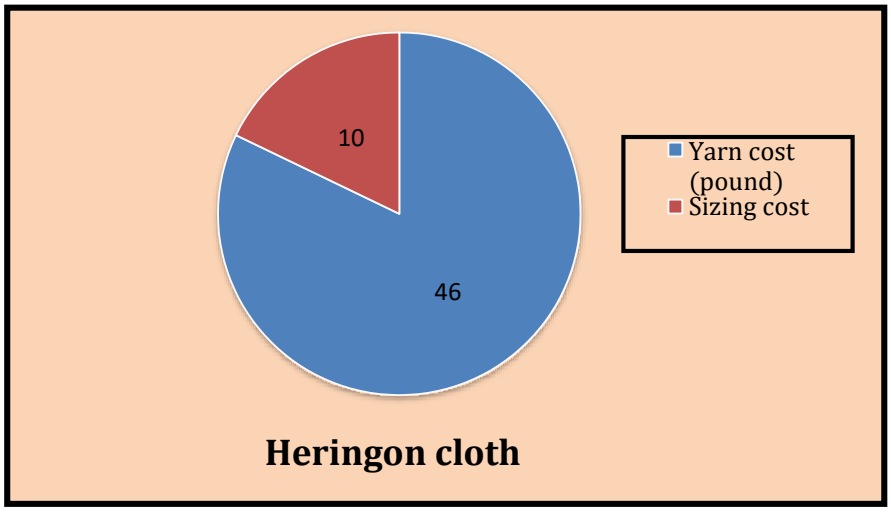

Figure 2.8: Showing various cost of Heringon cloth by a pie chart

Table 2.9: Inner Cost and Selling Price of Tisi Cloth

Particulars	Rate BDT	Volume	Cost	Selling price
Yarn cost (pound)	14	55,000 gauzes	24 taka/gauzes	26 taka/gauzes
Sizing cost	10			
Dying cost	-			
Printing cost	-			
Total	24			

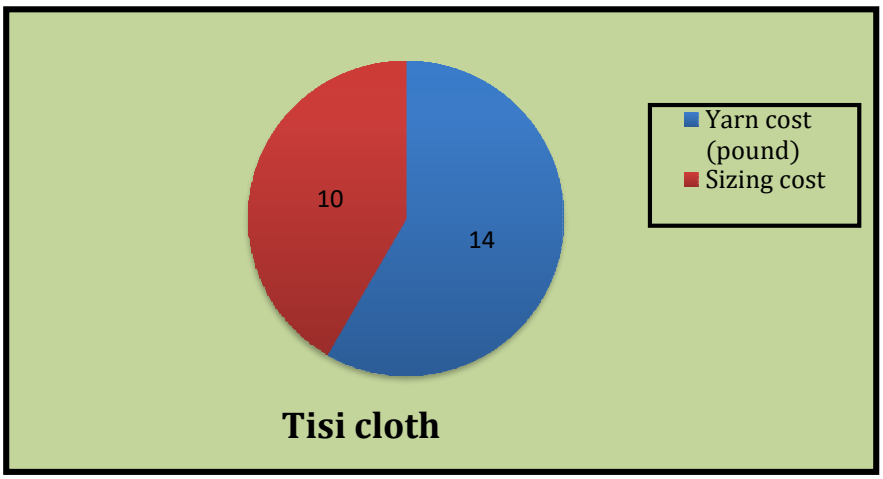

Figure 2.9: Showing various cost of Tisi cloth by a pie chart

Table 2.10: Inner Cost and Selling Price of Shirting Cloth

Particulars	Rate (BDT)	Volume	Cost	Selling price
Yarn cost (pound)	80	65,000 gauzes	110 taka/gauzes	120 taka/gauzes
Sizing cost	-			
Dying cost	15			
Printing cost	15			
Total	110			

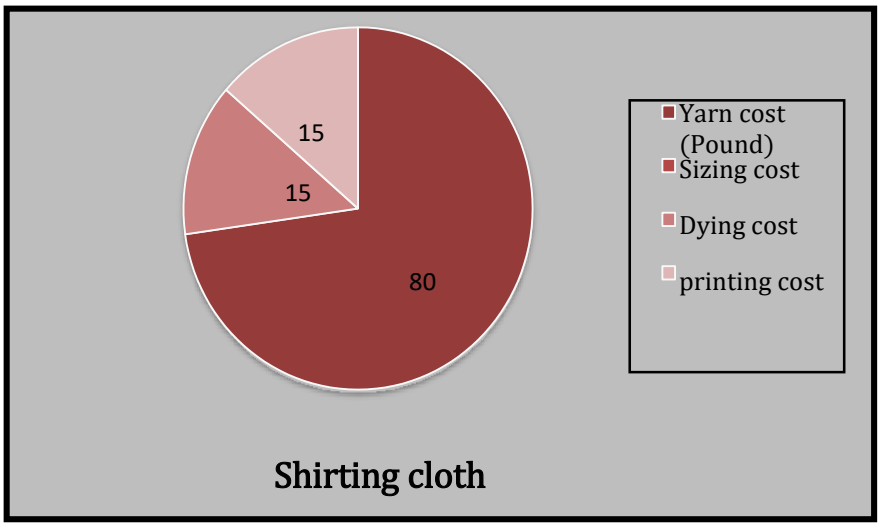

Figure 2.10: Showing various cost of Shirting cloth by a pie chart

Table 2.11: Inner Cost and Selling Price of Twin Cloth

Particulars	Rate (BDT)	Volume	Cost	Selling price
Yarn cost (pound)	40	52,000 gauzes	50 taka/gauzes	55 taka/gauzes
Sizing cost	10			
Dying cost	-			
Printing cost	-			
Total	50			

