Analyzing and modeling of supply chain performance in Bangladesh Ready Made Garments

By

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Certification

I certify that the thesis I submit which includes ideas, analyses, results and conclusions, for the award of MBA degree, is entirely my own efforts and have not been taken from others' work except those are acknowledged by maintaining proper reference method. I also declare that this is an original research with the help and guidance of my supervisor, Dr. Behrooz Asgari, and it has not been submitted to anywhere for any other degree or award.

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Abstract

Garment industry has been occupying as the largest source of exports and foreign currency as well as the second largest contributor to GDP (Gross Domestic Product) in Bangladesh for more than a decade. Millions of poor women and men are employed in this industry. Moreover, the quota system has been removed since 2005 in the USA. Thus the most important export earning sector has been struggling against some challenges which need to be properly addressed to continue Bangladesh's export and development of poor people's life. Besides quality and cost, the order winning criteria from buyers has shifted to decreased-lead time as the end consumers of apparel fashion market is continuously becoming time-sensitive. Our endeavor was to manage and exploit the opportunity that lies in an integrated supply chain which will provide competitive advantage to the Bangladesh garment factories. Firstly, a system dynamics approach has been used to identify the dominant variables of supply chain performance (such as enablers, performance or results, and inhibitors) in the ready-made garment (RMG) sector in Bangladesh. A survey and individual interviews were conducted with the senior management personnel, supply chain professionals, and merchandisers of the RMG industry. Based on the findings, a causal loop diagram is proposed to help understand the dynamic behavior among the said variables so that top management may take effective decisions in order to enhance the supply chain performance in the long run.

Secondly, a lead time management model has been proposed with the help of system dynamics under following background. The demand driven apparel industry is increasingly being marked by its players (brands, retailers and specialty stores)

competing for who can move faster their fashions to better respond to today's time sensitive customers. This competition of running against time has posed a great deal of challenges which are ultimately to be kept pace with by the apparel manufacturing firms. Therefore, time (lead time for garments delivery) has become a crucial performance parameter among apparel manufacturing economies around the world. China and India have a 55 and 65 day delivery time respectively while Bangladesh remains at a 90 to 120 day delivery time. To stay competitive in the global apparel market, Bangladesh needs to improve its lead time and research shows the opportunity is ample if it can achieve textile sufficiency from domestic production along with its inherent backward linkages. Thus, a system dynamics model has been developed to show how the domestic fabric production capacity can reduce lead time and enhance the backward supply chain strength for the Bangladesh ready-made-garment industry.

Keywords: Bangladesh, Causal loop diagram, Lead time, Ready-made garment industry, Integrated supply chain, System dynamics analysis, system dynamics model, Bangladesh garments, lead time management, domestic fabric production.

Chapter one: Introduction

1.1 Statement of the problem

The export of ready-made garments (RMG) from Bangladesh has been increasing so rapidly for the last two decades that it has come to occupy the lion's share of its total exports. Bangladesh started exporting RMG at an annual value of about US$32 million in 1983-84 but experienced a continuous massive growth which resulted in an almost US$18,000 million of export value of RMG in 2011-12 (Export Promotion Bureau, Bangladesh, 2012). Once heavily dependent on exporting jute products, the economy of Bangladesh is now experiencing more than three fourths of its export contributions from the RMG sector alone. In Bangladesh, the export value of RMG out of total exports was almost 76% in 2008 and 79% in 2012 (Export Promotion Bureau, Bangladesh, 2012). This newly born industry has become immensely significant in the economy of Bangladesh due to its high contributions to the total export value, Gross Domestic Product (GDP) and job creation, especially for women, as well as helping the backward-forward supply chain industries to grow.

Among developing economies such as Cambodia, Sri-Lanka, China, etc, Bangladesh has achieved a strong position as one of the global suppliers of RMG, mainly due to having one of the cheapest labor costs among the apparel manufacturing countries. The globalization of industries created pressure for location-based manufacturing economies which were also supported by the US and European Union (EU) import policies. The 'multi-fiber arrangement' (MFA), a quota system imposed by the US federal government forced US importers to source from less developed countries with the aim

of fostering their manufacturing ability and supporting the growth of the apparel industry in countries from South Asia, China and other developing nations. After the MFA system became defunct in 2005, Bangladesh started to counter more rivalry, both anticipated and unanticipated, from many producers and suppliers because it turned into an open market for all. Now, the RMG industry of Bangladesh is struggling with many global competitors in terms of cost, quality, customer service, and lead time.

In recent years many reputable organizations are purchasing products, and sourcing, distributing and selling simultaneously from different corners of the world. This globalization of operations has become inevitable because cheap labor is available in some countries while raw material is readily available in others. Moreover, the time, cost and quality sensitiveness are also significantly varied among customers in different regions of the world. Through an efficient implementation of integrated supply chain management, the RMG industry in Bangladesh could stay competitive by maintaining the required efficiency and responsiveness. This was the traditional view of all companies that they existed as single and complete units and operated their businesses separately.

However, the business environment has changed in the 21st century such that working alone is less competitive while collaborative working among upward and downward supply chain partners is more profitable. Through managing the supply chain, the ultimate objective of companies is offering maximum value to customers of the delivered products or services by achieving either responsiveness or efficiency. To add dynamic capability to the RMG sector and enhance supply chain performance,

manufacturers should plan and work collaboratively with the upward suppliers of fabric and accessories as well as the downward buyers and partners in the supply chain.

Scott and Westbrook (1991) and New and Payne (1995) describe the supply chain as "the chain linking each element of the manufacturing and supply processes from raw materials to the end user, encompassing several organizational boundaries". According to this broad definition, supply chain management (SCM) "encompasses the entire value chain and addresses materials and supply management from the extraction of raw materials to its end of useful life". Farley explains (1997) that SCM "focuses on how firms utilize their suppliers'' processes, technology, and capability to enhance competitive advantage".

Houlihan (1987, 1988) defined SCM as the technique of combining various key departments such as production, finance, marketing and human resource of a company so that this unified chain links tier-one suppliers and distributors to enhance performance by reaching the final customers on time. There is already some scholarly work that shows focal companies can utilize the vendors' manufacturing expertise and other R&D assets to design new products at lower costs through collaboration among trading partners.

Some of the key characteristics of the fashion industry are that the life cycle of any new styles of apparels is continuously decreasing, end demand for any garments is highly fluctuating and changing over time, various kinds of designs and styles are evolving everyday worldwide, and the total chain from yarn and cotton supplies to final garments

through a lot of suppliers from many countries is very dynamic and difficult to manage (Sen, 2008). So, apparel manufacturing companies of any country should manage the supply chain in a way that meets the total needs of the end consumers (Gunasekaran *et al.*, 2008). This has caused the fashion industry to become increasingly complex and dynamic, and this sector has attracted many new market entrants and thus has triggered intense competitions (Gunasekaran *et al.*, 2008).

The business of the fashion industry is so volatile and competitive that the driver for successful entrepreneurship is capitalizing on opportunities and scopes by integrated efforts among supply chain partners (Sen, 2008); apparel manufacturers and traders are engaging themselves to utilize integrated supply chain management as a source for improving their business performance (Gunasekaran *et al.*, 2008). Lam and Postle (2006) found in their study that supply chain management consciousness was still comparatively low among the apparel manufacturers and traders in Hong Kong. Lee and Kincade (2003) mentioned some of the key dimensions they found in the US apparel supply chain including "partnership, information technology, operational flexibility, performance measurement, commitment of top management and demand characterization".

The current RMG manufacturers of Bangladesh are importing most of the required woven fabrics from China, India, Pakistan and Indonesia. As a result, the total lead time is becoming longer, putting a negative edge on competitiveness. It is possible to reduce the total lead time through supply chain integration among upstream and downstream partners to make RMG manufacturers more competitive (Nuruzzaman and Haque,

2009). Supply chain integration makes it possible to manufacture fabrics before taking orders from buyers but requires more collaboration among buyers, fabric suppliers and garment manufacturers in Bangladesh.

Nuruzzaman *et al.* (2010) realized that a long lead time was one of the greatest problems of the RMG sector in Bangladesh and that its top five causes constituted the issues of integrated supply chain management (SCM). They emphasize that SCM is basically a complex process for countries, and a new in the apparel sector especially in the least developed countries like Bangladesh. Nuruzzaman *et al.* (2010) concluded that a country like Bangladesh may create a remarkable position in the world's total apparel export by managing the partners of the supply chain to reduce the lead time.

However, there are only a few in-depth studies about SCM for the RMG sector in Bangladesh and no study offers indications on how factories can increase productivity, reduce costs, and respond to changing customer needs using effective and efficient integration among supply chain partners.

1.2 Research Objectives

The primary purpose of the study is to identify the interdependence and dynamic behavior that exists among supply chain performance variables. This study identifies the performance variables through literature review and expert opinion. In addition to the above, it also finds the impact of domestic fabric supply, which is the main raw material, on lead time management and modeling it with the help of system dynamics.

1.3 Research Questions

1. How the supply chain performance variables are inter-related for Bangladesh RMG industry?
2. What's the next competitive factor for the continuous growth of Bangladesh RMG export and how can it (especially lead time) be managed in Bangladesh's favor?

1.4 significance of the research

This research endeavor will definitely help to maximize the scope of attaining optimum solutions in the supply chain since it will show the interdependence among variables and the dynamic behavior of the variables. A Causal Loop Diagram (CLD) is drawn and it shows a complete or an apt picture of how the whole supply chain variables are interlinked and how they can be affected by other variables. A department (in micro level) may obtain its optimum objectives even if sub-optimum solutions are taken by other departments or for the whole supply chain. Similarly, other country apparel industries (in macro-level) with similar socio-economic infrastructure such as India, Nepal, Cambodia and even China can get benefit from this study.

This study provides some important implications for government policymakers especially about how to accelerate the backward supply chain strength of RMG sector by producing more and more fabrics inside Bangladesh.

Chapter Two: Research Methodology

2.1 Research Design

The research methods, consisting of plans and procedures for organizing the study and collecting data and their analysis, are very important and vary varying with the nature of research. Creswell (p.1, 2009) has described three types of advanced research methods: 1) qualitative, 2) quantitative and 3) combination of both the qualitative and the quantitative methods. We have carried out this research in the framework of mixed method or combination of both quantitative and qualitative methods. As such, we included both close-ended and open-ended questions for the two surveys to capture mixed method for this research.

According to Creswell (p. 14, 2009), this research can be termed as "concurrent mixed method" since we collected both qualitative and quantitative data simultaneously and then merged to compare and analyze them. Thus, the method helped us to explain the outcomes of surveys and quantitative data complemented to qualitative method.

2.2 Questionnaires' Design

We put the utmost importance to the design of a good, deliberate and purposeful questionnaire since it is the key input to our research procedure and its output. We achieved the necessary knowledge through literature review and we identified the problems mainly from two sources of inputs. The first one is a literature review and the second one is the informal discussion with some experts in the RMG field of Bangladesh. All the apprehended questions were included in the questionnaires. As a result, the first survey questionnaire was a 10-page-long and the second was

2-page-long.

There are basically two types of questions for survey research (Zikmund, 2007). We asked mainly close-ended questions and we also included very few open ended questions on green supply chain management. Since green supply chain management is comparatively a new concept in Bangladesh RMG, we opted for few open-ended questions. We used open-ended questions to explore this new concept in the proposed industry and Zimund (p. 355, 2007) also suggested this type of questioning for an exploratory concept/research. All other supply chain concepts are more or less familiar in Bangladesh RMG but many of them not so practiced in a formal manner. That's why we used close-ended questions for this purpose.

Thomas (2004) suggested that there are some common mistakes in designing the questionnaire and those mistakes lead to wrong output of the research. Thomas (2004) termed those problems as "language, question phrasing, question length, question order and response format" errors. To avoid those mistakes, we used very simple, careful and understandable wording and we tried our best to avoid "jargon" words such green supply chain management, process integration and market sensitivity etc. Rather we broke up the jargon and terminology into some components so that we could bring out the response from respondents' mind but they did not feel bored or pressure on them while feeling the questionnaires. Thus, they didn't think that they were answering a difficult term or question. To maintain a friendly order, we poised easy and basic questions in the beginning of each section then slowly and smoothly into a deeper level. We also took care to avoid "leading", "ambiguous" and "double-barreled" questions by

following guidelines from Zikmund (pp. 359-364, 2007).

2.3 Sample and Respondents

Babbie (pp.188-200, 2005) and Thomas (pp.105-108, 2004) have discussed about two types of sampling methods. These are called probability and non-probability sampling. We had to opt for non-probabilistic and purposive or judgmental sampling because our first questionnaire for survey was 10-page-long, the concept of supply chain management is comparatively new in Bangladesh RMG, and it requires a total knowledge of the whole supply chain of the company to answer the questions asked in the questionnaire. It also requires higher education and senior position inside the company to properly answer the questions in our survey. As a result, we contacted with managing director, general manager, head of the department and industrial engineers to conduct the survey. Moreover, we choose only one respondent from each firm since the "firm" was decided as the unit of the sample in this research. Thus, our total surveyed respondents are twenty one (21) for the overall supply chain management in the apparel industry in Bangladesh through our first survey.

However, we conducted a second survey for lead time since lead time reduction has been raised as a burning issue by the respondents in the first survey. For the second survey, the questionnaire was 2-page-long and it was limited to lead time management issues. Though the questionnaire was short and simple but it requires top management personnel to answer the questions. We purposely selected only one merchandiser from each factory. This time, the number of respondents was a bit higher than the first survey. The number of surveyed respondents was more than 30 for the second set of

questionnaire.

Since the respondents were at least either graduated with a degree in industrial engineering or in other subjects, or head of the departments or managing director or merchandisers; we assume that the gathered data through two sets of questionnaires and two phases of surveys are true and reliable to represent the practicing scenario of supply chain management in RMG industry.

2.4 Data Collection

This research deals with two types of data, namely, quantitative and qualitative. Quantitative data are expressed in numbers and qualitative data is expressed in discrete categories. Qualitative data were collected through two ways. The first way is literature review which was collected through studying published articles in the national and international journals, working papers and books. Secondly, the qualitative data were collected through the questionnaire surveys too. Both the sources of qualitative data were effective to develop the proposed system dynamics frameworks and modeling for supply chain management.

Thomas (pp.116-123, 2004) explained different methods of conducting surveys such as interview, mail, telephone and internet with comparative advantages and disadvantages of each method. Both email and telephone interview were used to conduct the surveys and collect data for this research. Thomas (2004) also explained that email and telephone interview have an advantage of medium to high level of quality response with low cost. The majority of our surveys was conducted through emails. Some were

conducted through a phone interview for the people who are very busy but they were treated as experts in the RMG sector because of having long time experience.

Most quantitative data in this research are secondary data although some are, collected through surveys, primary data. Quantitative data were mainly collected from the World Data Bank, BGMEA, BKMEA, Ministry of Industry and Commerce of Bangladesh; Bangladesh Statistics Bureau, World Bank and International Monetary Fund. Quantitative data were helpful to explain some parts of the developed model for supply chain.

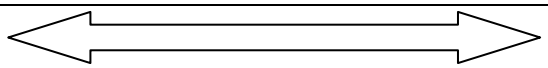
2.5 Measurement of the Questions

Measurement refers to assigning some numbers reliably against the attributes of concepts that we consider important for the research (Zikmund, p.310, 2004). Measurement process in the questionnaire is very important to get a reliable and valid research output. Zikmund (p.319, 2004) identified four levels of scales for measuring questions in the questionnaire. These levels are nominal, ordinal, interval, and ratio scales.

This research uses some dichotomous questions which have only two options of answers such as "yes/no". This type of question uses nominal and discrete scale and they are leveled with "1" for "yes" and "2" for "no" answers. For example, this research uses, do you have a supply chain department? Or does your company have few strategically buyers? Answers for these questions are either "yes" or "no" and they are measured using 1 or 2. This research uses many multiple choice questions which are

called as “closed format” questions. For example “how many times you can ship out within initial lead time?” The answer options include a. 70-80% b. 81-85% c. 86-90% d. 91-95% e. 96-100%. The numerical number 1 to 5 is assigned to codify and analyze the answers after we collected data from respondents. Our research uses a lot of importance-type questions using ordinal scale. Almost every section had importance type questions to identify important elements of different performance variables of supply chain management. We used five (5) steps to level the importance for any factor ranging from “not important” to “most important” which is shown as below.

Table 2. 1: importance level of questions

Not Important  most Important				
1	2	3	4	5
Not Important	Somewhat Important	Important	Very Important	Most Important

We also used some open ended questions for green supply chain management. Since the answers varied from respondent to respondent, we have written them in a descriptive format.

2.7 Research Instruments

This research employs system dynamics with the help of Vensim software to evaluate the performance variables of supply chain management in apparel industry in Bangladesh. Furthermore, this study also employs Microsoft excel software to analyze data gathered through two surveys.

Chapter Three

Supply chain performance and system dynamics modeling: A literature review

3.1 Introduction

As soon as the concept of supply chain management evolved as a management tool that can increase competiveness and ameliorate business performance, simultaneously the concept and efforts of measuring supply chain performance came into existence. There is a saying that "if you cannot measure what you do, you cannot control and improve it" which is very much applicable to supply chain performances. Many scholars used different attributes and metrics to measure the effectiveness of supply chain. Some argued for financial indicators and others argued for non-financial indicators as the performance measurement of supply chain. Although there is no consensus on performance measuring parameters or indicators in all industries or any single industry to date, a number of researchers have shown common measures that are used in particular sectors and others (Tan, 2002) have shown cross-industry performances that they have experienced in practice.

The reasons of not having a uniform and common measurement practices are mainly the breadth and complex relations that lie among the partners in a multi-tier supply chain. Measuring the performances of a single business organization becomes comparatively easier. However, measuring and establishing standard practices becomes very complex and difficult when it encompasses all the partners resting in the upward and downward multi-tiered relation in a supply chain (Khare *et al.,* 2012). Although, it is problematic

and there are no 100% common SC performance measurement practices, researchers took initiatives and wrote scholarly articles on this issue and some (Chan *et al.*, 2003) argued that measurements of business activities have to be incorporated in the supply chain to improve the performance of business. Scholars and academicians have published their works on SC performance measurement and some of the most cited are briefly explained in the following section.

3.2 Framework proposed by Gunasekaran *et el.* (2004)

Gunasekaran *et al.* (2004) introduced three levels to measure and implement performances of supply chains. These measures are in strategic, operational and tactical levels. All these levels have different priority functions and policies as well as they require different levels of managerial involvements. This approach is basically placing emphasis "on measurement systems and approaches as opposed to specific measures" (Gunasekaran *et al.* 2004).

Strategic level: This level deals with the measurements that are basically involved in manipulating the decisions taken by the top management including "broad based policies, corporate financial plans, competitiveness and level of adherence to organizational goals" (Gunasekaran *et al.* 2004).

Tactical level: Similarly, tactical level involves the processes of monitoring how efficiently the resources are allocated, how closely the performances are achieving as compared to those were set in strategic level, how the feedback from mid-level management are influencing in decisions that are being taken (Gunasekaran *et al.* 2004).