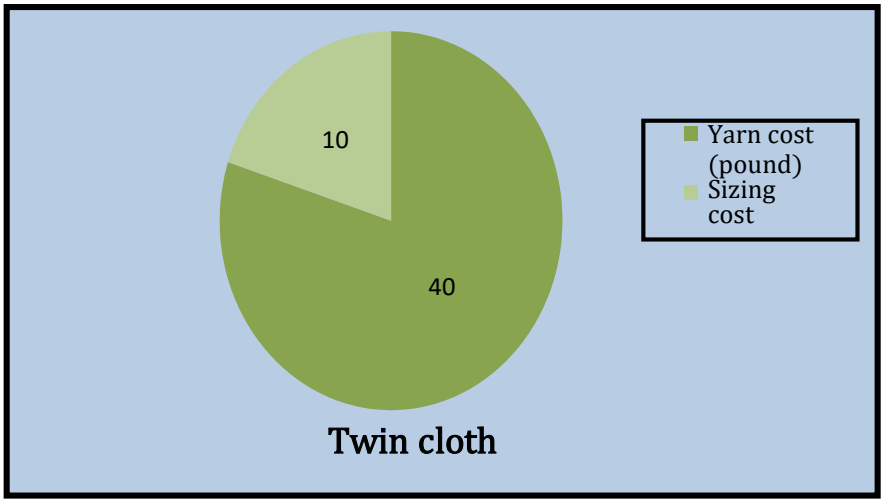

Figure 2.11: Showing various cost of Twin cloth by a pie chart

Table 2.12: Inner Cost and Selling Price of Denim-D Cloth

Particulars	Rate (BDT)	Volume	Cost	Selling price
Yarn cost (pound)	45	60,000 gauzes	80 taka/gauzes	90 taka/gauzes
Polestar yarn cost (pound)	15			
Dying cost	20			
Sizing cost	-			
Total	80			

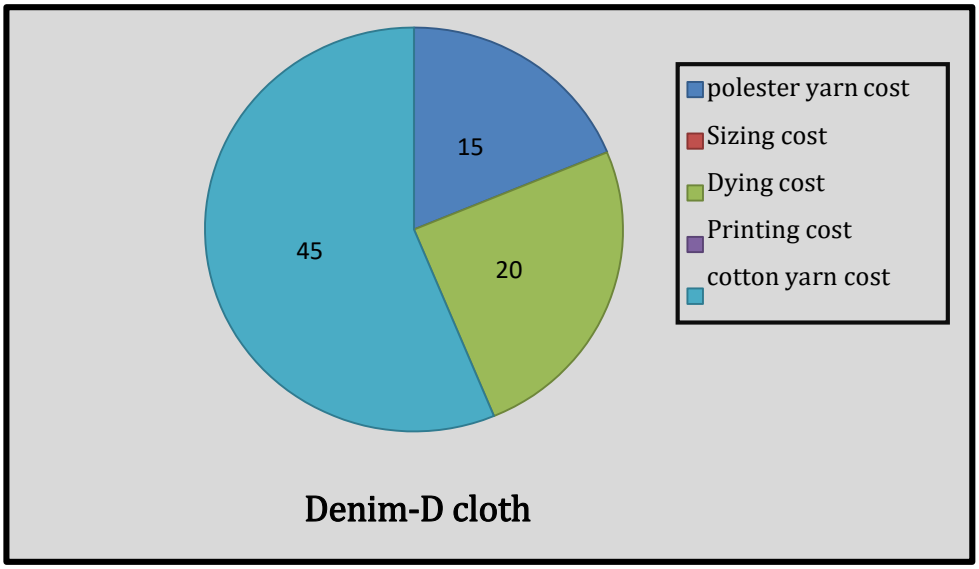

Figure 2.12: Showing various cost of Denim-D cloth by a pie chart

Table 2.13: Inner Cost and Selling Price of Shirton Cloth

Particulars	Rate (BDT)	Volume	Cost	Selling price
50-50 Yarn cost (pound)	65	50,000 gauzes	100 taka/gauzes	125 taka/gauzes
Slub yarn cost (pound)	30			
Dying cost	15			
Sizing cost	-			
Total	110			

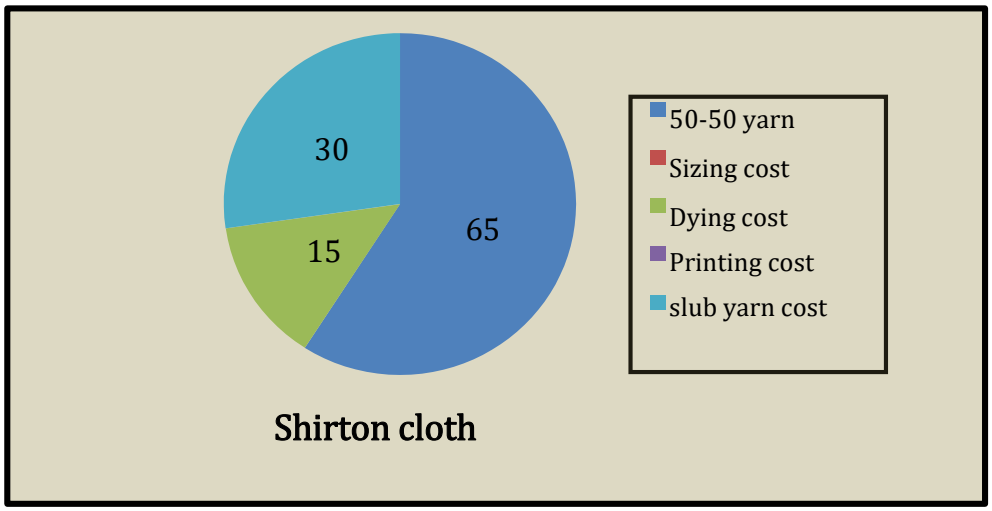

Figure 2.13: Showing various cost of Denim-D cloth by a pie chart.

2.30 Profit Measurement of Various Cloths (for 1 unit)

Here, I show costing price, selling price, volume and profit of eight types of cloths for unit quantity.

Table 2.14: Profit Measurement for Unit Quantity

Cloths	Volume (Gauzes)	Fabric Cost (BDT)	Selling Price (BDT)	Profit (BDT)
Shiting	60,000	34	37	3
Biscos	50,000	90	100	10
Heringon	70,000	56	60	4
Tisi	55,000	24	26	2
Shirting	65,000	110	120	10
Twin	52,000	50	55	5
Denim-D	60,000	80	90	10
Shirton	50,000	110	125	15

2.31 Difference Among Various Cloth's Costing Price, Selling Price and Profit

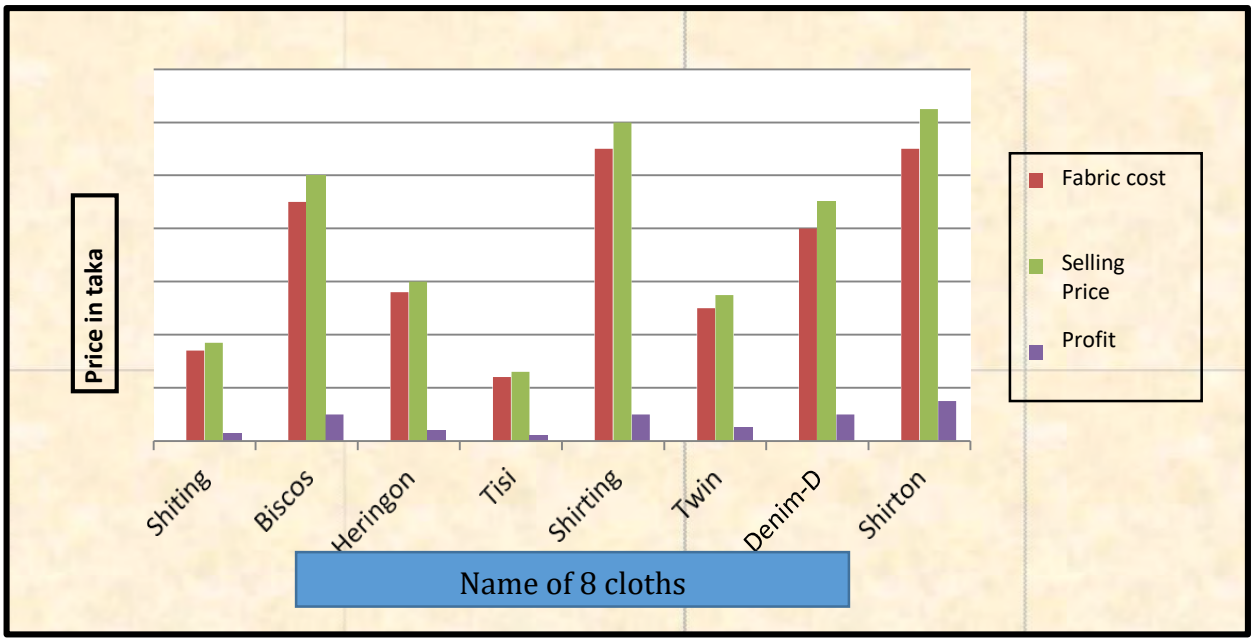

Figure 2.14: Eight types of cloths cost, selling price & profit for unit quantity.

Table 2.15: Profit Measurement for 1 Cycle

Cloths	Volume (Gauzes)	Fabric Cost (BDT)	Selling Price (BDT)	Profit (BDT)
Shiting	60,000	20,40,000	22,20,000	180,000
Biscos	50,000	4500,000	50,00000	50,0000
Heringon	70,000	39,20,000	42,00,000	2,80,000
Tisi	55,000	13,20,000	14,30,000	1,10,000
Shirting	65,000	71,50,00	78,00,000	6,50,000
Twin	52,000	26,00000	28,60,000	2,60,000
Denim-D	60,000	48,00,000	54,00,000	6,00,000
Shirton	50,000	55,00,000	62,50,000	75,0000

2.32 Risking Factor of the Industry

There are some risking factors which hamper the productivity. Some important factors are given below:

- Level of technology
- Product style, price point and production volume
- Training of workforce and management
- Motivation level of workforce and management
- Awareness of optimal productivity level
- High rate of non-first quality production

- Labor turnover and absenteeism
- Production scale
- Lead time
- Industrial engineering
- Labor relations
- Bearing all expanses of worker's accidents
- Failing to deliver products in time
- Lotting system products sale
- Wastage money in rejecting products etc.

Chapter 3

Linear Programming Model Formulation

3.1 Introduction

Linear programming is a method to achieve the best outcome such as maximum profit or lowest cost in a mathematical model of any business organizations. This technique has been useful for guiding quantitative decisions in business planning, in industrial engineering and to a lesser extent in the social and physical sciences. Linear programming (LP) is one of the simplest ways to perform optimization problems by making a few simplifying assumptions. Linear programming is a simple technique where we depict complex relationships through linear functions and then find the optimum points. The real relationships might be much more complex – but we can simplify them to linear relationships. Applications of linear programming are everywhere around us. We use linear programming at personal and professional fronts. We are using linear programming when we are driving from home to work and want to take the shortest route. Or when we have a project delivery we make strategies to make our team work efficiently for on-time delivery. Manufacturing industries use linear programming for analyzing their supply chain operations. Linear programming is also used in organized retail for shelf space optimization. Optimization is also used for optimizing delivery routes. Optimizations are also used in Machine Learning. The applications of Linear programming don't end here. There are many more applications of linear programming in real world like applied by Shareholders, Sports, Stock Markets etc.