Operational Level: Operational level is involved in the processes where analysis of routine operations are carried out, evaluation of decisions are done which are carried out by the junior managers and where shop-floor workers and supervisors prepare their daily operational objectives (Gunasekaran *et al.* 2004).

Gunasekaran *et al.* (2004) further developed a set of metrics that will enable us to determine and compare SC performance and explained the metrics in detail (see table 3.1).

Table 3. 1: Metrics to measure performances

Supply chain performance metrics framework			
Supply chain activity/process	Strategic	Tactical	operational
Plan	Level of customer perceived value of product	Customer query time	Order entry method
	Variances against budget	Product development cycle time	Human resource productivity
	Order lead time	Accuracy of forecasting techniques	
	Information processing cost	Planning process cycle time	
	Net profit Vs productivity ratio	Order entry methods	
	Total cycle time	Human resource productivity	
	Total cash flow time		
	Product development cycle time		
Source		Supplier delivery performance	Efficiency of purchase order cycle time
		Supplier lead time against industry norm	Supplier pricing against market
		Supplier pricing against market	
		Efficiency of purchase order cycle time	
		Efficiency of cash flow method	
		Supplier booking procedure	
Make/ Assemble	Range of product and services	Percentage of defects	Percentage of defects
		Cost per operation hour	Cost per operation hour
		Capacity utilization	Human resource productivity index
		Utilization of economic order quantity	

Deliver	Flexibility of service system to meet customer needs	Flexibility of service system to meet customer needs	Quality of delivered goods
	Effectiveness of enterprise distribution planning schedule	Effectiveness of enterprise distribution planning schedule	On time delivery of goods
		Effectiveness of delivery invoice methods	Effectiveness of delivery invoice methods
		Percentage of finished goods in transit	Number of faultless delivery notes
		Delivery reliability performance	Percentage of urgent deliveries
			Information richness in carrying out delivery
			Delivery reliability performance

(Source: Gunasekaran et al., 2004)

3.3 Framework proposed by Chan (2003)

Chan (2003) proposed the analytic hierarchy process (AHP) of SC performance management framework with the combination of both qualitative and quantitative metrics. Before proposing the structure, he mentioned that existing performance management systems (PMSs) have at least two major weaknesses and he tried to solve the shortcomings of the existing PMSs in his proposed AHP based method. These two existing shortcomings are:

- Lack of combination of both the financial and the non-financial measurement approaches, which are also named as balanced approach, are not considered in most PMSs.
- The second most visible shortcoming according to Chan's (2003) opinion that present PMSs do not consider the supply chain from the system's point of view and do not encompass all the upward and downward partners in every single tier of relationships in the chain.

So, Chan (2003) included two variables from quantitative perspective such as cost and

resource utilization. Then, he also included other five (5) measures from qualitative aspects. These qualitative measures are quality, flexibility, visibility, trust, innovativeness. Chan (2003) acknowledged the difficulty of measuring qualitative variables whereas quantitative variables like cost and resource utilization are comparatively easier to express in number. Finally, Chan (2003) proposed two levels of sub-criteria for each measurement parameters to express in some quantifiable number or ratios. For example, "trust" has four components in sub-criteria level 1 which are input, process, output and improvement.

And every of those have further components in sub-criteria level 2. For example, input has sub components of "labor" and "machine", process has "material handling", "routing" and "operation"; output has "volume", "mix" and "delivery"; and improvement has "modification", "new product" and "expansion" Chan (2003). Then, Chan (2003) further mentioned measurement criteria for every sub-criteria level 2. Thus, total 32 sub-criteria were suggested to measure SC performance in his proposed framework. Then AHP software can rank among the variables depending on the industry and importance of SC performances for that industry as well as can provide up-to-date ranking of performance by changing priority and variation.

3.4 Framework proposed by Beamon (1999)

Beamon (1999) first explained an overview of supply chain performance measures that were widely practiced and referred during 1990 to 1996. The common SC performance measures were cost minimization and sometimes a combined measurement of cost and responsiveness to customer demand. This insufficiency led Beamon (1999) commenting

that those performance measures were not complete and appropriate because some qualitative dimensions such as “customer satisfaction”, “exchange of information” and “management of risk” were not yet incorporated in the SC performance systems and SC modeling up to 1999. After reviewing the shortcomings of the existing performance measurement systems, Beamon (1999) proposed a new framework that includes strategic goals of the company and intra-organizational relations and actions among supply chain partners.

The proposed supply chain measurement system consists of components that are aligned with strategic goals of a supply chain. These are measurements of resources, output and flexibility. These three measures help to attain desired efficiency, better customer service and satisfaction, and able to respond to changed environments in the market. Measures are inter-related and they consist of individual performance measures.

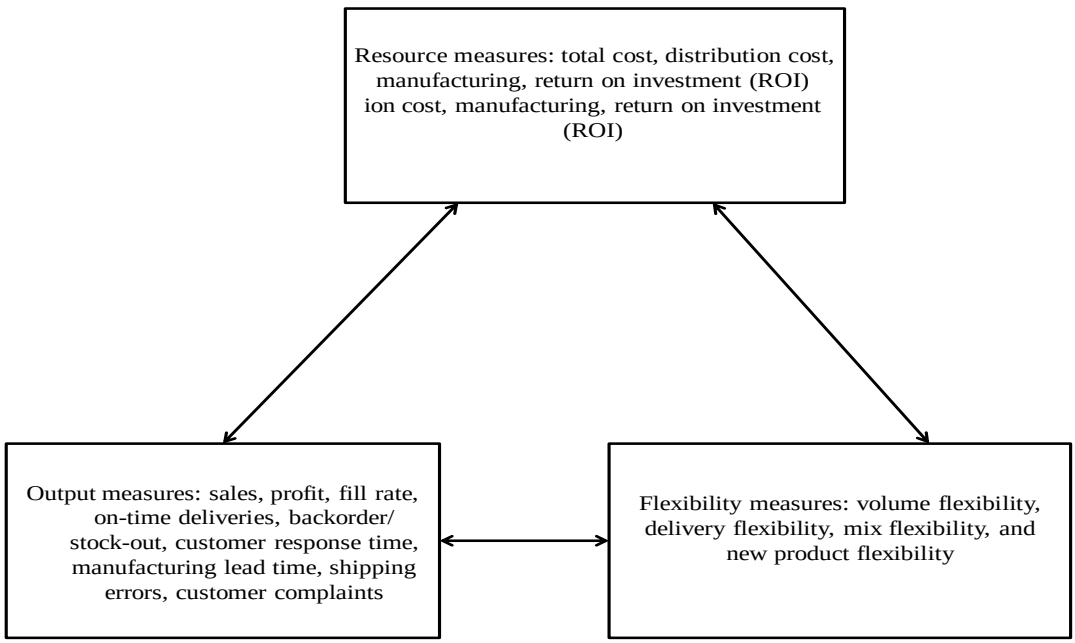


Figure 3. 1: System of measuring supply chain performance

(source: Beamon, 1999)

As the system is illustrated in the figure 1; measures of resources include costs of resources that are used in the supply chain are "distribution costs including transportation and handling, manufacturing costs including labor, maintenance, re-work; inventory costs of materials, obsolescence, work-in-process, finished goods" (Beamon, 1999). Measures of output include customer responsiveness as well as quality and quantity of products that are produced within a supply chain. Total revenues, the percent of requested orders that are filled, on-time deliveries, stock-out probability, etc., are considered as measures of output in the model. Flexibility pertains how the supply chain is capable of maintained if the volume of final products is changed, planned delivery is fluctuated, product mix is changed and new product introduction and modification of existing products are needed.

3.5 Framework proposed by Felix *et al.* (2003)

According Felix et al. (2003), they have proposed an innovative PMS that overcomes the shortcomings of existing systems including the systems proposed by Beamon (1999) and Gunasekaran *et el.* (2004). Supply chain (SC) performance is divided into qualitative and quantitative categories where "customer satisfaction, flexibility, information and material flow information, effective risk management and supplier performance" (Felix *et al.*, 2003) are categorized as qualitative performance measures. However, "cost minimization, sales, profit, investment on inventory, return on investment, fill-rate, customer response time, lead time and capacity utilization" (Felix *et al.*, 2003) are categorized as quantitative SC performances because these metrics can somehow be expressed in numbers. Felix *et al.* (2003) also developed a fuzzy set model

to measure SC performances of any complex supply chains. This system is termed as an innovative system (Felix et al, 2003). The system does not only look into a company or some parts of the supply chain but it also considers performances of the whole supply chain network starting from the suppliers of supplier up to the end customer. Thus it is also called a system-thinking approach. First, appropriate performance measures are selected from each process and then, a "performance measurement team (PMT)" (Felix *et al.*, 2003) is formed to measure and evaluate the metrics. Finally, weighted average score is given and index for every measure is calculated using a fuzzy set algorithm. As a result, it is called both a system-thinking and a process-based approach to PMS.

3.6 Framework proposed by Theeranuphattana *et el.* (2012)

Theeranuphattana *et el.* (2012) developed a new model to overcome the shortcomings of existing good models (Chan and Qi, 2009; Felix *et al.,* 2003) which are complex because they use fuzzy set models. This new model employs the level 1 of SCOR model and evaluates SC performances using the three approaches which are Multi-attribute Value Theory (MAVT), Swing Weight, and Eigenvector method. The proposed model is advantageous because it can convert the preference of managers to a 5-point or a 7-point likert scale into numerical scores. Finally, all SC performance measures can be expressed into a single index through integration process. Thus this model is very helpful and easier than other methods that use fuzzy sets and complex algorithms.

A set of metrics of numerous performance variables from SCOR model consisting of "Perfect Order Fulfillment (POF), Order Fulfillment Cycle Time (OFCT), Upside Supply Chain Flexibility (USCF), Upside Supply Chain Adaptability (USCA),

Downside Supply Chain Adaptability (DSCA), Supply Chain Management Cost (SCMC), Cost of Goods Sold (COGS), Cash-to-Cash Cycle Time (C2C), Return on Supply Chain Fixed Assets (ROSCFA), Return on Working Capital (ROWC)" (Theeranuphattana *et el.,* 2012) included in the model. The major drawback of this method is that it does not include parameters such as "customer satisfaction, trust, information flow" (Felix *et al.,* 2003) which are also important in a supply chain rather it mostly deals with cost and financial measurements.

3.7 Supply chain operations reference (SCOR) model

SCOR is one of the few approaches that deal with the designing of strategic issues in a supply chain (Huang *at el.,* 2004). The schematic diagram (see figure 3.2) of SCOR model shows that it encompasses the five management processes plan, source, make, deliver, and return.

Figure 3. 2: Supply chain model proposed by SCOR
(source: www.supply-chain.org, 2013)

SCOR has integrated three major processes that are process redesign or business process re-engineering (BPR), bench marking and determining best practices in an industry. As the figure 3.2 shows, SCOR model considers all phases of a supplier's

supplier to a customer's customer. Thus, it is an integrated approach. SCOR uses five attributes that are reliability, responsibility, agility, cost and assets to set measurement metrics for any supply chain. Then SCOR sub-divides the metrics into three levels. Level 1 metrics are usually called key performance indicators (KPI) of the supply chain and these KPIs basically help to determine strategic objectives of an organization. Level 2 is a diagnostic of level 1 to identify causes of poor performances. Similarly, level 3 helps to diagnose and identify poor performances of level 2 metrics.

3.8 What is System Dynamics

System Dynamics is evolved mainly from industrial dynamics that was first written by Jay W. Forrester in 1961. Forrester (Industrial Dynamics, 1961: 13) explained industrial dynamics as a complex system of inter-dependent industrial organizations; this interdependence changes over time as information feed-back changes and is thus called a dynamic system. Sterman (2000) used industrial dynamics for analyzing business systems depending upon changing information and time. Thus system dynamics is very useful to craft future policies for running businesses in a complex environment as time changes. In addition to tangible factors, it can also be used to model intangible factors that are not easily measureable such as human behavior, customer satisfaction, and employee skills. Simulation of intangible factors is sometimes called strategic simulation because it does not actually quantify the exact numerical value but shows a pattern of the likely outcome for intangible factors when they are acting in various feedback loops with inter-relations, change over time, or demonstrate a dynamic behavior.

There are two structural ways to analyze any dynamic systems: ‘causal loop diagram’ (CLD) and ‘stock and flow diagram’. CLD diagrams can be used to show the governing inter-relations among a number of different variables using feedback loops. A positive feedback loop means the dependent variable moves in the same direction as that of the independent variable; as such, the polarities are assigned as a plus (+) sign on the arrowhead of feedback loops. In the case of negative feedback loops, if the independent variable increases, the dependent variable decreases and vice versa. Thus a minus (–) sign is assigned to the arrowhead of the feedback loop.

The other structure of system dynamics is a stock and flow diagram that is used to explain both variables, i.e. the stocks and flows. Stocks refer to the status of variables at a point/moment of time while flows exist during a period of time. Stocks are accumulated over time through inflows and outflows. Apart from stock and flow variables, another kind of variable called an ‘auxiliary variable’ has been used here. Auxiliary variables are used to connect stocks and flows to each other as well as to themselves. By using all these three kinds of variables, we can explain dynamic systems more appropriately. Many researchers and authors have used stock and flow diagrams to model and describe supply chain performance variables (Agarwal and Shankar 2005; Campuzano and Mula 2011).

3.9 Model proposed by Forrester (1961)

The first supply chain modeling based on system dynamics was proposed by Forrester in 1958 and then, he expanded the basic model in 1961 in his book “industrial dynamics”. Thus system dynamics is originated from industrial dynamics in 1958. The

"Forrester-Model" interacts with the flows of materials, orders, money, personnel, capital equipment, and information. The model included supply chain partners in a four-tier relationship consisting of factory, warehouse, distributor and retailer. Thus, Forrester's model was clearly a step toward introducing integrated supply chain since it included stages from suppliers to customers.

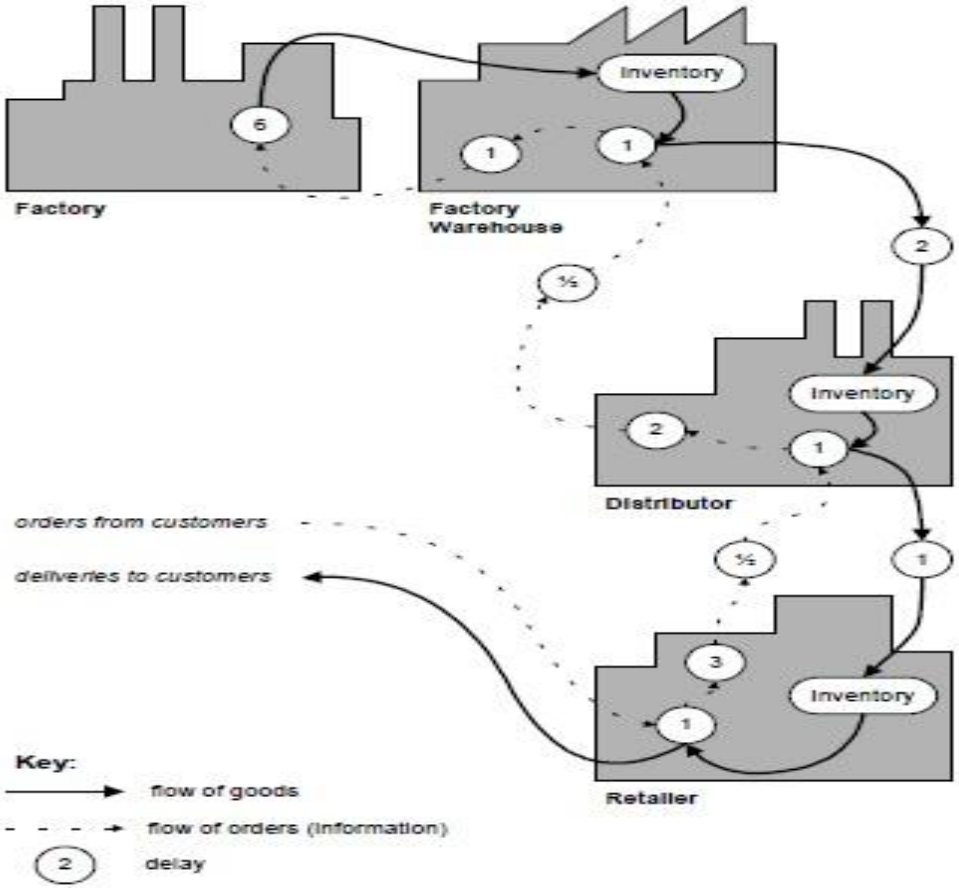


Figure 3. 3: The Forrester production-distribution system
(Source: Forrester, 1961)

Then, Forrester (1961) carried out simulations using Dynamo assuming different policy implications. Of the analyses carried out by Forrester, the bullwhip effect or demand amplification, delay in decision making, inventory fluctuations, centralized and decentralized controls, and information flow were considered as focal points to simulate

forecasted future scenarios that are still the most confronted issues in modern and international supply chains. Forrester (1961) also identified and prescribed some basic rules of system dynamics ranges from problem identification to model building which are also valid till date.

3.10 Model proposed by Barlas and Aksogan (1999)

This is one of the very few system dynamics models that deal with the apparel industry. The model basically developed various inventory policies to reduce costs for retailers and distributors in the apparel business. Barlas and Aksogan (1999) included four levels of the tiered relationship: "manufacturer, wholesaler, retailer and end customer" in their model which is similar to the model proposed by Forrester (1961) except that supplier is excluded. They (Barlas and Aksogan, 1999) actually developed a simulation model by using system dynamics so that the model can suggest reducing costs and maximizing retailers' sales volume of apparel goods. The second objective of the model was to test different policies that could be adopted to forecast the scenarios.

A stock and flow diagram was made for the model and, then, many simulations were run under changing conditions such as different order policies, market demands or fluctuations, various inventory positions. After running numerous simulations, they found a new result from the model and that the same order policies cannot be effective both in continuous and discrete/periodic inventory management systems. Finally, Barlas and Aksogan (1999) proposed new ordering policies for apparel retailers which is a "partially continuous and partially discrete inventory system".

3.11 Model proposed by Towill (1996)

In the paper, Towill did not build a model specific for supply chain management rather he had discussed different methodologies and ways to build system dynamics models to re-design and re-engineer of supply chains. The paper concluded with the comment that "best results are most likely to be obtained by adopting a holistic approach in which the basic disciplines of industrial engineering and business process re-engineering are integrated into a comprehensive methodology which starts with modeling a real-world situation and outputs an updated supply chain with enhanced competitive performance" (Towill, 1996). Towill presented an input-output framework for building SD models that are primarily based on the Cardiff Industrial Systems Dynamics Group Re-engineering Methodology. This methodology was successfully implemented for planning and implementing supply chains. Towill (1996) suggested that the knowledge of four inputs (see figure 3.4) is necessary to build effective models for supply chains.