3.2 Mathematical Model Formulation

Linear programming also called linear optimization is a method to achieve the best outcome (such as maximum profit or lowest cost) in a mathematical model whose requirements are represented by linear relationships. Linear programming is a special case of mathematical programming. More formally, linear programming is a technique for the optimization of a linear objective function subject to linear equality and linear inequality constraints.

3.3 Linear Programming Model

3.3.1 Common Terminology for Linear Programming

Linear programming models involve

- Resources denoted by i, there are m resources.
- Activities denoted by j, there are n activities.
- Performance measure denoted by z.

An LP Model:

$$\text{Maximize } z = \sum_{j=1}^{n} c_j x_j$$

Subject to,

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i \quad ; \forall \text{ i=1...m}$$

z: value of overall performance measure

x_j: Level of activity j (j=1...n)

c_j: performance measure coefficient for activity j

b_j: amount of resource i available (i=1...m)

a_{ij}: amount of resource i consumed by each unit of activity j

Decision Variables: x_j

Parameters: c_j, a_{ij}, b_j

3.3.2 Standard Form of the LP Model

A Linear programming problem can be expressed in the following standard form:

$$\text{Max } z = c_1x_1 + c_2x_2 + \cdots + c_nx_n$$

Subject to,

$$a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n \leq b_1$$

$$a_{12}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n \leq b_2$$

. . ..

. . ..

$$a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n \leq b_m$$

$$x_1 \geq 0$$

$$x_2 \geq 0$$

...

$$x_n \geq 0$$

Objective functions: overall performance measure

$$c_1x_1 + c_2x_2 + \cdots + c_nx_n$$

Constraints:

$$a_{i1}x_1 + a_{i2}x_2 + \cdots + a_{in}x_n \leq b_i \; \forall i = 1 \ldots m \; (functional\ constraints)$$

$$x_j \geq 0 \quad \forall j = 1 \ldots n \qquad (nonnegativity\ constraints)$$

3.4 Applications of LP Model

Some important fields where linear Programming is widely used

- Profit maximization model
- Radiation Therapy Design
- Regional Planning
- Controlling Air Pollution
- Reclaiming Solid Water
- Personnel Scheduling
- Distribution Network
- Product Mix
- Planning read, etc.

3.5 Profit Optimization Table Formulation

This study is to maximize the profit of each cloth type and minimize the cost of production. Here I introduce short form of every cloth to calculate easily

1) Shiting → SH
2) Biscos → BIS
3) Heringon → HER
4) Tisi → TIS
5) Shirting → SHR
6) Twin → TW
7) Denim-D → DNM
8) Shirton → SHR

In the following table, we can see the profit for each cloth, various types of cost available in one unit of each of the cloths, the minimum requirement of costs and volume of cloths per cycle.

Table 3.1: Model Formulation Data for Unit Quantity

	SH	BIS	HER	TIS	SHR	TW	DNM	SHN	Min Requirement
profit	3	10	4	2	10	5	10	15	
Costing price	34	90	56	24	110	50	80	110	980
Selling price	37	100	60	26	120	55	90	125	600
Labor cost	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	15
Machine cost	42	42	42	42	42	42	42	42	720
Other cost	6	6	6	6	6	6	6	6	120
Volume (1 cycle)	60000	50000	70000	55000	65000	52000	60000	50000	550000

For the model the decision variables are:

X_{SH} =volume of shiting cloth for 1 unit

X_{BIS} = volume of Biscos cloth for 1 unit

X_{HER}=volume of Heringon cloth for 1 unit

X_{TIS}=volume of Tisi cloth for 1 unit

X_{SHR}=volume of Shirting cloth for 1 unit

X_{TW}=volume of Twin cloth for 1 unit

X_{DNM}=volume of Denim-D cloth for 1 unit

X_{SHN}=volume of Shirton cloth for 1 unit

In addition, the industry has the following limitations of expenditures: (for 1 unit)

a) Maximum investment for costing price is taka 980
b) Maximum investment for selling price is taka 1500
c) Maximum investment for labor cost is taka 15
d) Maximum investment for machine cost is taka 720
e) Maximum investment for other cost is taka 120
f) Maximum volume of cloths per cycle is gauzes 80000

Our objective function is

Maximize $\boldsymbol{z = 3X_{SH} + 10X_{BIS} + 4X_{HER} + 2X_{TIS} + 10X_{SHR} + 5X_{TW} + 10X_{DNM} + 15X_{SHN}}$

Subject to constraints are:

$$34X_{SH} + 90X_{BIS} + 56X_{HER} + 24X_{TIS} + 110X_{SHR} + 50X_{TW} + 80X_{DNM} + 110X_{SHN} \leq 980 \quad (1)$$

$$37X_{SH} + 100X_{BIS} + 60X_{HER} + 26X_{TIS} + 120X_{SHR} + 55X_{TW} + 90X_{DNM} + 125X_{SHN} \geq 600 \quad (2)$$

$$1.25X_{SH} + 1.25X_{BIS} + 1.25X_{HER} + 1..25X_{TIS} + 1.25X_{SHR} + 1.25X_{TW} + 1.25X_{DNM} + 1.25X_{SHN} \leq 15 \quad (3)$$

$$42X_{SH} + 42X_{BIS} + 42X_{HER} + 42X_{TIS} + 42X_{SHR} + 42X_{TW} + 42X_{DNM} + 42X_{SHN} \leq 720 \quad (4)$$

$$6X_{SH} + 6X_{BIS} + 6X_{HER} + 6X_{TIS} + 6X_{SHR} + 6X_{TW} + 6X_{DNM} + 6X_{SHN} \leq 120 \quad (5)$$

$$60000X_{SH} + 50000X_{BIS} + 70000X_{HER} + 55000X_{TIS} + 65000X_{SHR} + 52000X_{TW} + 60000X_{DNM} + 50000X_{SHN} \leq 550000 \quad (6)$$

$$X_{SH}, X_{BIS}, X_{HER}, X_{TIS}, X_{SHR}, X_{TW}, X_{DNM}, X_{SHN} \geq 0 \quad (7)$$

Where, equations (1), (2), (3), (4), (5), (6) describe the fabric cost, selling price, labor cost, machine cost, other cost and volume respectively that associate to the company to produce eight products. Equations (7) is the boundary constraint that illustrate the limit of the production amount of eight cloths. These constraints are for unit quantity of production.