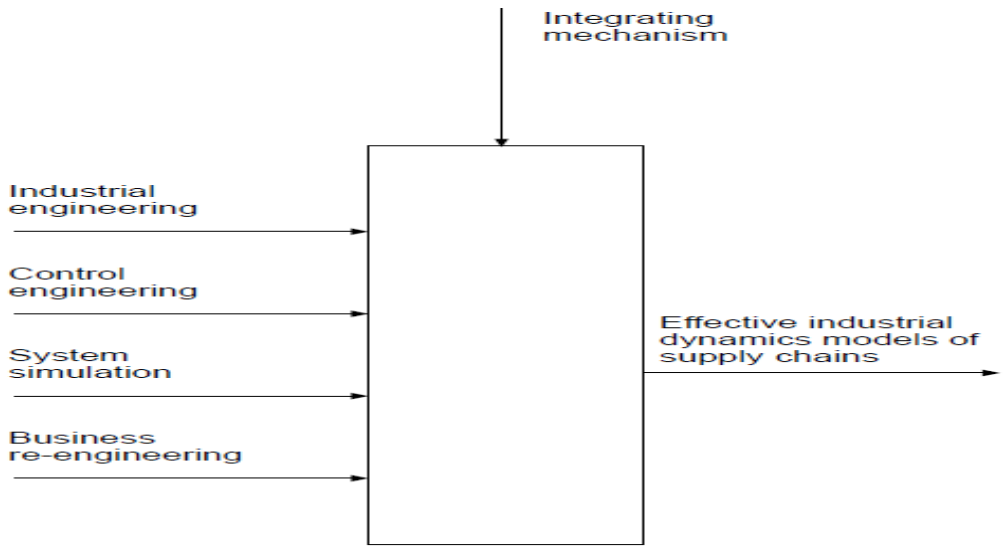


Figure 3. 4: input-output diagram for building system dynamics model for supply chains (Source: Towill, 1996)

3.12 Model proposed by Ge *et al.* (2004)

Ge *et al.* (2004) developed a SD model for supermarket chain in UK using MATLAB. This model basically deals with demand amplification or bullwhip effect. And the effect of information sharing, information distortion, information delays and forecasting methods were tested on demand amplification of supermarket chains in the UK. Therefore, this SD model is mainly about information feedback and bullwhip effect causal relationship. Ge *et al.* (2004) built the model using five subsystems or tiers in the supply chain; these are "the end consumers, the retailer's store, the retailer's distribution centre, the manufacturer's factory, and its procurement system" (Ge *et al.*, 2004). The simulation results of this model show that information sharing among supply chain partners within every tier relationship is very important to enhance supply chain performance.

3.13 Model Proposed by Sterman (1989)

Sterman built a system dynamics model for managing stocks (see figure 3.5) which can be applicable "in many situations such as raw material handling, production control, or at a macroeconomic level, the control of the stock of money". Sterman (1989) further explained that "*in most realistic stock management situations the complexity of the feedbacks among the variables precludes the determination of the optimal strategy*". After building the model, Sterman (1989) conducted a "Beer Game" production-distribution system in a simulated environment and all the actors were asked to minimize costs as their primary objective. However, the actors could not behave rationally to minimize costs by managing inventories due to time delays in multiple feedbacks along the supply lines and decision making process was not perfect for global optimization but the actors were rational for local optimization.

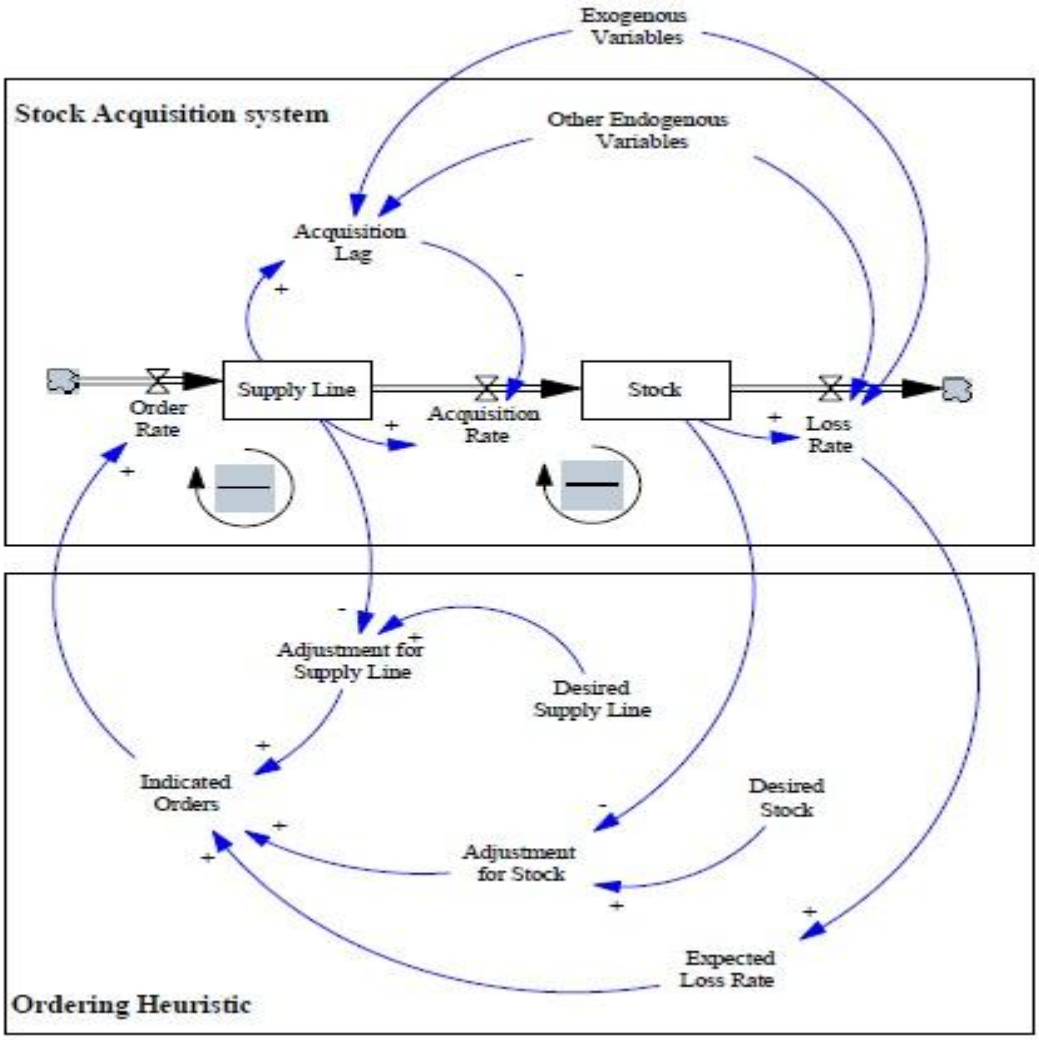


Figure 3. 5: System dynamic model for stock management
(Source: Sterman, 1989)

3.14 Conclusion

This chapter is intended to provide an overview of supply chain performance measurement and system dynamics modeling. There are multiple researches that have measured SC performances and modeled SC performance in the previous decades, but all the concepts of measurements and models are not widely accepted both in academia and industries. We have discussed some of the SC performance measuring frameworks

that are either combining in terms of both quantitative and qualitative measuring metrics or widely referred in scholarly articles. System dynamics modeling has become popular in SC management in last two decades although it was first coined by Forrester in 1961. Our research shows that SD modeling in inventory and stock management is quite abundant but it has few modeling in fashion or apparel industry specifically in terms of lead time management and combining all the qualitative and quantitative variables. Therefore, these are the important scopes of further research in SC with system dynamics modeling.

Chapter Four: Analysis of Questionnaire

4.1 Ownership structure

Ownership structure in the garment industry in Bangladesh is mainly divided into three categories, namely, single/proprietorship, partnership and corporation. Bangladesh export processing zones authority (BEPZA) has further divided the garment factories into three types such as Type A: 100% foreign ownership, Type-B: joint venture between foreign and Bangladeshi owners, and Type-C: 100% Bangladeshi owners (EPZ Bangladesh, 2013). This categorization of BEPZA is to provide fiscal and non-fiscal facilities among garment factories and to attract FDI in the garment industry in Bangladesh. We did not find any sample factory as a "corporation" in our survey. However, we have found from online databases that only very few garments are listed as corporation either in Dhaka or Chittagong stock exchange. Not being listed and structured as a "corporation" in stock exchanges may be a reason of poor performance in terms of compliance issues for some garments to the least degree. In this study, we found 48% factories are single ownership, 38% are partnership and 14% are fully foreign ownership. But the total population of garment factories does not have 14% foreign ownership as we apprehend. It was 14% in our survey because eventually we surveyed more foreign-owned garments.

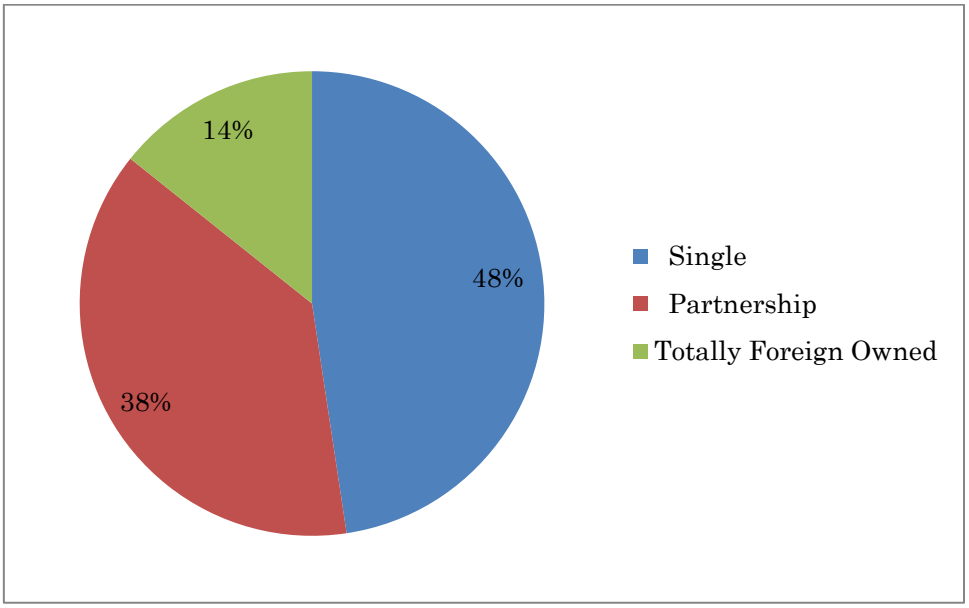


Figure 4. 1: ownership structure in garment industry
(Source: survey-2013)

4.2 Product types

Bangladesh garment factories mainly produce knit and woven garments although they make small quantities of sweaters for meeting seasonal demand of buyers. 48% 0f the surveyed factories reported that they produce only woven garments and 29% factories produce only knit garments. However, 24% factories produce both woven and knit garments. The survey shows that the difference between knit factories and woven factories is not so big nowadays. But ten years ago, knit production was almost half of the woven production and so was number of knit factories. But in 2012, both knit production and export value of knit products were higher than those of woven garments.

4.3 Production process

The production process is an important issue when the value addition is considered (see lead time management, chapter: 6). In our survey, it is reported that 29% of the factories work on the basis of CMT (cut, make and trim), 61% work on FOB-1 (arranges input

but design is given by buyers) and only 10% work on the FOB-2 basis (which includes both input of raw materials and design). These 10% factories, who work on the FOB-2 basis, were fully foreign-owned and they have design sections in their overseas offices. In reality, Bangladeshi producers usually do not carry out any design of garments.

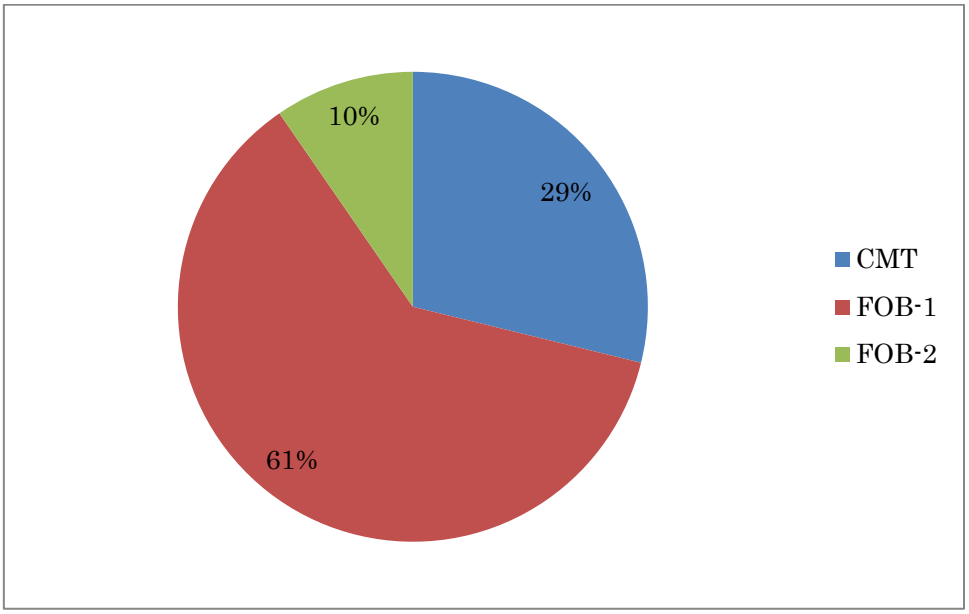


Figure 4. 2: processes of production

(Source: survey-2013)

4.4 Establishment, capital and employee

We have divided the duration of garments factory development into three categories: 'before 1985', 'during 1985 to 2004', and 'from 2006 to 2012'. The major exporting of garments basically started in the fiscal year of 1984-95 and the MFA quota was phased out in 2005. Our plan is to analyze the trend of growth of garment factories during MFA quota facility and after the MFA quota was phased out. Our study shows that, among our surveyed factories, 19% of the factories were established before 1985, 52% were established during 1985-2004 and the rest 29% were established during 2006 to 2012.

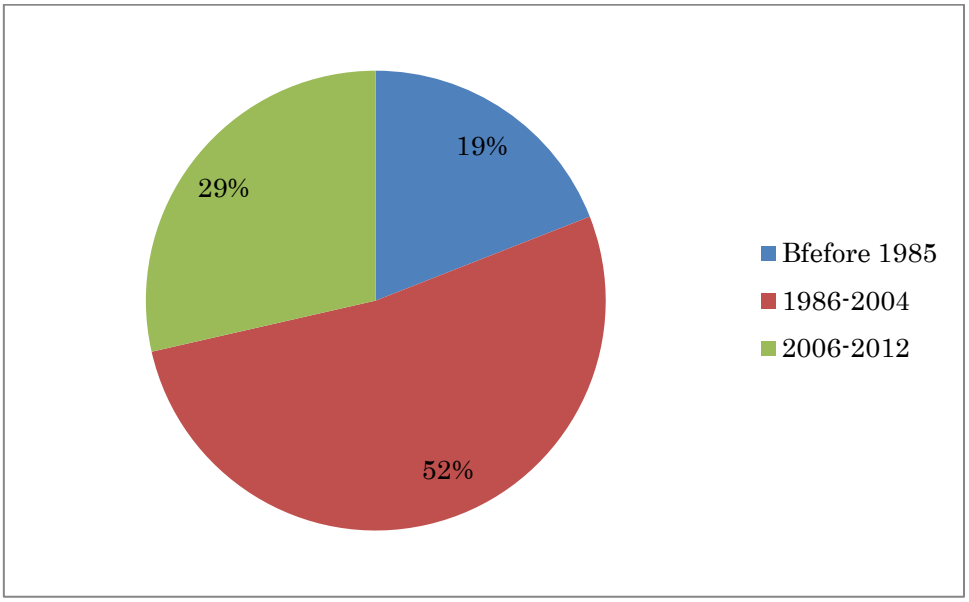


Figure 4. 3: year of establishment
(Source: survey-2013)

If we compare the growth of garment factories of two periods then the growth in the post MFA (2006-2012) is also quite promising and increasing. Among the surveyed firms, at present, 90% of the factories have more than 20 million taka and the rest 10% have within 10 to 20 million of taka as working capitals respectively. It means that, presently, the startup capital for doing garments business is initially high. Regarding workforce analysis, 5% of the factories have 101-500 employees, 5% have 501-1000 employees and 90% have more than 1000 employees. This analysis means that Bangladesh garment industry is highly labor intensive and it can create employment and employ lots of people as well as solve the unemployment problem in Bangladesh.

4.5 Sources of raw of material

The Bangladesh apparel manufacturing industry is highly dependent on two countries for its raw materials including fabrics, accessories and threads. Almost 60% of the garment manufactures import raw materials from China and 14% of them import from

India and Pakistan respectively. Majority of the factories import fabrics both from China and India. For some special fabrics, sometimes they import from Turkey and Japan as well. Nowadays, 90% of the knit fabrics are sourced from domestic suppliers while 80% of woven fabrics are imported from overseas. Besides this, there are also differences of import to total demand of their total raw materials since there are some textile factories, accessories suppliers at present and they are growing every year in Bangladesh. These domestic textiles and accessories factories are growing each year both in production capacity and in numbers. Our survey analysis shows that 100% of the firms import raw materials ranging from "less than 20%" to "more than 80%". Still 20% of the firms are importing more than 80% and about 50% firms are importing more than 50% of their demanded raw materials. Positive scenario is that about 50% are importing below 50% of their demand. This strength in the backward supply chain is a positive sign for Bangladesh RMG growth and competitiveness in the days to come.

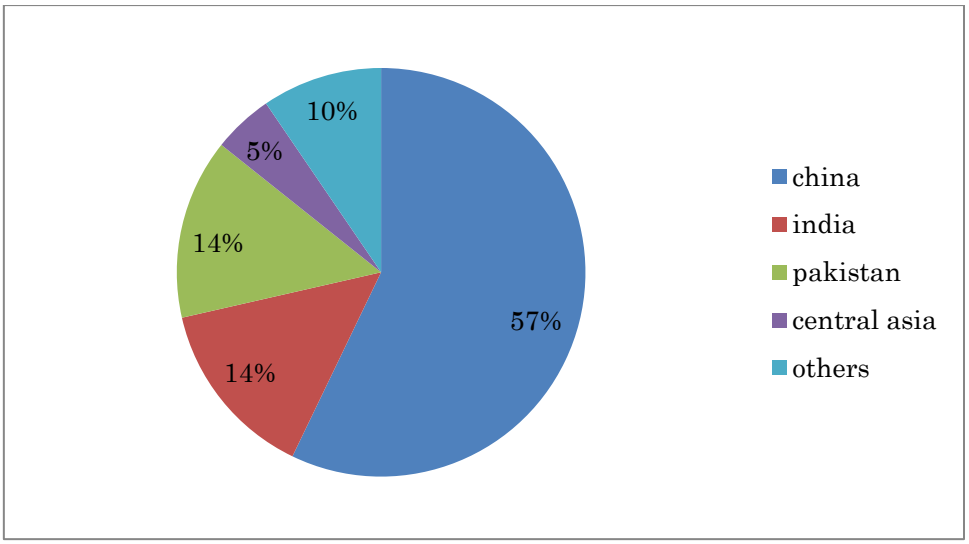


Figure 4. 4: sources of imported raw materials
(Source: survey 2013)

4.6 Supply chain department and its functions

The concept of supply chain management (SCM) is apparently newer in ready-made-garment industry in Bangladesh. Only 33% of the factories have an SCM department while 67% do not. Very famous and foreign garment factories even do not have dedicated SCM department in Bangladesh operations. Moreover, the firms who have SCM depart are also very new because only 5% firms have SCM from 10 years ago. Most are introducing supply chain department within last 2/3 years. This study divided probable core activities of the SC department for RMG firms into 1) purchasing and sourcing of raw materials 2) coordination of import and 3) coordination of export. The survey reveals that only in 5-10% factories, SCM department is conducting these activities. These core activities of SC department are mostly being (90%) performed by commercial and merchandising department according to our survey.