Table 3.2: Model Formulation Data for 1 Cycle

	SH	BIS	HER	TIS	SHR	TW	DNM	SHN	Min requirement
Profit	180000	50000	280000	110000	650000	260000	600000	750000	
Costing price	2040000	4500000	3920000	1320000	7150000	2600000	4800000	5500000	31900000
Selling price	2220000	5000000	4200000	1430000	7800000	2860000	5400000	6250000	35000000
Labor cost	312500	312500	312500	312500	312500	312500	312500	312500	2500000
Machine cost	51700	51700	51700	51700	51700	51700	51700	51700	413600
Other cost	260000	260000	260000	260000	260000	260000	260000	260000	2080000
Volume (1 cycle)	60000	50000	70000	55000	65000	52000	60000	50000	462000

Our objective function is,

Maximize z $= \mathbf{180000}X_{SH} + \mathbf{50000}X_{BIS} + \mathbf{280000}X_{HER} + \mathbf{110000}x_{TIS} + \mathbf{650000}X_{SHR} + \mathbf{260000}X_{TW} + \mathbf{600000}X_{DNM} + \mathbf{750000}X_{SHN}$

Subject to constraints are:

$$2040000X_{SH} + 4500000X_{BIS} + 3920000X_{HER} + 1320000X_{TIS} + 7150000X_{SHR} + 2600000X_{TW} + 4800000X_{DNM} + 5500000X_{SHN} \leq 31900000 \quad (8)$$

$$2220000X_{SH} + 5000000X_{BIS} + 4200000X_{HER} + 1430000X_{TIS} + 7800000X_{SHR} + 2860000X_{TW} + 5400000X_{DNM} + 6250000X_{SHN} \geq 35000000 \quad (9)$$

$$312500X_{SH} + 312500X_{BIS} + 312500X_{HER} + 312500X_{TIS} + 312500X_{SHR} + 312500X_{TW} + 312500X_{DNM} + 312500X_{SHN} \leq 2500000 \quad (10)$$

$$51700X_{SH} + 51700X_{BIS} + 51700X_{HER} + 51700X_{TIS} + 51700X_{SHR} + 51700X_{TW} + 51700X_{DNM} + 51700X_{SHN} \leq 413600 \quad (11)$$

$$260000X_{SH} + 260000X_{BIS} + 260000X_{HER} + 260000X_{TIS} + 260000X_{SHR} + 260000X_{TW} + 260000X_{DNM} + 260000X_{SHN} \leq 208000 \quad (12)$$

$$60000X_{SH} + 50000X_{BIS} + 70000X_{HER} + 55000X_{TIS} + 65000X_{SHR} + 52000X_{TW} + 60000X_{DNM} + 50000X_{SHN} \geq 462000 \quad (13)$$

$$X_{SH}, X_{BIS}, X_{HER}, X_{TIS}, X_{SHR}, X_{TW}, X_{DNM}, X_{SHN} \geq 0 \quad (14)$$

Where, equations (8), (9), (10), (11), (12), (13) describe the fabric cost, selling price, labor cost, machine cost, other cost and volume respectively that associate to the company to produce eight products. Equations (14) is the boundary constraint that illustrate the limit of the production amount of eight cloths. These constraints are for one cycle of production.

3.6 Sensitivity Analysis by Three Variables of Profit Optimization Program

Sensitivity analysis depicts the extent to which the optimal solution of the model is affected by the
changes in its input parameter values. Here, the sensitivity analysis for maximum profit is carried
out with respect to the changes in the values of the parameters of linear equation, SH, DNM, and SHN. The sensitivity analysis is performed by considering variation in each one of the above parameters by 5% change in stipulated standard value, keeping all other remaining parameters as fixed.

The formulated LPP has been solved using AMPL. The program consists of three parts: model file, data file and run file. After developing a model file, it must arrange a data file according to the model file. Both the model and related data file must be called in command file with proper codes. Then to obtain the output of the problem it must call command in AMPL. Then the solution can be found by run file using solver cplex.

Table 3.3: Sensitivity of 3 Parameters with Optimal Solution Per Cycle for LP Model

Changing parameters	5% change	Value of XSH	Optimal solution
XSH	+5%	2142000 2331000 328125 54285 273000 63000	3865030
	+10%	2249100 2447550 344531.25 36999.25 286650 66150	3842080
	+15%	2361555 2569927.5 361757.8125 59849.2125 300982.5 69457.5	3820220
	+20%	2479632.75 2698423.875 379845.703125 62841.673125 316031.625 72930.375	3799400
	+25%	2603614.3875 2833345.06875 398837.9882815 65983.75678125 331833.20625 76576.89375	3779580
	-5%	1938000 2109000 296875 49115 247000 57000	3915770
	-10%	1841100 2003550 282031.25 46659.25 234650 54150	3943800
	-15%	1749045 1903372.5 267929.6875 44326.2875 222917.5 51442.5	3973320

Changing parameters	5% change	Value of XSH	Optimal solution
	-20%	1661592.75 1808203.875 254533.203125 42109.973125 211771.625 48870.375	4004390
	-25%	1578513.1125 1717793.68125 241806.5429685 40004.47446875 201183.04375 46426.85625	4037090

Changing parameters	5% change	Value of XDNM	Optimal solution
XDNM	+5%	5040000 5670000 328125 54285 273000 63000	3792320
	+10%	5292000 5953500 344531.25 56999.25 286650 66150	3700120
	+15%	5556600 6251175 361757.8125 59849.2125 300982.5 69457.5	3639380
	+20%	5834430 6563733.75 379845.703125 62841.673125 316031.625 72930.375	3639380
	+25%	6126151.5 6891920.4375 398837.98828125 65983.75678125 331833.20625 76576.89375	3639380
	-5%	4560000 5130000 296875 49115 247000 57000	4035260

Changing parameters	5% change	Value of XDNM	Optimal solution
	-10%	4332000 4873500 282031.25 46659.25 234650 54150	4230280
	-15%	4115400 4629825 267929.6875 44326.2875 222917.5 51442.5	4435550
	-20%	3909630 4398333.75 254533.203125 42109.973125 211771.625 48870.375	4651640
	-25%	3714148.5 4178417.0625 241806.54296875 40004.47446875 201183.04375 46426.85625	4879090

Changing parameters	5% change	Value of XSHN	Optimal solution
XSHN	+5%	5775000 6562500 328125 54285 273000 52500	3850000
	+10%	6063750 6890625 344531.25 56999.25 286650 55125	3850000
	+15%	6366937.5 7235156.25 361757.8125 59849.2125 300982.5 57881.25	3850000
	+20%	6685284.375 7596914.0625 379845.703125 62841.673125 316031.625 60775.3125	3850000

Changing parameters	5% change	Value of XSHN	Optimal solution
	+25%	7019548.59375 7976759.765625 398837.98828125 65983.75678125 331833.20625 63814.078125	3850000
	-5%	5225000 5937500 296875 49115 247000 47500	3960180
	-10%	4963750 5640625 282031.25 46659.25 234650 45125	4034980
	-15%	4715562.5 5358593.75 267929.6875 44326.2875 222917.5 42868.75	4113700
	-20%	4479784.375 5090664.0625 254533.203125 42109.973125 211771.625 40725.3125	3856300
	-25%	4255795.15625 4836130.859375 241806.54296875 40004.47446875 201183.04375 38689.046875	4418060