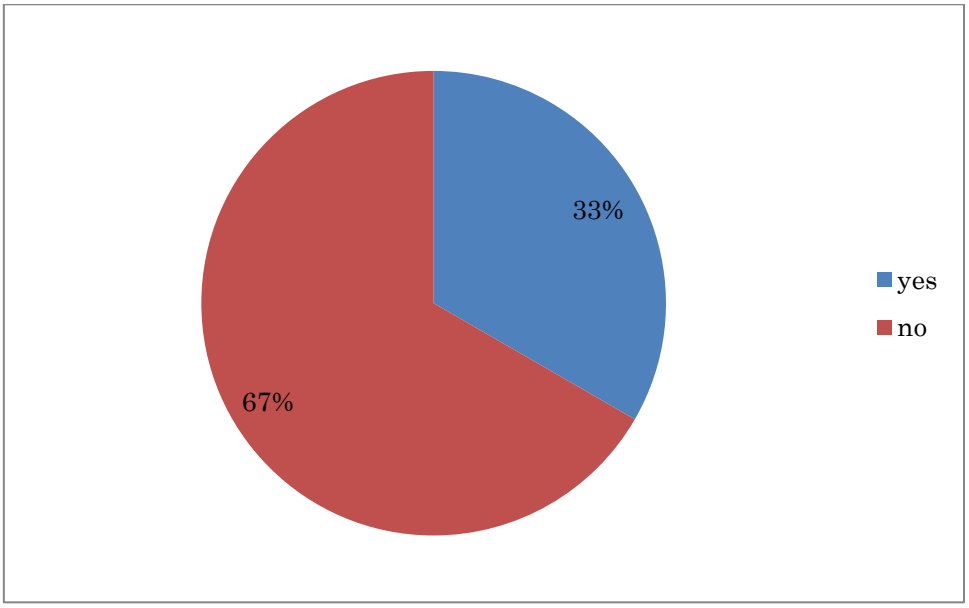


Figure 4. 5: having a supply chain department
(Source: survey-2013)

4.7 Order winning factors

We asked the respondents to identify the factors that decide whether they can obtain orders from buyers or not. Respondents ranked "quality" as the top most position with an average point of 4.52 out of 5.00. This means quality is the highest priority where respondents viewed cost (4.33) as the second and lead time (3.90) as the fourth important factor for obtaining orders from buyers. Customer service was ranked as the third factor with an average of 4.19. From the analysis, it is evident that all these three factors except lead time are simultaneously most important to win orders from overseas buyers. However, the lead time is also very important for getting orders. The level of importance which is followed in this chapter is expressed in the table 4.1.

Table 4. 1: importance level of scores

Range of Mean Score	Rating	Level of importance
1.00 – 1.80	1	Not important
1.81 – 2.60	2	Somewhat important
2.61 - 3.40	3	important
3.41 – 4.20	4	Very important
4.21 – 5.00	5	Most important

4.8 Strategies to reduce lead time

Respondents of our survey were asked to rank which measures or steps may be exercised to reduce lead time for the Bangladesh garment industry. It is seen that availability of raw materials (4.40) in Bangladesh is given the highest priority to reduce lead time. "Having own textile factory" (4.32) was ranked as the second most important factor to minimize lead time which is also supporting the availability of raw materials in domestic market. After these two factors, information sharing with suppliers (with an

average of 4.2), with buyers (4.2), mutual trust with buyers and suppliers (4.05) and joint planning with buyers and suppliers (3.95) were ranked as very important steps to work toward reducing lead time. That's why, this study has conducted a second survey and modeling to reduce lead time with domestic supply of fabrics with the help of own textile mills.

Table 4. 2: Importance of various steps to reduce lead time

Measurement or policy	Average	Standard deviation	Comment
Use of internet, emails & IT, planning software	4.15	0.875	Very important
Information sharing with suppliers	4.25	0.786	most important
Information sharing with buyers	4.2	0.834	Very important
Training of workers	3.3	1.129	important
Improvement of quality	3.8	1.361	Very important
Upgrading of technology	4.0	0.795	Very important
Collaborative(joint) planning with buyers and suppliers	3.95	0.887	Very important
Import of Raw materials from overseas	3.45	1.276	Very important
Availability of raw materials & accessories in Bangladesh	4.4	0.598	most important
Mutual trust with buyers and suppliers	4.05	1.191	Very important

Efficiency increase in production process	3.7	1.174	Very important
Fabrics and accessories are supplied by buyers	3.32	1.057	Important
If you have your own textile factory	4.32	0.820	most important

4.9 Market sensitivity

In the survey, only one factory responded that they can start sourcing raw materials before the order is finalized. This happens because that factory is totally foreign owned and they work on the FOB-2 basis. FOB-2 means that the factory is involved with product design and arrangement of input as well. Thus that factory knows well advance about the final product. However, most factories in Bangladesh work on the FOB-1 basis and they cannot source raw materials until they receive final confirmation of orders from the buyers. 95% of the factories use sophisticated machineries to increase manufacturing ability and quality to meet the demand of market and 90% factories train their human resource to prepare for future market changes.

4.10 Probable future changes

As end customers' demand is changing, so is changing from corporate buyers' side. Respondents were asked to predict the factors that will probably be changed in the near future that will determine orders from buyers. Informants of the survey ranked all of the five factors as very important. They ranked "timely shipment (4.75)" as the number one and "quality improvement (4.70)" as the second important factor (see table 4.3). Timely shipment is going to be one of the newly challenging tasks for exporters of Bangladesh

garment industry. At present, many factories extend their lead time and shipment dates by negotiating with European and American buyers but, in future, it may be very difficult as our survey indicates.

Table 4. 3: Factors that will probably change in future

Factors	Average	comments
Lead time reduction	4.45	Most important
Quality improvement	4.7	Most important
Cost minimization	4	Very important
Timely shipment	4.75	Most important
Sophisticated items	3.7	Very important

4.11 Process Integration

Respondents were asked whether they have some fixed buyers and suppliers or not. Management experts say that if companies have some fixed suppliers and buyers then it is easier to work together for long term and will have better process integration. 76% of the factories responded that they have fixed buyers and suppliers while 19% factories do not have fixed buyers and 14% do not have fixed suppliers. The number of fixed buyers ranges from 2 to 10 buyers. On the contrary, the number of fixed suppliers was found from 3 to as many as 80 suppliers. We investigated why some factory had so many suppliers as many as 80 suppliers. It is found that Lusuka group has 80 fixed suppliers of fabrics and accessories because it has many sister concern factories and it has a huge sales turnover per year.

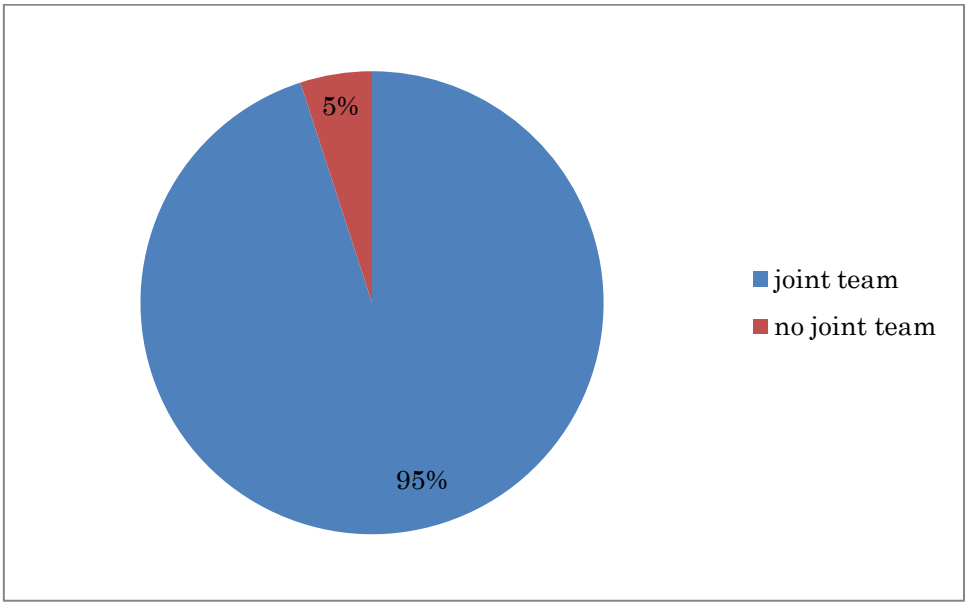


Figure 4. 6: joint team for problem solving
(source: survey-2013)

95% of the factories solve their problems together with the help of buyers and suppliers and only 5% responded that they do not. Similarly, 95% of the factories responded that they continually share updated information about their production and inventory status which is a very important step toward achieving process integration. Respondents were asked what measures they usually adopt to integrate processes with buyers and suppliers. We found from the questionnaire survey that providing proper feedback to buyers and working with them are the most important factor with an average point of 4.3 and 4.2 respectively. Working with suppliers (4.00) and information sharing (3.85) with them were ranked a little bit lower than that of buyers. This means, Bangladeshi garment producers are putting somewhat less attention to suppliers. According to Toyota production system and other newly emerged management systems, suppliers may be of great help to have better quality with less cost and lead time. So, this is a finding of this study where garment manufacturers should pay more attention to improve relations and process integration with suppliers as good as that with buyers.

4.12 Collaborative planning

The survey finds that 90% of the factories have some sorts of central teams that supervise and control various activities within the factories or production floors. Respondents have also commented that almost 90% factories are informed on time if buyers change any product specification or design. These two things are necessary for collaborative planning in any factory. Respondents reported that about only 52% factories are informed by the buyers if there is any possible change of demand. This is a critical point where buyers and factories may work further to get proper information about future demand and seasonal demand fluctuations. If factories are informed about seasonal demand changes then they can plan accordingly about raw material sourcing, hiring and training properly of manpower, increase or decrease production capacities. 95% of the factories provide their production status and reports to their buyers while 71% provide this information to their suppliers. It means that there is a gap between factories and suppliers in terms of collaborative planning. Probably, Factories normally want to apply as their buyer's bargaining power which debars mutual understanding and collaborative planning.

4.13 Usage of Information Technology (IT)

IT has been identified as one of the key enablers that can enhance supply chain performance in Bangladesh ready-made garment industry. To appropriately address the impact of IT, this study divided the questions into three sections such as purchasing, operation and buyer relationship. 90% of the respondents replied that they negotiate price issues with buyer through internet while 76% exchange garment samples through internet and 71% finalize their orders over the internet. It shows that buyer-manufacturer's initial communication is highly dependent on internet but

sometimes they depend on face-to-face contact for final order confirmation. Thus, Bangladesh RMG manufacturers have some scope to increase usage of IT in final stages. However, it is still in a good situation that huge number of factories is using internet technologies to contact and settle issues with their buyers. Our survey found that about 43% of the factories use some sophisticated technology in cutting section to cut fabrics instead of traditional hand cutting. About 38% of the factories use some software to manage their inventories and about 48% manufacturers use some kinds of software for production planning. These software are from different suppliers and are in different names but with somewhat similar in functions. Most garment factories use Auto CAD, Optitex, Tally, Electra, Investonica, SAP, FastReact, GSD, Kormi, and Fast React for managing their inventories. All (100%) respondents commented that they use different types of software either to reduce the wastes or to enhance the speed of work. 57% of the factories are using software for both waste reduction and quick work according to this study.

4.14 Uncertainty

For this study, the uncertainty in apparel supply chain is mainly limited to the sources of raw materials in overseas and at the producers' end in Bangladesh. These sources are mainly about shipment quantity, lead time and delay at sea port and customs. About 62% of the factories ship out with exact quantity for 97-100% times, while 14% reported they supply within the allowed ranges in 95-96% times. 14% of the respondents reported that they can supply 80-90% times with exact quantity that the customers ordered. Thus, it shows that at least 14% factories should increase their quantity performance from 80-90% times to 95-100% times to reduce uncertainty at the

producers' end in Bangladesh. About 4% of the respondents replied that they do part shipments ranging from 16% to 20% instead of sending the whole quantity in one shipment. This is also a source of uncertainty. Since part-shipments may cause delays at different points in the logistic supply chain and thereby increases risks, RMG factories should work to minimize part-shipments wherever possible. According to survey respondents, at least 48% of the factories experienced cancellation of orders in their business history, even though the orders were confirmed by buyers. 29% of factories never faced order cancellation from buyers' end so far in their business. Only about 40% percent of domestic fabric suppliers could supply their fabrics with exact quantity in 96-100% cases which was required by garment factories. It shows that Bangladeshi textile factories have to work a lot to supply with exact quantity to reduce supply chain uncertainty and risk. This situation may pose a serious threat to factories because when they do not get fabrics from domestic suppliers it might cause lead time extension which most of the time resulting with a penalty of financial loss and bad reputation at the buyers end. 60% of foreign suppliers could supply with exact quantity in 96-100% cases. Thus, it is evident that foreign suppliers performed better than domestic suppliers. 70% of respondents commented that they face delays in customs in 1-5% cases which seems to be very good performance by the Bangladesh government to support the apparel industry although it has rooms to improve.

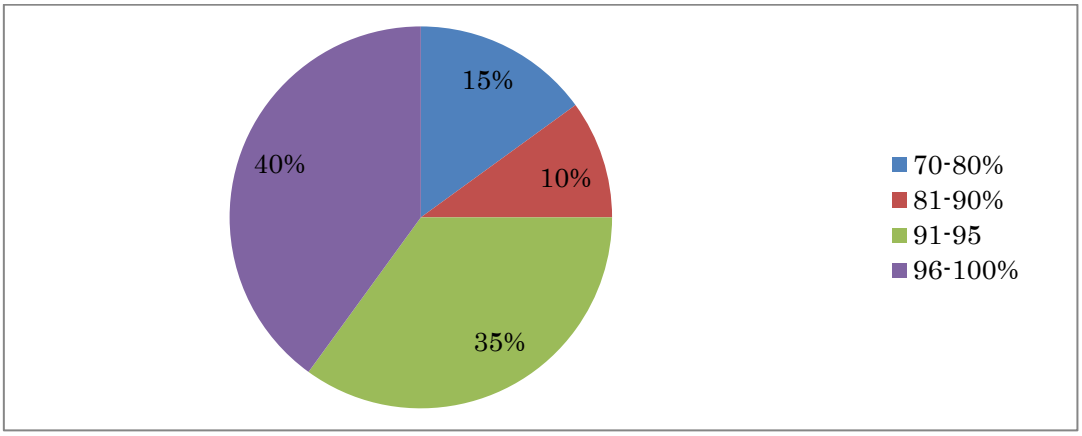


Figure 4. 7: percent of domestic suppliers supply with 100% quantity

4.15 Causes of shipment uncertainty

We asked respondents to rank the importance of reasons why they ship out their garments either in less quantity (partial shipment) or with extended lead time. These two things create uncertainty both in quantity and quality as well as time. The survey questionnaire included five factors to identify reasons behind uncertainty are given below.

Table 4. 4: Causes of shipment uncertainty

Factors	Average	comments
Lack of production efficiency	3.7	Very important
Sophisticated items	3.2	Important
Suppliers' distance from factories	3.6	Very important
Poor sewing quality	3.3	Important
Poor fabric from suppliers	3.1	Important

It shows that production efficiency and distance from suppliers are the two main sources of shipment uncertainty in terms of quantity, quality and lead time. It clearly indicates

that if raw materials are supplied from inside Bangladesh then all these three kinds of uncertainty can be reduced.

4.16 Components of customer satisfaction

This study investigated to identify and rank the components of customer satisfaction so that factories and policy makers can set priority to have satisfied customers at the end.

Table 4. 5: Components of customer satisfaction

Factors	Average	Standard deviation	Comment
low lead time	4.38	0.740	Very important
quality improvement	4.80	0.402	most important
cost minimization	4.19	1.077	Very important
ability to sew	3.67	1.317	important

Here it shows that low lead time is the second most important factor to satisfy buyers while better quality is the first factor to maintain and satisfy buyers.

4.17 Green supply chain management

We lightly looked also into the present scenario of green supply chain management in RMG industry though it was beyond the scope of this study. This study just surveyed some elementary steps towards green SCM. 52% of the surveyed factories have ISO-14000 certification which is a very initial step toward green supply chain. But, we doubt that this is not the common scenario in the Bangladesh apparel industry. However, 48% of the factories do not have any such certification and this percentage probably will be higher in reality. The hope is that 67% factories, who do not have environmental management certification, are practicing rules that will lead toward achieving ISO

14000 certification in the future. 33% of the factories responded that they are not even planning to achieve any environmental certification. About 43% factories reported that 81-100% of their foreign suppliers' has environment certification (ISO 14000). And another 43% reported about and 51-80% of foreign suppliers have ISO 14000 certification. When the question came about domestic suppliers, it showed that 15% of the suppliers' have 81-100% ISO certification and 25% factories responded that 50-80% suppliers are ISO 14000 certified. Thus, it indicates for a huge gap of green SCM in domestic suppliers of raw materials.

Respondents were asked "what they do with rejected items?" 70% replied that they sell their rejected items at Bangladesh domestic market instead of exporting. One reported that they did not have such events till now as their duration in the business is short and one reported that they can sell their rejected in international market with discounted prices. There were questions to differentiate how factories deal with domestic and overseas fabric and accessories suppliers. 100% respondents reported that they return defective fabrics to the domestic suppliers and replacement with required quality fabrics. But 70% of the factories reported that they negotiate with foreign suppliers and receive some discounts on price instead of replacing poor quality fabrics. Foreign suppliers replace partially if the quality is very low. This indicates that sourcing from overseas is sometimes responsible for the poor quality of fabrics and lead time problem as well as late shipment. Thus, fabric and accessories supply from domestic sources can ensure better quality and low lead time if the capacity of the backward supply chain is built up to that standard which will in turn also pave the way for green supply chain.

Chapter Five: Analysis and Findings with System Dynamics

At the beginning of the analysis of RMG supply chain; this study presents two most important factors, namely variables of performance measurement and their components, which were identified from the literature review and expert opinion. Then, these variables along with their corresponding components were included in the survey questionnaire to capture the supply chain practices in Bangladesh.

5.1 Variables of the system dynamics model for RMG in Bangladesh

As the 'multi fiber arrangement' (MFA) phased out in 2005, the Bangladesh RMG industry had to compete with all other apparel manufacturers and suppliers those are competing from around the world. As a result, it was forced to reduce costs while maintaining reasonably good quality. According to experts in the industry, good quality means sophisticated products that are somewhat difficult to sew and conform to buyers' requirements. They also comment that buyers from USA focus more on reducing costs while buyers from Europe emphasize on high quality and fashionable products, but also simultaneously on reasonable costs. As the product life cycles are decreasing continuously, the lead time is also decreasing and putting extra pressure to the Bangladesh RMG industry. So, RMG manufacturers have to supply high quality products at a reasonably lower cost and shorter lead times than before to attract customers from USA and Europe. Some key variables have been identified from the literature review and opinion of experts in the RMG sector. These variables are classified as results, enablers and inhibitors (Table 5.1).