3.7 Graphical Presentation for the Effects of Parameters on Profit Per Shift

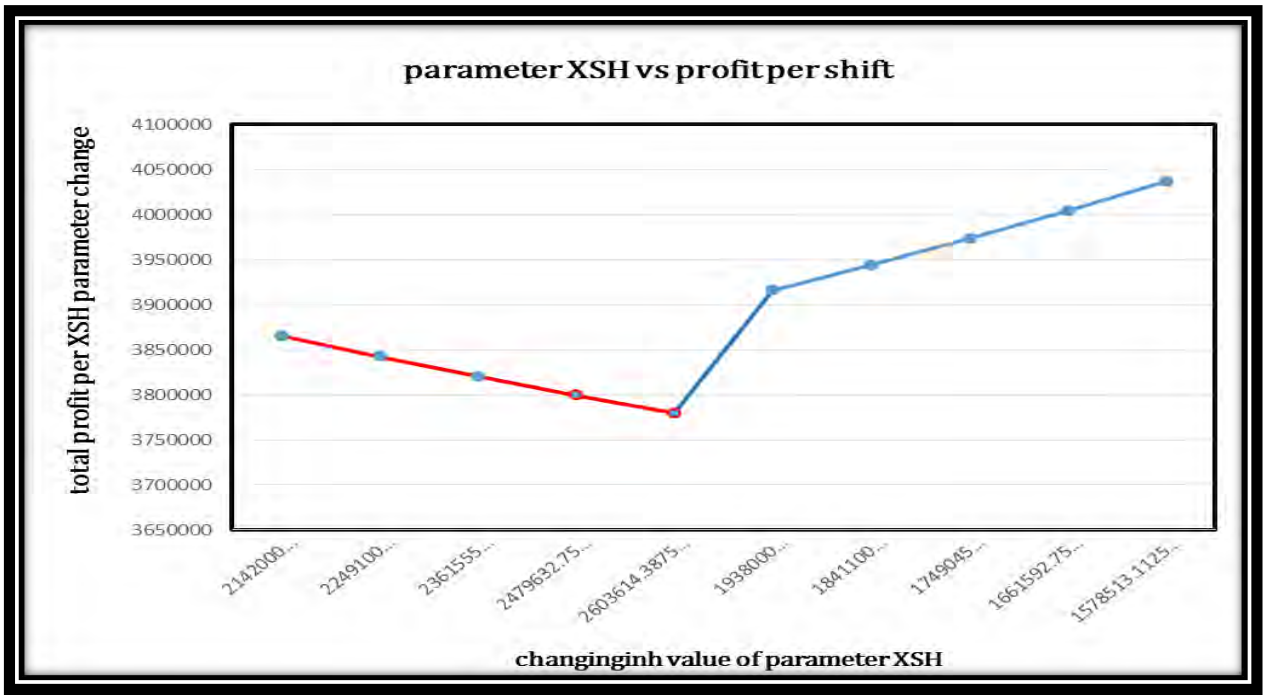

Figure3.1: Effect of Shiting Cost on Profit per Shift

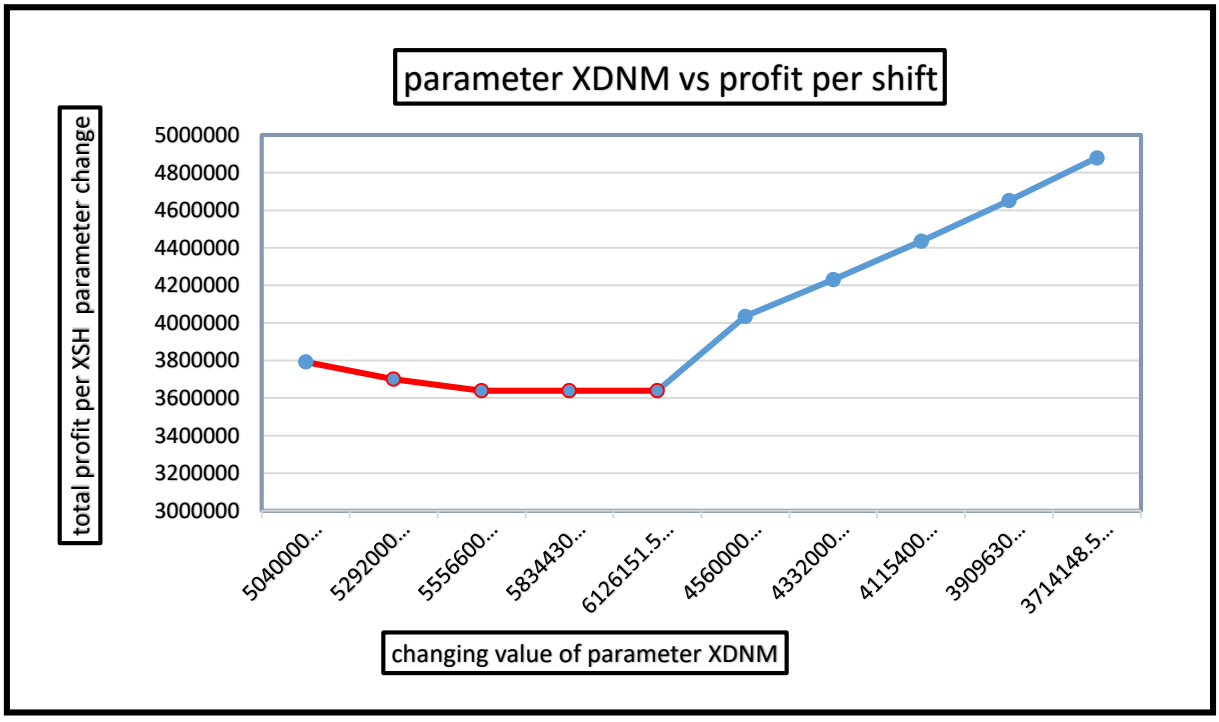

Figure3.2: Effect of Denim-D Cost on Profit per Shift.

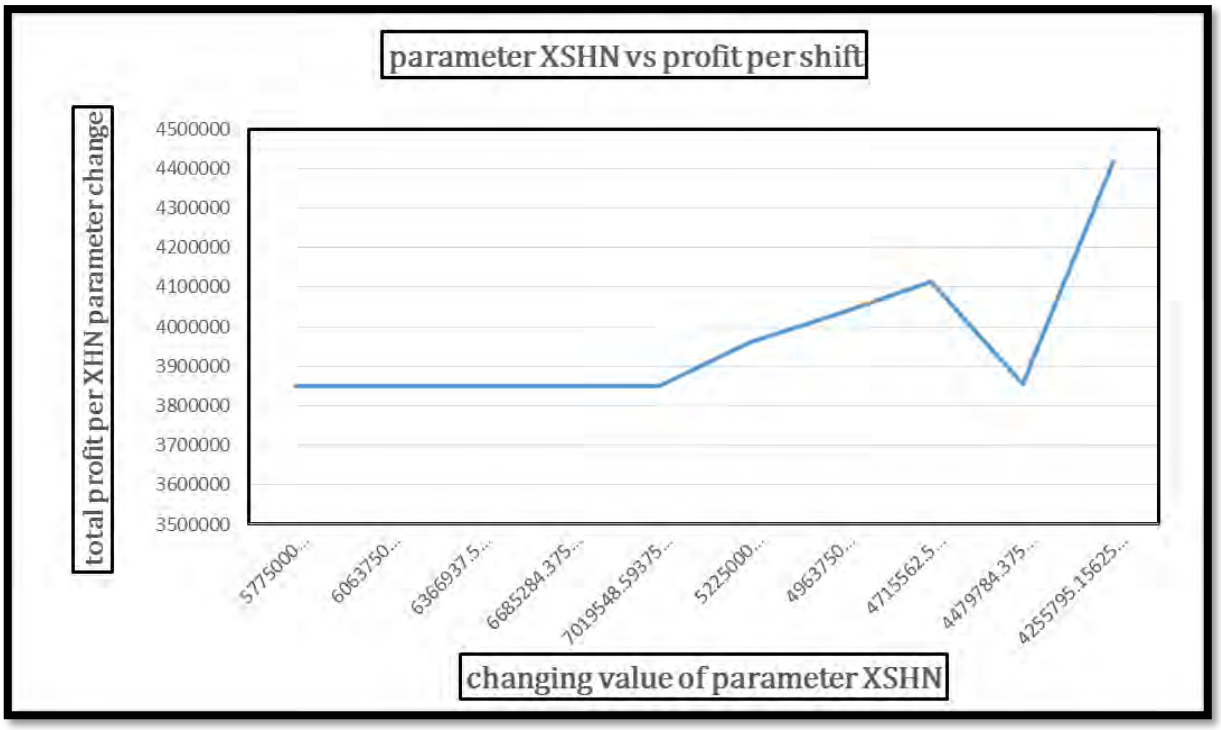

Figure3.3: Effect of Shirton Cost on Profit Per Shift.

In the graphs 3.1, 3.2 and 3.3 illustrate that all the cost parameters have significant effect on profit. They demonstrate that how profit changes if the cost parameters decrease. Further, if cost parameters decrease, then profit increase. Graph 3.2 shows that Denim –D cloth cost has significant influence on profit.

3.8 Conclusion

The profit optimization model has been upheld with the costs of Shiting, Denim-D and Shirton cloth per shift. This model can aid the manager in concisely determining the effect of profit per shift for variation of Shiting, Denim-D and Shirton cloth cost. It is evident that

- When the values of parameters of linear equation increase then the total profit per shift increase as well as when the values of parameters of linear equation decrease then the total profit per shift decrease.
- When the costs of Shiting, Denim-D and Shirton cloth increase then the total profit per shift decrease as well as when the costs of Shiting, Denim-D and Shirton cloth decrease then the total profit per shift increase.
- But it is observed that at some certain decreasing and increasing costs of Denim-D and Shirton, profit is fixed. Because there is no impact of some increasing and decreasing values of Denim-D and Shirton on the total profit per shift.

Chapter 4

Conclusion and Observation

4.1 Conclusion

In this dissertation, it is considered linear programming model to maximize the profit at level best in the textile industry. In this research, eight variables have selected for eight types of cloths to maximize the profit. This study can optimize profit of several types of cloths. This research used AMPL programming language to maximize profit mathematically using a standard Linear Programming model. Labor cost, machine cost and other cost have also been taken into consideration. Then using these data, a Linear Programming Model is formulated. In this Linear Programming Model, objective function is to maximize profit. Labor cost, machine cost and other cost are considered as subject to constraints. After that, the Linear Programming Model is solved by using AMPL, a mathematical programming language. Sensitivity analysis that helps the company to improve their business policy are carried out on cost parameters are increased by 5%, 10%, 15%, 20% and 25%. Then it is found that profits decreased. Again, cost parameters are decreased by same percentages. In this case, it is found that profits increase. Both cases have been shown graphically. It is known that labor cost is very low in this country. Machine cost is also very low here. But fabric cost is very high. If the fabric cost can be reduced, this sector will become more profitable. Out of eight types of cloths three types of cloths (Shiting, Denim-D, Shirton) are more profitable. So the company should emphasize on production of these three types of cloths.

Like this company, applying of mathematical programming can help the owners of business organization to take correct decisions. This can identify the future production patterns and outlook resulting in the establishment of new production units, while thinking for maximizing profit and minimizing the cost of the company.

4.2 Observation

Despite all the challenges that exist in Bangladesh the companies can still highly benefit from its sourcing offering. Together effort from three main stock holders like government, suppliers and buyers can work to overcome these various hurdles to success. Some observations are given below:

- **Zero rating on import and export of all textile machinery:** Government should impose zero rating on import and export of all textile machinery so that costing price of various products of textiles will decrease and profit will increase.

- **Tariff reduction:** The tariff of textiles products is so high at present. But if the government takes steps to reduce tariff then production of many textiles products will be high in quantity.
- **Incessant energy supply to textile units:** The machines of many textiles company run all day long to place order on time. Some company maintain double shift. So incessant energy supply is very necessary to Textiles Company.
- **Issues relating to the market access:** Budget should be formed market friendly of many textiles products and different issues relating to the market access should be

controlled by the government.

- **Quality products with delivery:** The textiles companies should ensure quality products with delivery to increase the regular flow of profit. Delivery products on door to door of buyers could be one step ahead to our economy.
- **Duty free market to US & EU:** The government should give concern to duty free market access to European Union and United States.
- **Image building of Bangladesh:** The country should try heart and soul to build a positive image of Bangladesh to attract Foreign Direct Investment (FDI) to invest money to our textiles production.
- **Focus on Value Addition:** The textile ministry should focus on value addition according to the increment of products
- **Technology Up-gradation and Capacity Building:** Day by day science and technology are updating. New innovation of technology should use in the textile company so that we can cope with the developed countries of the world. And one another important part is upgrading capacity of production house.
- **Improving Textile Production:** To gain lots of profit on textiles products we should take attempts to improve the quality of production.
- **Awareness of International Quality Standards:** We cannot ignore international quality standards to produce products and we should raise awareness to produce international quality products in our country.
- **Introducing concept of on-the- job-training:** For the betterment of working efficacy, the authority should arrange many training, workshops on different work based through the year.
- **Bonded warehouse facilities:** Each and every company should maintain bonded warehouse facilities to reduce space problems.
- **Closer monitoring of leakage in the market:** The government should keep monitoring of leakage in the market to reduce devastating loss of many textiles companies.
- **Appointment of advisory committee:** The authority should appoint an advisory committee to represent the industry to the government.

However, it was very obvious to me on one of my factory visits that affluent treatment and disposal in the industry is a very serious problem. The need for more power is mentioned, but no plans have been devised on how the expansion will be undertaken. The recommendations are badly needed for our country to alive our textile industry.

4.3 Future Work

Some ideas of future works are given below:

- Nonetheless, additional work may be needed to further completely estimate the influence as Education, Status, Income, Cost, Price, Transportation Facility and Security.

- More data such as dying, printing, packaging, finishing details etc. could be included in future work to extent this work with more realistic way. When we want to collect data the industry owners did not want to disclose their real data. So we will try to collect real data from different factories sothat we can work smoothly.

- In future we will apply mixed integer programming model.

- We can use this model in other industries in future.

- Therefore, more data is necessary to re-estimate the model's parameters. Future study can be done by collecting data from more industries to get better result. In future some other cost parameters such as transportation cost can be included.

- In this paper, there is no discussion on shadow price. In future, anyone can work on it.

- This study can be used anyone for developing his/ her thesis. Through using these study one can improve one's mill's profit.

- For better study, we will collect secondary data along with primary data and more examine in case of acquiring data.

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