Table 5. 1: Definitions of of SCM variables

Variables	Remarks and Meaning	Types	References
Supply chain performance / orders/sales	Includes all variables listed below. Lead time reduction, cost minimization and quality improvements are achieved through all other activities as listed below.	Supply chain performance index	Agarwal & Shankar (2005)
Lead time reduction	One of the key order winning criteria from buyers. Lead time is the duration of time from order placement to order shipment date. Lead time reduction signifies agility of the particular company's supply chain.	Result	Towill (1996)
Cost minimization	Another key order winning criteria along with lead time reduction. It can be achieved through lean manufacturing, collaborative planning, and integrated supply chain	Result	Mason-Jones, Naylor & Towill (2000)
Quality improvement	Sophisticated products at a reasonably low price. It's very important for EU buyers.	Result	Christopher & Towill (2001)
Process integration	Working together with suppliers & buyers, a joint effort to solve problems or develop products or quality or system	Enabler	Christopher (2000)
Collaborative planning	Use partners' facilities and opportunities to maximize efficiency, capture market potential	Enabler	Christopher & Towill (2001)
Delivery speed	Prepare for short-term and long term changes based on market trends/changes and buyers' expectations	Enabler	Christopher & Towill (2001)
Use of IT	Using software and hardware to share information effectively and to improve quality and production speed	Enabler	Yu *et al*, (2001), Fasanghari *et al.* (2008)
Uncertainty	Effect of changing market situations, and supply chain unpredictability, bullwhip effect	Inhibitor	Agarwal & Shankar (2005), Mason-Jones & Towill (2000)

Market sensitiveness	Achieve quick responsiveness to the changing market environment in terms of demand pattern and quality so that supply chain becomes agile.	Enabler	Christopher (2000)

5.2 Components of each variable

A number of factors were identified to represent each enabler, result and inhibitor variable, through a search in the literature including published articles and supply chain management textbooks. After listing these factors, questionnaires were distributed among the respondents of the sampled factories to collect their opinions. Factors associated with each variable have been listed in the Table 5.2.

Table 5. 2: Factors associated with the variables under study

Variable	Components (associated factors)
Market sensitivity	Starting time of raw material sourcing and procurement. Training managers, technicians, workers in manufacturing ability of sophisticated and fashionable garments. Procuring sophisticated machinery to increase the sewing ability of sophisticated garments and improve quality
Delivery speed	Assigning importance/priority for special tasks to meet future requirements of market demand such as training of human resources, usage of IT, working together with buyers & suppliers, exchange of necessary information among supply chain partners, enhance collaboration with suppliers and buyers, having stable workforce
Process integration	Strategically fixed and fewer numbers of suppliers and buyers. The joint work team with buyers and suppliers to solve problems. Providing feedback information to buyers and suppliers to keep them updated.
Collaborative planning	Using centralized collaboration teams among factories or production facilities. Informing suppliers and buyers about changes of product design/specification well in advance so that necessary preparation can be taken to reduce waste. Maintain and share up-to-date production and inventory status with buyers and suppliers

Use of IT	Using both hardware and software at least in three aspects such as internal operations, purchasing and vendor management, and on buyer relationship. Different kinds of hardware and software can be used for managing all these aspects like ERP software, marker and pattern making software, inventory management software, etc.
Uncertainty	How many times did the buyers change their order quantities and product specifications? What is the rate of shipments of 100% quantity of original orders or without shortage by the factories? How many times factories could not ship out within the original lead time? How frequently did the overseas and domestic suppliers fail to deliver fabrics and accessories within lead time, without quantity shortage and with appropriate quality?

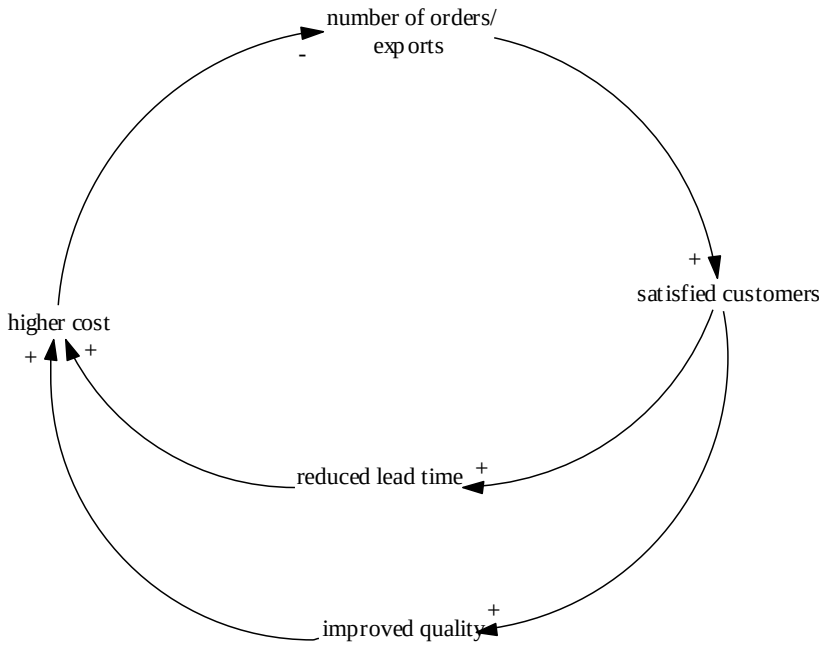


Figure 5. 1: Vicious cycle in Bangladesh RMG

5.3 Techniques of breaking the vicious cycle

This figure explains the broadly prevailing concept in RMG sector. The number of orders or total export increases if the customers become more satisfied. There are three parameters for having satisfied customers or buyers. These parameters are cost, quality and lead time. We name this circle as a 'vicious cycle' for this study and analysis. When

customers look for short lead time then garment producers cannot supply in a shorter time instead of a usual long lead time. Garment factories can supply garments with shorter lead time with temporarily increased manpower, sub-contracts with other factories and overtime of working hours which, in turn, adds more production and supply chain costs. Thus, garment producers look for more unit-price from the buyers which lead to loosing of orders or dissatisfied customers. Sometimes, buyers look for improved quality without increased amount of unit-price but apparel manufacturers cannot supply the improved garments with existing prices. Garments' owners argue that they need to employ more workers in the production processes and quality checking and assurance departments to enhance product qualities than a usual level which, again, adds more costs to the unit-price of the final products. Thus, increased costs cannot attract more buyers and more orders. That's why, we call this is a 'vicious cycle' of the RMG sector in Bangladesh.

However, this study explores that the vicious cycle is a traditional view of cost, lead time and quality. There are some ways to overcome this vicious cycle with latest supply chain management practices, techniques and tools. Some of these potential ways are discussed in the following sections.

5.3.1 Process Integration

As process integration emphasizes building long term relationship with few strategic buyers and suppliers, it increases the trust and ability to work among supply chain partners and facilitates collaborative planning. Some scholars suggest that 100% process integration is not achievable if a focal company does not have few strategic buyers and

suppliers. When garment companies have some strategic fixed buyers and suppliers, then they can share important, critical and even secret information among themselves. Supply chain partners can have joint teams to solve problems. If the buyers inform their upcoming fashions and designs and order-quantity well advance of actual order placements then garment factories can adjust their production capacities, sub-contracts, workforce alignment as well as sourcing of fabric and accessories. All these efforts can reduce costs and lead time. Even factories can prepare for production processes and train workers if they are informed about upcoming high quality requirements which will also help to reduce lead time and improve qualities.

Katunzi (2011) has explained several benefits for manufacturing firms if supply chain integration is achieved. These benefits are more market-share and increased sales, lower inventory, low cost along the supply chain, shortened order to fulfill cycle time which is actually shorter lead time, asset utilization is increased and cost of capital is decreased, flexibility to meet end customers requirement which helps to achieve agile supply chain, more profitability on assets and sales as well as better forecast. So, process integration among supply chain trading partners can break the vicious cycle and increase competitiveness of the garments manufacturers in the world market.

Katunzi (2011) has described some key hindrances that resist supply chain integration among supply chain partners in the upward and downward supply chain links. Katunzi (2011) has termed them as “silo mentality” and “lack of trust” among trading partners and even among departments inside a company. Silo mentality means the tendency to maximize profits of his/her own company or department only which is because of the

failure to visualize the complete picture in the whole supply chain. In other words, it can be said that silo mentality achieves only local optimization rather than achieving globally optimized profits maximization or cost minimization. However, Agarwal and Shankar (2005) have explained that silo mentality and the lack of trust can be minimized through collaborative planning and increased use of IT which encourage more information sharing among downward and upward supply chain partners and joint problem solving.

5.3.2 Collaborative Planning

Collaboration among supply chain partners can help to achieve coordination of operations which benefits a lot along the supply chain operations (Chopra *et al.*, pp.509-515, 2011; Genoulaz *et al.*, p.243, 2010). According to Chopra *et al.* (2011), collaboration can reduce the replenishment lead time, manufacturing costs, inventory variability and its cost, transportation cost and increase availability of products. Genoulaz *et al.* (p.243, 2010) suggested that collaborative planning can reduce costs and increase benefits for every partner as well as to minimize risks in the supply chain. Agarwal *et al.* (2005) has explained that collaborative planning can increase trust among partners, improve quality of products, increase accuracy of shared information and can have more satisfied customers in the end. Genoulaz *et al.* (p.243, 2010) has divided collaboration into strategic level and operational level. Strategic level encompasses "where" to establish a factory or production facilities and regional distribution centers as well as make or buy decisions etc. Operational level of collaboration includes "what" and "when" to produce using which raw materials such as fabrics, accessories etc. Genoulaz *et al.* (2010) showed that buyer-vendor collaboration

and coordination can achieve excellence in operations. Thus, both the levels of collaborative activities can be feasible for RMG or apparel supply chain.

Information sharing about demand and supply changes is a great way to achieve collaboration among business partners and simultaneously lack of information sharing is the major obstacle to collaboration. If demand information is properly shared then bullwhip effect can be constrained to a minimum level. For example, if some buyers from the USA or Europe of any particular factory in Bangladesh keep ordering bigger order sizes for a few seasons and do not inform that this trend is not going to continue for next few years then factory will expand its production facilities and recruit more workforces which will be wrong decision in practice. However, if buyers and factory owner are in a collaborative relationship then buyers will inform the manufacturers about future demand changes, shifting of fashions and product requirements which, in turn, reduce manufacturers' risks and increase profitability. Thus from the reviews of articles, this study argues that having a central team or department who will share and manage information among factories, departments and buyers and suppliers as well as it is a necessary requirement to achieve collaboration. Secondly, collaboration is also dependent on what kind of information is shared among trading partners. Information about seasonal demand change and product specification change is a vital point in this process.

Li (2011) has divided supply chain collaboration into two types, namely, cooperative and exploitative collaboration. This view is very important in today's business. According to Li (2011), in exploitive collaboration, buyers force the suppliers to

collaborate with buyers' requirements due to buyer's size, market share and bargaining power as a whole. Though the exploitive collaboration forces suppliers to deliver with low costs within short lead time, it has a negative side-effect. This relationship does not care of suppliers and it becomes fragile in the long run. However, it has a positive side-effect and it somehow improves supplier's efficiency to reduce costs forcefully. Li (2011) suggested that Wall-mart practices exploitive collaboration with its suppliers.

However, Toyota (Li, 2011) practices cooperative collaboration with its suppliers. This relationship takes care of both parties of the supply chain inter-facing partners. As a result, cooperative collaboration accelerates process and supply chain integrations. In this view of management, buyers do not only look for short term benefits of its own business but also they plan with long term vision for quality, cost, flexibility and continuous improvement in suppliers' capacity keeping pace with the changed situation (Li, 2011). The output motive of cooperative collaboration is long term and continuous. In cooperative collaboration, buyers usually invest in favor of suppliers to enhance their capacity and efficiency while buyers tend to shift their costs on suppliers' shoulders to make quick profit in exploitive collaboration.

5.3.3 Use of Information Technology (IT)

Information technology has become a major enabler in any supply chain. IT has a great role in enhancing collaborative planning, accurate, timely and sufficient information sharing, process integration and reducing uncertainty in the supply chain management (Agarwal *et al.*, 2005; Chopra *et al.*, 2011). Two types of ways that IT can improve supply chain performance; 1) making the necessary information available and 2)

making the information more visible (Chopra *et al.,* 2011). When the information is available between business partners then it increases collaboration. And the visibility of information facilitates decision making. Both of these help integration and reduce uncertainty in the supply chain. To capitalize benefits from IT usage, many companies have been using some supply chain planning and ERP software such as SAP, Oracle etc.

IT can be used in many operations along supply chain such as production planning, inventory management, transportation and logistics, pricing analysis and decisions, sourcing raw materials and finished goods. Fasanghari *et al.* (2008) divided the areas of IT uses into five categories. These areas are IT on logistic, operation, customer relationship, purchasing, and vendor relationship management. Due to the limitation of time-frame of the study, we have focused on three aspects, namely, purchasing and vendor relationship, operation, and buyer relationship management. The practical scenario which is summarized through gathered data and their analysis of these sections is presented in the chapter "Survey analysis and findings". Farsanghari *et al.* (2011) were limited to enterprise resource planning and identification technologies such as RFID but this study extends IT up to cutting technologies and marker software including the scope of Farsanghari's (2011) IT definition.

5.3.4 Market Sensitivity

Market sensitiveness is also an important enabler in the supply chain. Market sensitiveness (MS) refers to the forecast ability about upcoming changes in terms of demand, supply, raw materials, fashion, and customers' requirement in the market (Christopher, 2000). Thus, MS helps to prepare for future market without depending on

reactive feedback from the immediate customer only rather it encourages gathering data on pro-active way. Moreover, MS is one of the corner stones of the agile supply chain (Christopher, 2000). MS can help to increase collaborative planning and quality as well (Agarwal *et al.,* 2005). For example, if Bangladesh RMG manufacturers can foresee that European customers are looking for high quality and fashionable items then they can train up human resources and procure machineries to meet European customers' demand. In the same way, if manufacturers can gauge the cost sensitiveness of US buyers then they look for achieving efficiency over time through the lean supply chain and minimizing costs. There are also changes in the supply of raw materials such as fabric market. For example, India is producing and supplying more fabrics to Bangladesh than it did in the past decade and many manufacturers are importing fabrics from China and India. However, India might support more on their domestic apparel sector to develop further the industry and it takes long time to import from China. So, Bangladesh has to invest in textile and produce fabrics to support its apparel exports. All these proactive decisions come from MS.

5.3.5 Delivery Speed

When factories can gauge the future changes in market and adopt action plans accordingly to tackle the predicted changes then delivery speed increases. However, delivery speed not only considers the predicted changes but also tackle the present situation in the marketplace as well (Agarwal *et. al.,* 2005). If a company increases its delivery speed then it works with its suppliers to leverage opportunities and build partner relations (Power *et. al.,* 2001). Thus delivery speed can help to increase process integration and reduce lead time as well as increase collaborative planning (Agarwal *et.*

al., 2005). Factories can increase delivery speed in a number of ways such as reciprocally increased information sharing with suppliers and buyers, training own workforce including production workers, technicians, engineers and managers, installing new and sophisticated machineries to serve the next days' market.

5.4 Lead Time

Usually, lead time means the total time from the order placement to the receiving of goods at the hand of customers. However, the lead time in Bangladesh RMG stands for the duration from order placement date to shipment date to reach at the Chittagong sea port. Almost all respondents in the first survey opined that lead time is the highest critical factor for success and continuous growth of the apparel sector in the upcoming days. Then, this study conducts second survey dedicated to only on lead time issues to identify its obstacles, factors, and ways to minimize lead time. Most manufacturers in Bangladesh are apprehending that lead time will be a crucial factor to survive in the days ahead. The details about lead time have been stated in a separate chapter. However, to the minimum level of discussion about lead time to form CLD is presented in this section. If lead time is reduced then total costs in the whole supply chain stages can be dramatically reduced as inventory holding time and capital investment are reduced. Reduced lead time can have more satisfied customers and can capture the market trend in time to increase sales (Agarwal *et. al.,* 2005).

5.5 Cost

According to the managers' opinion of Bangladesh apparel factories, cost is the most important decision variable for US buyers while quality and cost both are the primary decision variables for European buyers. Cost has many components including direct and

indirect materials, labor, transportation, inventory, and overhead costs. If minimizing total supply chain cost is the objective then it ultimately increases competitiveness. If any garment factory only looks for minimizing its own manufacturing, fabrics and other costs then the total supply chain cost may not necessarily be reduced. The silo mentality cannot minimize costs across the whole supply chain. The increased cooperation, collaboration, and coordination by developing an integrated supply chain among the upward and downward trading partners which will extend their hands from design and development stages to manufacturing to distribution up to the end customers can minimize the total costs (Chopra *et. al.,* p.48, 2011). To become competitive, total cost view is very important over individual costs in apparel industry. There are some suggested ways to reduce costs like achieving economies of scale through bigger quantities of orders, reducing lead time and having integrated supply chain (Agarwal *et al.,* 2005).

5.6 Quality

Quality is one of the three main result variables in our study. There are different kinds of definitions of quality. This study tackles only manufacturing quality since RMG is a manufacturing industry. The ability to meet stated features is often regarded as a quality. For manufacturing products, quality refers without defects, and deviations in required features and measurements (Business Dictionary, 2013). Experts in RMG sector commented that making garments of complex features and designs are termed as high quality products. Producing high quality products, which are free from defects and without significant variations in measurements, is difficult and adds additional costs. Thus, product cost increases for high quality garments. But this study tries to analyze

how to reduce costs while making high quality garments by capitalizing the scope within an integrated supply chain.

5.7 Uncertainty

Due to the time limitation and difficulties to measure other inhibitors such as lack of trust, this study considers only one inhibitor that is uncertainty. Uncertainty mainly results from demand and supply sides in a supply chain. Demand uncertainty is higher when the product is a fashion item and it has low product life cycle. Apparel sector includes many fashionable items and these fashions are changing very quickly and, thereby, demand and requirements are changing quickly from year to year in the same market. There are also lots of uncertainties in supply sides of raw material and accessories of apparel industry. Price and quality of materials, political instability, trade barriers between countries and exchange rate fluctuations are major sources of supply uncertainty. In 2010-2011, the prices of cotton and fabrics fluctuated so abruptly in Bangladesh and Indian markets that many RMG producers faced very bad situations and could not procure raw materials on time.

Having said that uncertainty is an inhibitor, it puts obstacles to perform at their full potential by companies in a supply chain. However, many companies started vertical integration in upward supply chain to minimize supply side uncertainty but, recently, keiretsu in Japan has brought a new type of solution to reduce uncertainty (Bechtel and Handfield, 2002). The more the uncertainty is in a supply chain, the more the bullwhip effect is in demand forecast (Mason-Jones and Twill, 2000). The best solution, to minimize demand and supply uncertainty, is to share more information through using IT

and build partnership and trusted relationship among supply chain partners (Bechtel and Handfield, 2002; Mason-Jones and Twill, 2000). Besides the use of IT and information sharing, Christopher and Twill (2001) have suggested “decoupling” of operations to reduce uncertainty in supply chains. Decoupling or postponement of operations is a very useful technique to achieve lea-agile supply chain. Operations achieve lean manufacturing up to decoupling point with large amount of production and quick delivery is possible after de-coupling point with customized features when orders are placed. This technique is widely practiced in the paint distribution system. However, some manufacturers and retailers of clothes and fashions in Bangladesh have been practicing this technique. Manufactures are sewing garments of certain common designs for some common sizes and making particular sizes after consumers buy them. Thus, they reduce total inventory, uncertainty of demand fluctuation and obsolescence risk.

5.8 Development of Causal Loop Diagram and Discussion

There are several loops among supply chain performance variables in the casual loop diagram (Figure 5.2), while the variables have been grouped into three categories of enablers, results and inhibitors. The supply chain performance is the sum total of all these three kinds of variables. We have used sales as the proxy for supply chain performance under the assumption that if the total number of orders increases then it proportionately increases the sales value and signifies the level of supply chain performance variables at any particular time. So, the higher the sales value is, the higher the total supply chain performance index is.

The Vensim software can show all the loops among the variables at different nodes. At the supply chain performance node, there are five loops among the variables involving

different numbers of variables. For example, if the target cost minimization increases then the difference between target cost minimization and actual cost minimization increases and the feedback loop between them is positive. As the difference in cost minimization increases, the company obtains fewer numbers of orders from the buyers. Thus the feedback loop between target cost minimization, actual cost minimization and supply chain performance variables becomes negative (the first loop at the node of supply chain performance).

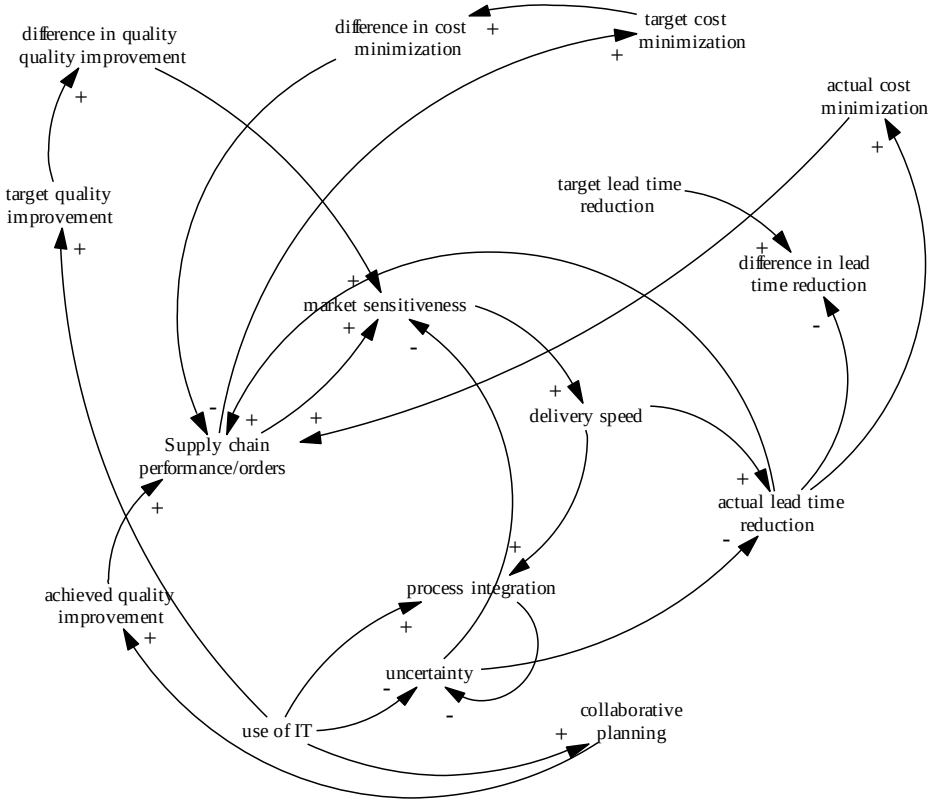


Figure 5. 2: Causal loop diagram among variables in the RMG supply chain

In the second loop, when companies plan to obtain more orders from buyers they increase market sensitiveness which also helps to increase the delivery speed. When the delivery speed increases it reduces the lead time of the orders for production and shipping. Reduced lead time has become the second most important factor for USA

buyers and the most important order winning criteria for European orders as well as for any fashionable items or orders irrespective of markets (USA or Europe or any part of the world). As the product life cycle is decreasing continuously, the reduced lead time is playing an important role for securing orders from buyers. Thus increased market sensitiveness, increased speed of delivery and reduced lead time increase the sales or supply chain performance index and the feedback loops among these variables are positive (Figure 1).

If we move from the second loop to the third loop, an additional variable involved is actual cost minimization. From the third loop, we see that lead time is reduced through increased market sensitiveness and speed of delivery. When lead time decreases, the throughput in the supply chain increases rapidly. All the inventories including finished garments, fabrics, accessories and other raw materials and any unfinished items (work-in-process) will stay in the store for a shorter length of time than usual. Thus the inventory turnover ratio will increase and the financial ratios will be positively affected. As a result, cost minimization will be achieved proportionally, minimizing the cost and helping secure more orders from buyers.

In the fourth loop, the variables involved are supply chain performance/orders, market sensitiveness, delivery speed, process integration, uncertainty and actual lead time reduction. In this loop, market sensitiveness and delivery speed tend to increase process integration. When process integration increases among the companies, then uncertainty of buyers and suppliers in the entire supply chain decreases. Thus the feedback loop between delivery speed and process integration is positive, as is the one between process integration and uncertainty. When uncertainty is reduced and process integration is increased, lead time is again reduced which in turn increases sales or the supply chain

performance (as described in the previous paragraph).

The fifth loop shows how increased process integration and reduced uncertainty can lead to increased actual cost minimization by reducing lead time. This loop encompasses two extra variables, namely process integration and uncertainty, and shows a combination of one to four loops.

5.9 Some empirical evidence from Bangladesh RMG

It is very difficult to exactly quantify the value of market sensitiveness and process integration since they have various qualitative and quantitative dimensions. So, we have assumed the number of factories and domestic supply of fabrics as proxies for market sensitiveness and process integration and the sales as a proxy for supply chain performance. The number of garment factories is assumed to represent the proactive market sensitiveness in responding to an increased demand for Bangladeshi garments in the global market. We have assumed that the present factories (BGMEA, 2013) are fully capable of meeting their present demands, and the numbers of factories in previous years have been divided by the number of factories in 2010-2011 (as base year) to get the market sensitiveness for the corresponding years. The sales of garments have constantly increased as market sensitiveness increased (Figure 2)

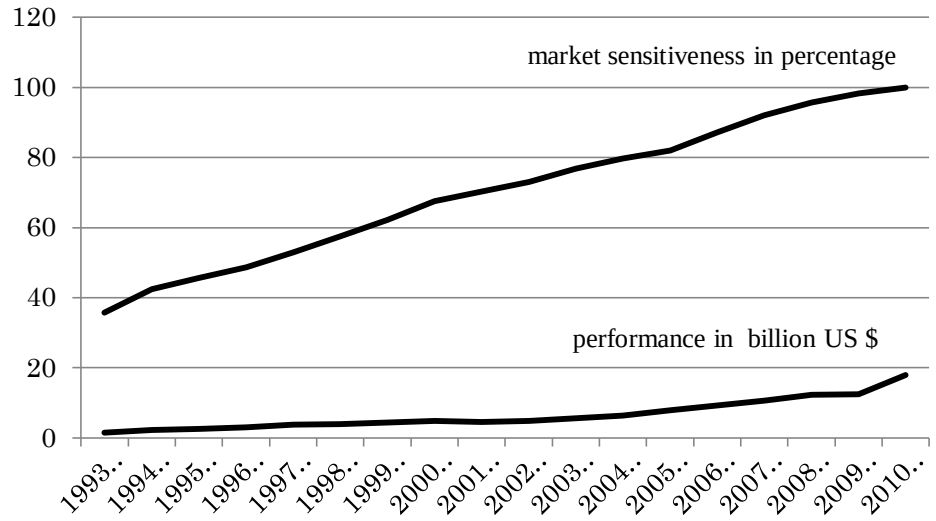


Figure 5. 3: The relationship between market sensitiveness and supply chain performance

Since fabric is the single most important raw material to produce garments, the percentage of its domestic supply to total demand (BTMA and Bangladesh Ministry of Textile, 2013) indicates the strength of process integration in the backward supply chain of garment industry. The more fabrics supplied from the domestic textile industry, the less Bangladesh garments are dependent on imported fabrics, thus an indication of improvement in process integration. The domestic supply of fabrics can reduce lead time and cost and improve quality by providing swift feedbacks and joint work which is less feasible with foreign textiles. Figure 3 demonstrates that performance has increased greatly as the supply of fabrics from domestic sources has increased.

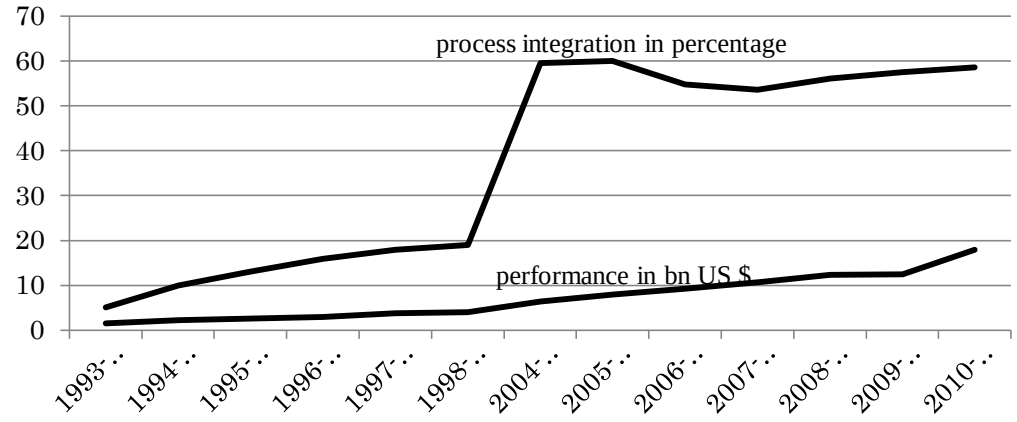


Figure 5. 4: The relationship between process integration and supply chain performance

The results of our survey responses and depth interviews confirm that the lead time has become a crucial factor to increase competitiveness. We have divided lead time into two components of export and import lead time (World Databank, 2013). These two lead times are largely beyond the control of garment manufacturers, instead the government and other players in the backward and forward supply chain linkages are the main actors; however, they have decreased over time as the garment sector has played a key role in the national GDP and exports. Supply chain performance has increased as these two variables decreased over time (Figure 4).

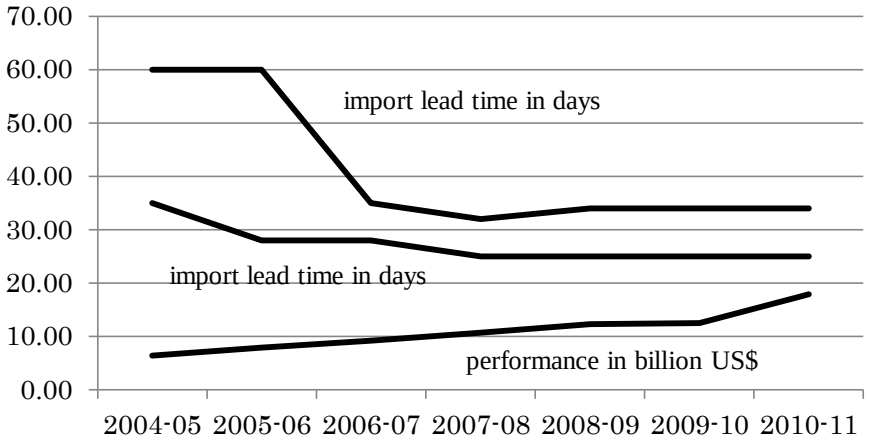


Figure 5. 5: The relationship among import and export lead times and supply chain performance

Chapter Six: System dynamics model to analyze impacts of domestic fabric supply in lead time management in Bangladesh garments industry

6.1 Introduction

As the impact of physical boundaries is decreasing with the advent of the latest information and communication technologies, markets are continuously becoming more globalized, and new competitors are progressively entering into the market with newer and more innovative products and services to compete with the existing ones. The apparel industry is highly globalized with a number of key exporters and importers from Asia, Europe and the Americas. Moreover, the product life cycle of apparel products, many of which are fast fashion items, is decreasing quickly. Consequently, the time allowed for design-to-market is decreasing over time which is directly pushing suppliers or manufacturers of garments to reduce the duration of the "order issue date to the shipment date". Bangladesh garment manufacturers do not deal with the design and the marketing stages, dealing with only "raw materials sourcing to garment manufacturing to shipments at Chittagong port". With the emergence of new competitors, the presence of existing players, and the Bangladesh garment sector no longer enjoying the MFA (Multi Fiber Arrangement) in the US market since 2005; the garment business is increasingly becoming more and more competitive in terms of quality, cost and lead time. In such a competitive environment, many suppliers from China, Hong Kong, India, Sri-Lanka, Vietnam and Turkey etc. are supplying similar or better quality apparel at a reasonable cost. However, an industry that can supply a reduction in the product life cycle will garner more customers, who are time sensitive, over competitors who are still struggling with lead time.

It can be concluded that while several competitors can simultaneously serve higher quality products and at a reasonably low cost, reduced lead time is the last and most important criteria for the industry clientele. So, this study is dedicated to investigating the reasons of long lead time in the supply chain and providing solutions for the Bangladesh Ready-Made-Garment (RMG) industry. In our investigation, these problems are identified in both the backward and forward supply chain links.

6.2 Literature related to lead time

Time has become such a valuable asset that any company that can exploit it can increase its competitiveness to a greater extent than ever before. Timing has become a crucial factor in many aspects of business including but not limited to planning, innovating, manufacturing, selling, distributing, and adopting strategies and policies (Stalk, 1988). Stalk (1988) also suggested that while cost, quality, manufacturability, newness /innovation evolved as a source of competitive advantage, time has positioned itself as the latest weapon to compete in the marketplace.

Martin Christopher (p.149, 1998) also asserted that time has become very important to compete against competitors and the main reason for this change is the change of the customers' awareness and preference for time. In the fashion market, new styles are released frequently, lasting for a short period of time, being replaced by new trends. Thus, end consumers are also becoming more conscious about the latest fashion trends in the apparel market. Now, innovative designers around the world are also bringing new designs to the market with an ever increasing frequency. It has been noticed that a new and fantastic style, which conquered the market in one season (summer/winter),

will also be replaced the following season. So, it's very difficult to forecast whether the same popular fashion trend will continue into the following season. As a result, seasonal and cyclical demands are fluctuating severely. So, it clearly indicates a shortening of the fashion life cycle in the end consumer market.

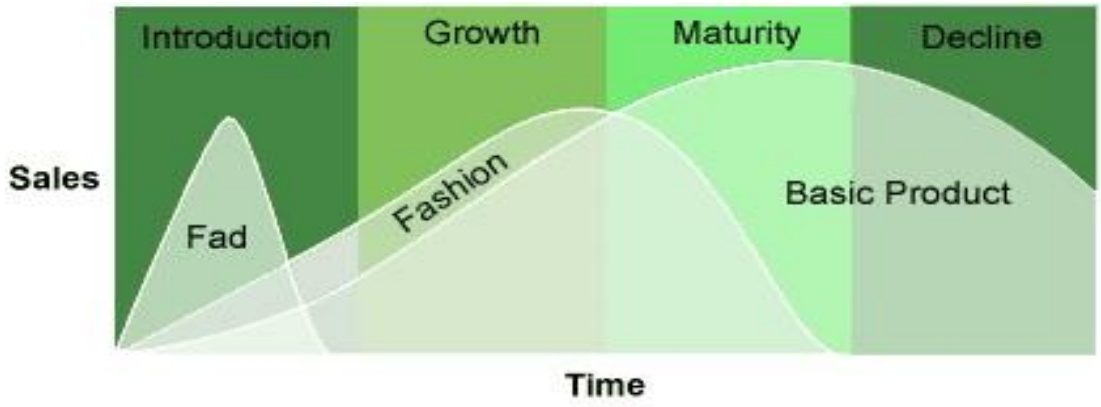


Figure 6. 1: Comparison of life cycle pattern between fashion and basic products (Source: Cornell University, 2013)

Products usually pass through the different stages of the life cycle which requires different planning strategies in order to enhance its success. Each successful product goes through at least the four stages in the product life cycle which are: introduction, growth, maturity and decline. The product life cycle length is also different depending on the product, where the fashion life cycle usually experiences a sharp decline at the end of the growth stage. According to Figure 1 (Cornell University, 2013), the growth stage is noticeably shorter when compared to a basic product. This means that the declining stage starts immediately after its apex in the growth stage, making fashion item inventories very difficult to manage. Due to the sharp decline seen in Figure 1, there is immense pressure on the manufacturing industry to deliver apparel within and short and limited time span. Hence, the lead time for manufacturers is also decreasing.

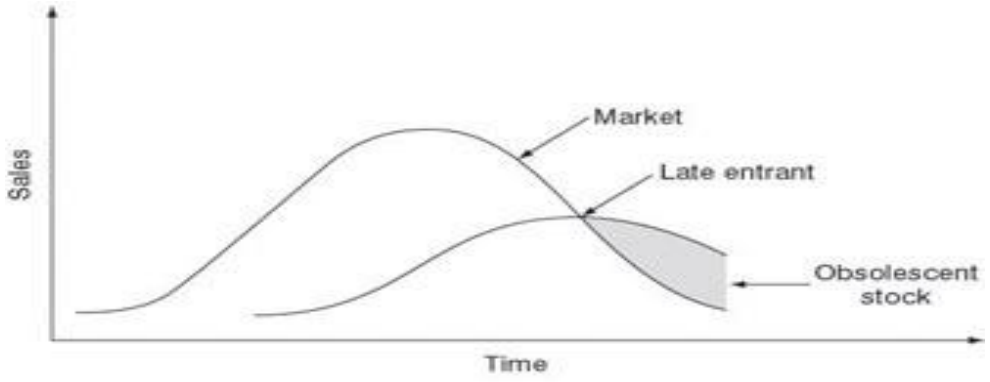


Figure 6. 2: Obsolescence problem for late entrant in the fashion market (Source: Christopher, p.151, 1998)

Christopher (p.151, 1998) explained (see Figure 2) that if any company introduces its apparels in the market later than its trend, it will probably have a huge number of outdated items as shown in the grey area. Owing to these two important factors; short duration of fashion apparels and obsolescence resulted by late delivery (combining with Fig. 1 and Fig. 2), the lead time from designing to market will be shorter and crucial. As Bangladesh garment factories begin manufacturing only after obtaining orders, their concerns revolve mainly around manufacturing lead time. Thus, the time from design to market has become crucial for all fashion garments worldwide.

6.3 Bangladesh garment industry in the global value chain

The apparel industry is a perfect example of a buyer-driven value chain (Gereffi & Memedovic, 2003) and lead firms who are mainly from the United States, Europe and Japan, dominate the market structure in terms manufacturing location(Fernandez-Stark et al., 2011). They also determine the market prices of apparel products.

Fernandez-Stark et al., (2011) classified the global apparel supply chain into five

identifiable sectors: (1) raw material supply, including: natural and synthetic fibers; (2) provision of components, such as the yarns and fabrics manufactured by textile companies; (3) production networks made up of garment factories, including their domestic and overseas subcontractors; (4) export channels established by trade intermediaries; and (5) marketing networks at the retail level. Our analysis shows that the Bangladesh RMG industry is partially involved in the second category and fully (100%) involved in the third category to produce garments as per buyers' orders. How this positioning of the Bangladesh RMG industry makes it profitable is explained in Figure 3.

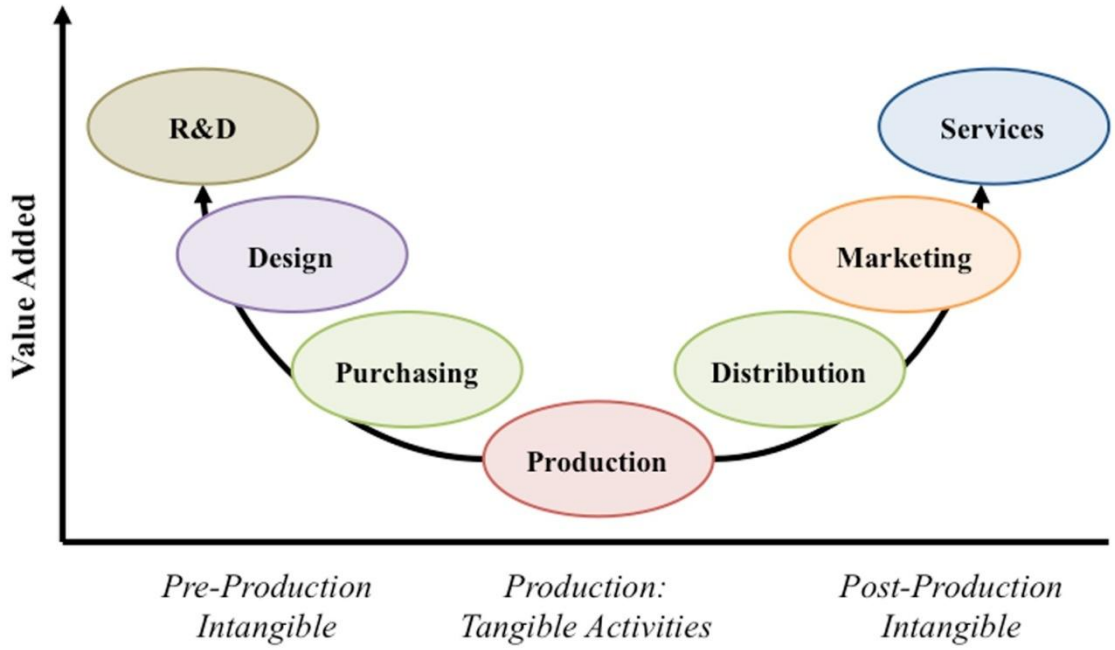


Figure 6. 3: phases of value addition in global apparel value chain

(Source: Frederick, 2010, Fernandez-Stark et al., 2011)

Value added activities are carried out in different stages and this is shown in the above Figure 3. Most top firms from America and Europe carry out new research and

production initiatives with an aesthetic and style design, distribution, market and services which add high value. Thus those top firms obtain the major part of the profits as well. The Bangladesh apparel sector supplies a small portion of woven fabrics as well as a major portion of the knit fabrics. Therefore, the Bangladesh apparel sector carries out its "production" activities in the low value added stage as shown in Figure 3 above. Thus, the Bangladesh RMG must capitalize on cheap labor and quick delivery in the production process within a short lead time in order to turn a profit.

6.4 Concept of lead time in Bangladesh garment industry

Lead time is the duration between the start and ending of a process. Within lead time, every necessary activity is carried out to fulfill a consumer demand and ultimately brings the product within the consumers reach (elsmar, 2013). It includes the elapsed time that starts at the moment an order is placed and the moment when the goods are delivered to the final destination (Chopra, p.317, 2010; Nuruzzaman and Haque, 2009; Christopher, p.157, 1998). In the case of the Bangladesh RMG, we have been informed by the respondents and experts' opinions that lead time is mentioned nowhere in the order confirmation paper. Rather it is implied by two dates; 1) order issue/confirmation date and 2) the shipment date. The time gap between these two dates is treated as lead time in the Bangladesh RMG business. The lead time in this case is somewhat different from that which is described by Chopra (p.317, 2010) and Christopher (p.157, 1998). Chopra and Christopher included shipment time into the lead time equation however, the Bangladesh RMG does not account for that factor. This factor is considered and dealt with by the merchants from Europe and the Americas rather than the garment manufacturers in Bangladesh.

Researchers (Nuruzzaman and Haque, 2009; Antonin, 2013) have divided lead time into two parts such as “information lead time” and “manufacturing lead time”. **Information lead time** includes the time when correspondence between buyers and the RMG factory merchandisers takes place to negotiate about the garments quality, color break down, cost/price per unit, order quantity and required delivery date. **Order lead time** can be defined as starting immediately after the order issue date and spanning up to the last shipment date, in general, at the Chittagong sea port. During manufacturing lead time, factories source/buy fabrics, the main raw material, either from local markets or outsource from China, India, Pakistan, Sri Lanka, Indonesia or other countries. Sourcing fabrics is a big time consuming factor in the RMG business and it’s included in order lead time.

Order lead time plus shipment time is the **replenishment lead time** for the overseas merchants who procure garments from Bangladesh. The less replenishment lead time is allowed, the more pressure there is on every supplier in the supply chain, which is a source of competition among manufacturers (Nuruzzaman and Haque, 2009; Christopher, p.149, 1998). However, any company who can supply with a shortened lead time will increase sales as this gives rise to positive customer response. Another reason for shorter lead time need is the safety inventory which is an idle investment of capital. If lead time can be reduced by “X” percentage then the safety inventory will be reduced by ✓X (Chopra p.326, 2010). Many merchants, including Wal-Mart (Chopra p.326, 2010) are demanding the delivery of garments within a short lead time to reduce their investment in safety inventory in order to minimize idle capital in the business.

Considering expert opinions gathered through phone-discussions, we have identified the key activities that are carried out during order lead time by garment companies in Bangladesh. At first, RMG companies import fabrics from overseas countries, mainly from China, India, Pakistan, Indonesia, Srilanka, Thailand, or buy from local producers in Bangladesh, then manufacture the garments according to the merchant requirements and, finally, ship out at the Chittagong sea port. So, Bangladesh factories mainly have the following components in lead time:

For Bangladesh garments (in general):

Lead time =Fabric manufacturing time+ time to import fabrics+ fabric inspection / other processing + Garments Manufacturing (cutting, sewing, washing, finishing and packing) + Garments Final Inspection and sending to Chittagong sea port + buffer time (woven garments)

Lead time= 25+ 28 +7 + 20+5+5= 90 days

Lead time = manufacturing time of fabrics+ manufacturing time of garments (knit garments)

6.5 Research Questions for the purpose of lead time modeling

On the basis of this literature review, this study was focused to answer the following research questions.

1. What are the crucial factors for long lead time?
2. How long time can be reduced so that it can increase competitiveness of Bangladesh apparel industry?
3. What might be the impact of different policies that can be adopted by the

government and industry players?

6.6 Methodology

Both qualitative and quantitative research strategies were applied to deeply look into the breadth of the research questions and to find their possible solutions. A Quantitative research method was applied for conducting a survey among target respondents in which a well-defined survey questionnaire was used as the research instrument, which was full of close-ended questions. The other set of the questionnaire was distributed among experts which was full of open ended questions. Most merchandisers responded from different factories because they usually deal with lead time including order negotiation and import of necessary raw materials such as fabrics and accessories. Survey questionnaires were developed preceded by a literature research and expert discussion over the phone. The structured questionnaire was composed mostly of "yes/no" and multiple choice questions. The questions for identifying reasons behind long lead time were asked by using a 5-point Likert scale. These questions had the following multiple choice rating scale given by: 1 = strongly disagree, 2 = Disagree, 3 =Neutral, 4 = Agree, 5 =strongly agree.

6.7 Variables and their inter-relationships

Here we define, explain, and show the inter-relationships among the different variables. The variables are listed in Table 1 including their type and measurement units.

The primary strength of the Bangladesh RMG industry is low cost labor availability and good quality in garment sewing. However, respondents of the survey have identified long lead time as the most critical problem to compete against China, India and Sri Lanka. For woven garments, China and India can deliver the products within 50-60 days

and 60-70 days respectively whereas Bangladeshi exporters can deliver within 90-120 days on the average. This long lead time is appearing as a potential threat to the future growth of the apparel industry. The respondents opined that China and India have their own textile factories to produce woven fabrics which have enabled them to deliver within a shorter lead time. Bangladesh textile mills, as the domestic source of woven fabrics, can only supply 40% of the total demand and the other 60% are mostly imported from China, India, Pakistan, Indonesia, Indonesia and Turkey. Contrary to the woven fabrics, Bangladeshi textiles can supply 90% knit fabrics of the total domestic consumption per year. As a result, the knit sector can compete almost equally to the lead time of both China and India. So, this study has identified the lack of woven fabric production in Bangladesh or import from other countries as the major cause of long lead time. It takes about 28 days to import fabrics from overseas countries (count is based on the major source, China). Some experts have suggested that lack of a deep sea port at Chittagong is another determining factor for long time to import as it takes almost one extra week at a Singaporean or Sri-Lankan (Colombo) deep sea port to change ships. At present, only some feeder vessels ply directly from Shanghai to Chittagong, which only covers 10 % of the total shipment of Chittagong Port from China, however, the other 90% of the time, the route through Singapore is employed, where mother vessels unload to feeder vessels.

From the analysis of the survey questionnaires, we have identified two main variables that contribute to the major factors of lead time and where policies can possibly be adopted to reduce it. The domestic supply of fabrics and the deep sea port at Chittagong can drastically reduce lead time as well as build a strong and integrated backward

supply chain of the RMG industry.

Table 6. 1: variables in the lead time management model

Variable name	Type	Measurement unit	
		Woven fabric	Knit fabric
Domestic fabric production	Stock/level	Million meters	Million kgs
Total fabric demand	Stock/level	Million meters	Million kgs
Growth in fabric production	Auxiliary	million meters/ year	mill kgs/year
annual demand increase in fabric consumption	Auxiliary	million meters/ year	mill kgs/year
import requirement	Auxiliary	million meters	mill kilograms
production capacity addition	Flow	million meters	mill kilograms
percent that can work 60 days	Auxiliary	Dimensionless	Dimensionless
import lead time	Auxiliary	Days	Days
demand accumulation	Flow	million meters	mill kilograms
time reduction factor	Auxiliary	Dimensionless	Dimensionless
total lead time reduction	Auxiliary	Days	Days
forecast lead time	Auxiliary	Days	Days
present lead time	Auxiliary	Days	Days
impact of deep sea port	Auxiliary	Days	Days

Based on the survey and its analysis, domestic fabric production (DFP) has been identified as the key stock variable that will determine future lead time. DFP is primarily determined by two factors (see Fig.4). The first factor is the present amount of production which is already taking place in existing textile factories in Bangladesh. The amount of present DFP is collected from the website of the Bangladesh Textile Mills Association (2013). The other factor is growth in fabric production (r) which is calculated on the average growth of production capacity during the last three years.

Thus DFP can be expressed as:

$$DFP(t) = DFP(0)e^{rt} \quad (1)$$

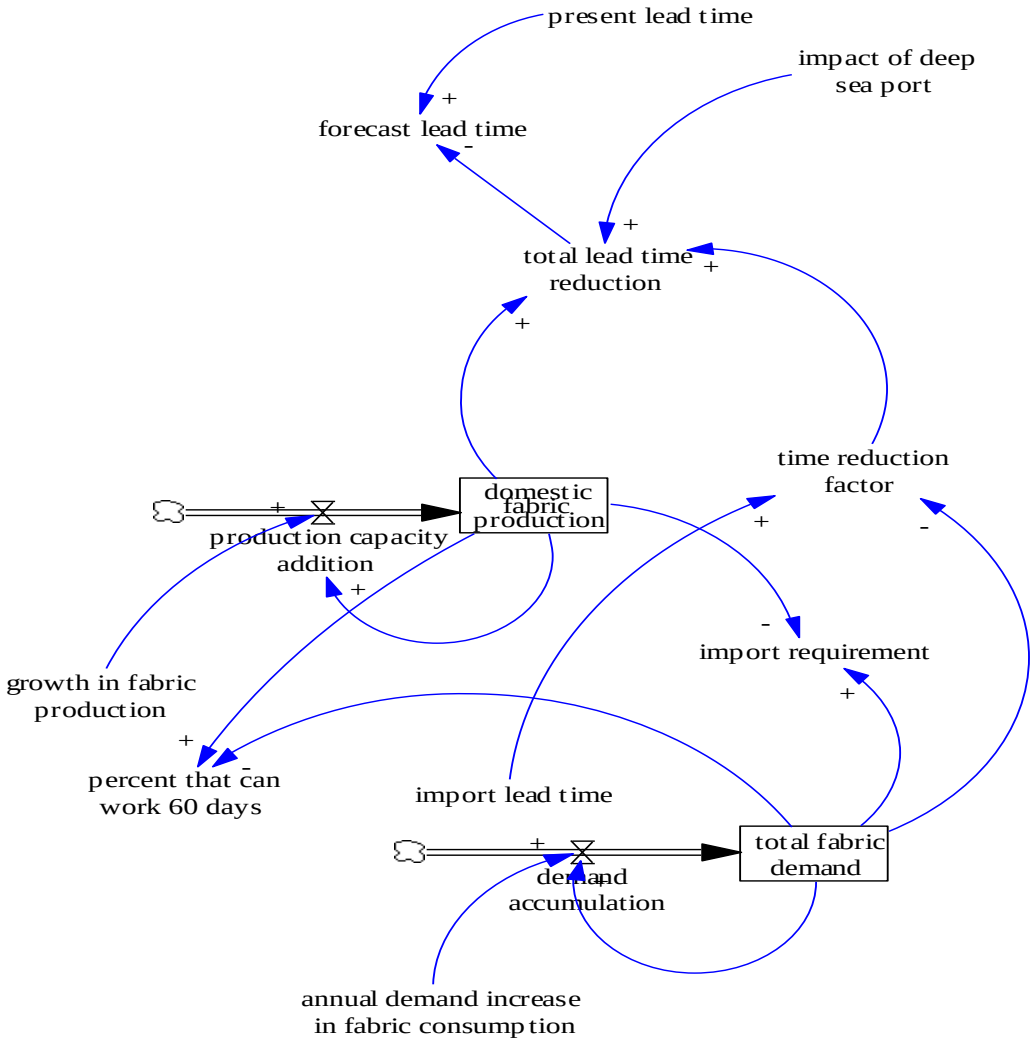


Figure 6. 4: system dynamics diagram for lead time management

After domestic production capacity, the second most influential factor is total fabric demand (TFD) which determines the lead time and import requirements. This demand is increasing every year depending mainly on two factors. First, the number of newly established garment factories is growing and, second, the production capacity is also increasing through their experience, expansion and increase of orders. Forecasted TFD

may be viewed as the total potential for growth of the Bangladesh RMG industry. So, the higher value of TFD for any time and its increasing trend is a good sign for Bangladesh's economy. However, TFD at any time in the future will be characterized by two factors such as present TFD and annual demand increase in fabric consumption (a). The value of "a" is estimated based on the average growth in fabric consumption during the last five years in Bangladesh. Thus TFD (t) at any time is expressed below as:

$$\text{TFD (t)} = TFD(0)\ \text{e}^{at} \quad (2)$$

The import requirement (I_{req}) to meet the total demand TFD (t) is simply the algebraic difference between domestic production and total demand by garment manufacturers. Import requirement (I_{req}) is mainly determined by two other factors of DFP (t) and TFD (t). These two factors are "r" and "a". Government entities or policy makers can manipulate these two growth rates to control future imports and exports. The simulation scenarios manipulating these two variables may be used for policy making.

$$\text{I (t)} = TFD(\text{t}) - \text{DFP (t)} \quad (3)$$

The less the value of "I" is, the less the lead time the apparel sector will be for Bangladeshi exporters which is the top competitive advantage. So, the objective of policy makers should be to minimize I (t) whereas they have to maximize both DFP (t) and TFD (t).

For the sake of analysis, if we assume that all domestically produced fabrics are consumed by some factories to meet their 100% demand and they will not import any fabric from overseas, then we find that those factories can deliver garments within 60

days of lead time as they do not need to wait 28 days for the fabric to arrive. This shows a strength level of the apparel sector revealing a smaller dependence on imported raw material. In this study, the percent of factories that deliver within 60 days of lead time **(η)** is measured below as:

$$\boldsymbol{\eta}(\mathrm{t}) = \frac{DFP\ (t)}{\mathrm{TFD\ (t)}} \mathrm{x}100 \qquad (4)$$

The time reduction factor (TRF) is a ratio which is dependent on import lead time (ILT) and total fabric demand. With the welfare of several local and bilateral trade facilitation initiatives (in forms of reducing trade barriers among nations and improving infrastructure development of international ports etc) we, presently, enjoy fabric import lead times of 28 days and 20 days respectively from China and India while these were respectively 38 days and 28 days just 15 years back. There is only a little scope of further improvement in fabric import lead time through infrastructure development (Chittagong Port's capacity and efficiency and inland roads / waterways capacities to and from Chittagong Port) within the existing system. Albeit it remains as a matter of hope, this will not substantially improve lead time even if it occurs. Hence the remaining alternatives are domestically sufficient fabric supply (which makes input import time zero) and a deep sea port (which will reduce both import time, albeit at a minimum, and export time to a substantial extent (not less than a week)). So, we focus on building textile and fabric production capability and setting a deep sea port.

$$\mathrm{TRF\ (t)} = \frac{\mathrm{ILT}\ (t)}{\mathrm{TFD\ (t)}} \qquad (5)$$

Total lead time reduction (TTR) is the multiplication of domestic fabric production and

the time reduction factor plus the impact of the deep sea port (DSP). TTR is an important objective which is achieved through a controlled growth of the domestic capacity and the imports of fabrics. The deep sea port is another option which will have a very good effect to reduce both import and export lead time. However, for more than a decade there has been many political and social debates in Bangladesh regarding this solution. No government agency has made the decision and started the construction work necessary to construct a deep sea port at Chittagong. That is why this study basically focuses on the enhancement of domestic fabric production capacity to reduce dependence on imports. Simulation results are shown without a deep sea port in the next section.

$$\text{TTR (t)} = TRF\ (t) * DFB\ (t) + DSP \quad (6)$$

The final outcome on which the policy will be based on is the forecasted lead time (LTF). Forecasted lead time is the difference between the present lead time (LT) and the achievement in lead time reduction (TTR). The significant reduction in LTF will be the best policy to adopt.

$$\text{LTF (t)} = LT(0) - TTR(t) \quad (7)$$

6.8 Impact of domestic fabric supply on lead time

We have assumed from the survey analysis that fabric production in Bangladesh is the best solution to reduce lead time. Moreover, growth in domestic textile production capacity will reduce the dependence on other nations from where fabrics are imported as the prime raw material which will also increase the strength in the backward supply

chain link. It is found that domestic fabric production growth is approximately 10% during the last three years and the growth in total fabric consumption is approximately 2.5% in the last five years. This data was collected from the BTMA (2013) and the Global Agricultural Information Network (2013).

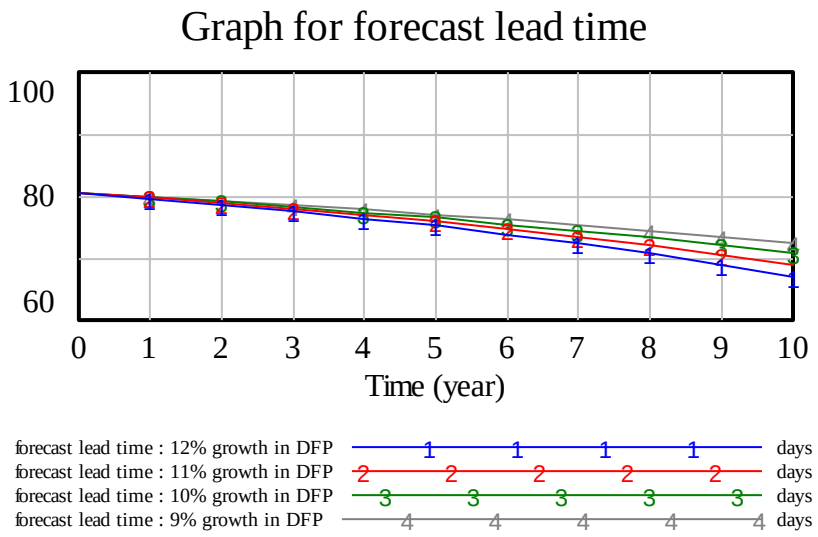
Total fabric consumption has been kept constant at its present growth rate because it seems that the RMG sector has reached its mature phase and growth might not be experienced in an accelerated rate. Experts are saying that growth in total exports of RMG from Bangladesh may suffer because the US and European markets are facing economic recessions. The textile sector can grow more than the present growth rate because there is a huge gap between demand and available production in case of woven fabrics. Data is showing that 90% knit fabrics are supplied from domestic sources; thus we have limited our simulation analysis to woven fabrics. There is a big part of the other 10% of knit fabrics which cannot be easily produced in Bangladesh because those are of special quality and their demand is too small to be feasible to be built a factor or enjoy economies of scale.

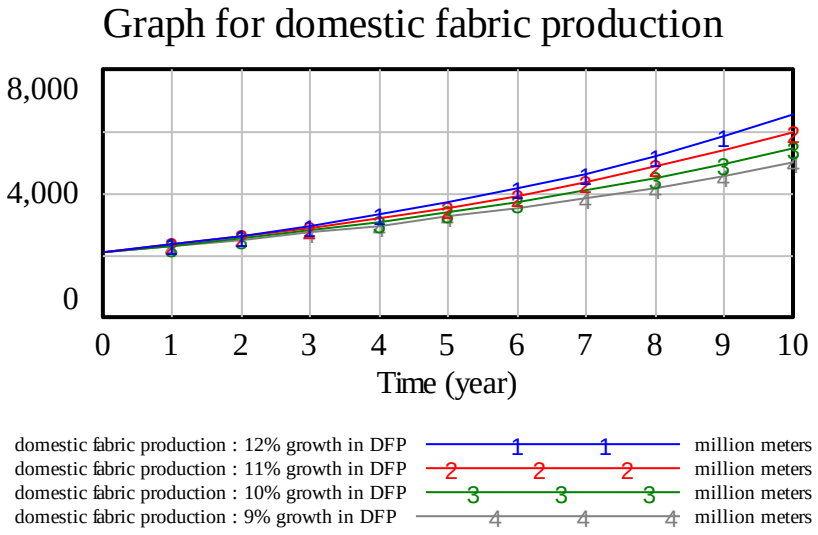
However, we have simulated the parameters assuming four scenarios.

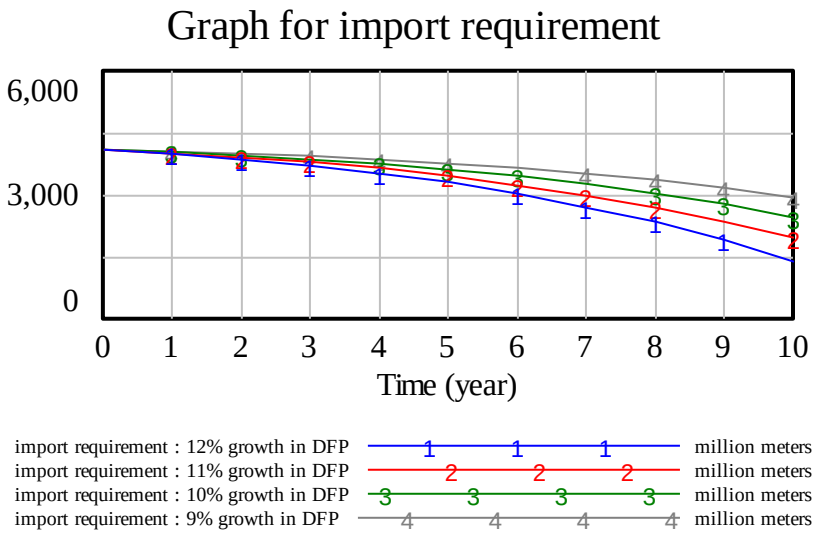
- Scenario 1: growth in domestic production will decrease up to 9%
- Scenario 2: growth in domestic production will continue with at 10% (current scenario)
- Scenario 3: growth in domestic production will increase up to 11%
- Scenario 4: growth in domestic production will increase up to 12%

Table 6. 2: simulated results of four target variables

		scenario 1		scenario 2		scenario 3		scenario 4	
variables	Present (actual)	Year-5	Year-10	Year-5	Year-10	Year-5	Year-10	Year-5	Year-10
LTF	90	77	72	77	71	76	69	75	67
DFP	2100	3231	4972	3382	5447	3539	5963	3701	6522
I	4080	3761	2940	3610	2464	3454	1948	3291	1389
η	33.98	46.21	62.84	48.36	68.85	50.61	75.37	52.93	82.45







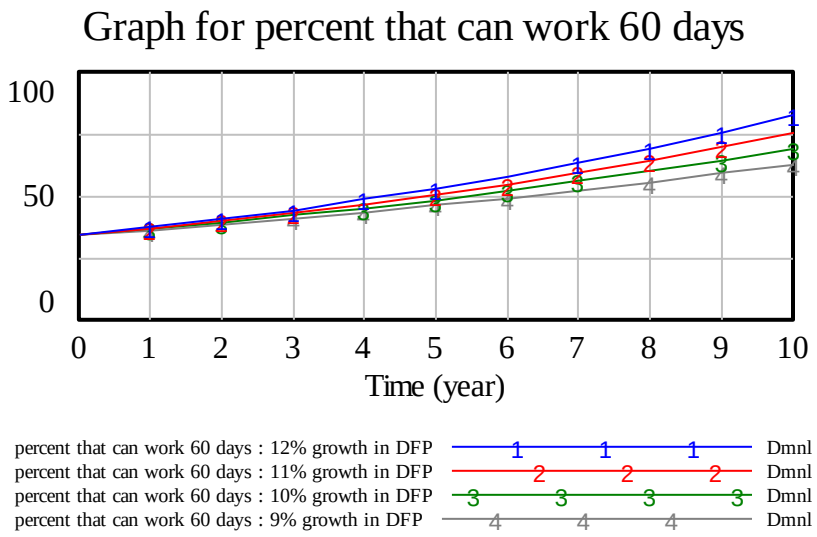


Figure 6. 5: forecasted scenarios of main variables

6.9 Conclusion

This study shows how the fabric supply from inside Bangladesh can reduce total lead time and increase the response of the whole supply chain of the apparel industry. To cope with the increased competition from China and India, Bangladesh has no alternative but to develop a backward linkage of textile mills and a domestic fabric supply. A system dynamics model has been developed to analyze and simulate the

variables that are linked with lead time management. As it's difficult to rapidly change the value of the stock variable, this analysis has shown that it takes at least 10 years to raise the production capacity of fabric to meet about 80% of the total demand. However, government has two choices to follow. The best and inevitable choice is to invest more on textile mills specifically to produce woven fabrics. The second, which is the most probable and facilitating choice, is to build a deep sea port at Chittagong which will further reduce import and export lead time not only for apparel goods but also for other commodities. Thus, the investment in textile mills to produce fabrics is the best policy advice for the time being.

It must be noted that there are some restrictions of this model. It has not taken other affecting factors such as political instability and production cost of fabrics in Bangladesh. Experts have commented that China and India are supplying the same quality fabrics with 6% to 7% cheaper than Bangladesh can. Therefore, the government is expected to be more responsive in ways of e.g. extending Cash Assistance from its present 5%, reducing to a single digit bank interest rate of credit and increasing the time limit in loan repayment for this sector, making ways for Special Textile Zones (Textile Pallis), taking an initiative to create a Special Fund for Technological Up-gradation in this sector and granting some so voiced duty withdrawals and tax exemptions. All these variables could also be modeled but they are not included in this study. However, this model will help to understand the dynamic relationship among the stated variables and to also help build further complex models including the aforementioned additional variables.

Chapter Seven: Conclusion

7.1 Conclusive discussions

The cost, quality and lead time are the most important influencing variables to sell garments to the overseas buyers. While many other competitors from different countries are providing garments with the same quality at reasonably low costs, then reduced lead time becomes the remaining and final criterion to secure sales. Thus, both the sales and supply chain performance can be improved if apparel manufacturing companies can further reduce the lead time. When lead time is reduced, it has a great impact on other key variables such as cost and quality. Not only waste in different processes and departments along the garment supply chain partners can be minimized but also cost may decrease because significantly reduced the inventory cost and capital investment is resulted due to the reduced lead time. As a result, a company can gain more orders from the buyers. The use of information technology (IT) among the supply chain partners and within the planning and operations of internal processes such as pattern making, cutting, sewing and finishing, etc. may to help reduce the lead time. When the use of IT is increased, collaborative planning and process integration also increase. As a result, it helps to reduce uncertainty along the total chain and results in increasing supply chain performance and meeting buyers' order quantities and delivery dates.

The survey responses and depth interviews show that the competitiveness of Bangladesh garment industry is such an important issue that most respondents in the survey ranked it one of top priorities for securing new orders. We also discussed this matter with the experts in the industry. All the respondents agreed that reduction in lead time can help increase industry's competitiveness and sales accordingly. To emphasize

on this point, we included a separate section about lead time reduction strategy in the questionnaire to collect suggestions from the respondents.

The CLD diagram for all variables and the SD model for reducing lead time will hopefully help to maximize the scope of attaining optimum solutions in the supply chain since they show the interdependence among variables and the dynamic behavior of the variables. The CLD shows a complete or apt picture of how the whole supply chain variables are interlinked and how they can be affected by other variables. A department may obtain its optimum objectives even if sub-optimum solutions are taken by other departments or for the whole supply chain.

The system dynamics model can help to achieve local optimum solutions for a global supply chain, through better understanding and policy making. The system dynamics model helps policy makers to understand how to integrate supply chain trading partners in backward and forward linkage to maximize supply chain surplus. Finally, it can help the top management to understand and analyze how the performance variables are inter-related, where to de-couple some performances, and where to emphasize and de-emphasize to achieve the whole supply chain objective.

7.2 Limitations of the research and future research directions

There are some other enabler variables such as data accuracy and introduction of new products, and two other inhibitors, namely, a lack of trust and resistance to change (Agarwal et al., 2005) that can greatly affect supply chain performance. These variables are not considered in this research. Customer satisfaction was also excluded from our

research although it could be used as a result variable. Though customer satisfaction is the measure of availability of garments to the buyers' location when they are required, measuring this index seems to be very difficult in the case of Bangladesh RMG industry given time frame for this research. Thus customer satisfaction has not been considered in our research. Nowadays, green supply chain management has a significant impact on the sales performance of garments in developed countries. But green supply chain has also not been taken into consideration to develop the causal loop diagram and modeling because its exact impact on supply chain performance was difficult to identify for the time being. Separate researches may be carried out to measure and model customer satisfaction, and green supply chain management in Bangladesh RMG as further research. We have considered the cost, quality and delivery (CQD) as the order qualifiers; flexibility has not been considered, though it can have a significant impact on sales or the order winning process. The results of the supply chain models might vary when more variables are included.

As for future research, it seems that compliance issues have become a newly emerging vital factor to attract orders from developed countries after some deadly fire accidents, building collapse and some other types of accidents in Bangladesh garment factories. So, it should be taken into consideration in the future for the sake of growth of the industry. A few more variables such as the effect of research and development (R&D), domestic cotton production, and supply chain complexity can be invoked to model the performance more accurately. Moreover, new components can be added to the proxy parameters for market sensitiveness and process integration as well as lead time.

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Appendices

Sample Questionnaire-01

1. <u>Profile of Respondents</u>

1.1. Name of the garments firm:

……

……

1.2. Address:

……

……

1.3. Name of owner or Managing Director

……

1.4. Name of interviewee:

……

……

1.5. Email:

……

…

1.6. Types of ownership:

□ Single □ Partnership □ Corporation □ Joint-venture with foreign firms

□ Totally Foreign Owned

1.7. If the firm is owned by Joint venture, what is the ratio of foreign partner owns?

□ 1%~49% □ 50%~99%

1.8. Type of products that you produce:

□ knitted garments □woven garments □ both □Others (……....)

1.9. The process of production:

□Cut, Make, & Trim (CMT) □ FOB-1 (including arrangement of input but excluding design) □ FOB-2 (including arrangement of input and design)

<u>2. Background of the RMG firm</u>

2.1. Year of establishment:

□ Before 1985 □ 1985~2004 □ 2005~2012

2.2 What is your Current Capital in BDT?

□ Less than 5 million □ 5 million to less than 10 million □ 10 million to less than 20 Million □ more than 20 million

2.3. How many Employees do you have now?

□ 1~100 □ 101~500 □ 501~1000 □ more than 1000

2.4. Do you use imported raw materials for production?

□Yes □No

2.5. If yes, what is the percentage of your imported raw materials?

□ 1%~20% □21%~50% □51%~80% □ More than 80%

2.6. From which countries, do you import your raw materials?

□China □India □Pakistan □ Central Asia □others (…….)

2.7 Which are your top three markets for exports in terms of export value at present?

(Please put the tick (✔) mark in your desired answer column)

Country	**Export Performance**			
	1st	**2nd**	**3rd**	**Not Significant**
U.S.A				
E.U				
Japan				
Canada				
Mexico				
Australia				
Brazil				
Middle East				
Turkey				
South Africa				
Others (Specify				

2.8. How do you export your products?

□ Export directly □ Export through international traders □ Export through international buyers

2.9. If you export through international traders, could you mention the name of the international firms and it's originate country?

Traders Name	Originate country

2.10. If you export through buyers, which company/companies are your top buyers?

□GAP □H & M □Levi Strauss □Adidas □Target □Children's Place

□Wal-Mart □The William Carter □VF jeans wear □Matalan

□Blue Star □Nike □PVH □C&A □JC Penny □khol's □MGT

□American Marketing □ others (please Specify)…S. Oliver……

Supply chain department background:

3.1 Do you have a dedicated supply chain department?

□Yes □No

3.2 If yes, what is the age of the department?

□ 1~2 year □3~5 years □6-10 years More than 10 years

3.3 Which department does conduct purchasing and sourcing of RM & accessories?

□supply chain □commercial □merchandising □store and warehouse

3.4 Which department does coordinate major functions of your exports?

□supply chain □commercial □merchandising □store and warehouse

3.5 Which department does coordinate major functions of your imports?

□supply chain □commercial □merchandising □store and warehouse

3.6 What are the Order winning criteria from buyers? Please rank them

Please rate the degree of importance and circle the appropriate number (1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 =most important)

Factors	**Ratings**
Lead time reduction	**1 2 3 4 5**
Quality improvement	**1 2 3 4 5**

Cost reduction	**1**	**2**	**3**	**4**	**5**
Service level	**1**	**2**	**3**	**4**	**5**
Customer service	**1**	**2**	**3**	**4**	**5**

4.1 Lead Time Reduction strategy and factors:

What are the factors, you think, contribute to reduce lead time?

Please rate the degree of importance and circle the appropriate number (1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 =most important)

Factors	**Ratings**				
Use of internet, emails & IT, planning software	**1**	**2**	**3**	**4**	**5**
Information sharing with suppliers	**1**	**2**	**3**	**4**	**5**
Information sharing with buyers	**1**	**2**	**3**	**4**	**5**
Training of workers	**1**	**2**	**3**	**4**	**5**
Improvement of quality	**1**	**2**	**3**	**4**	**5**
Upgrading of technology	**1**	**2**	**3**	**4**	**5**
Collaborative(joint) planning with buyers and suppliers	**1**	**2**	**3**	**4**	**5**
Import of Raw materials from overseas	**1**	**2**	**3**	**4**	**5**
Availability of raw materials & accessories in Bangladesh	**1**	**2**	**3**	**4**	**5**
Mutual trust with buyers and suppliers	**1**	**2**	**3**	**4**	**5**
Efficiency increase in production process	**1**	**2**	**3**	**4**	**5**
Availability of vendors	**1**	**2**	**3**	**4**	**5**

Fabrics and accessories are supplied by buyers	**1**	**2**	**3**	**4**	**5**
Fabrics and accessories are sourced by yourself	**1**	**2**	**3**	**4**	**5**
If you have your own textile factory	**1**	**2**	**3**	**4**	**5**
Others (Please specify)	**1**	**2**	**3**	**4**	**5**

Market Sensitivity:

5.1 When do you start manufacturing or procuring any raw materials, accessories?

□before confirm order □ After confirm order □ combination of both

5.2 Do you train and upgrade your managers, technicians, workers to manufacture new & upcoming fashionable and sophisticated items to increase your manufacturability (production efficiency & quality)?

□yes (%) □ no

5.3 Do you procure and use new & sophisticated machineries to improve your chance to win orders from buyers?

□yes (%) □ no

Delivery Speed: (incorporating long-term & short term goal based on customer and market trends)

6.1 What specifications and requirements may be changed in the near future from buyers' side?

Please rate the degree of importance and circle the appropriate number (1 = not possible, 2 = somewhat possible, 3 = possible, 4 = very possible, 5 =most possible)

Factors	**Ratings**				
Lead time reduction	**1**	**2**	**3**	**4**	**5**
Quality improvement	**1**	**2**	**3**	**4**	**5**
Cost minimization	**1**	**2**	**3**	**4**	**5**
Timely shipment	**1**	**2**	**3**	**4**	**5**
Sophisticated items	**1**	**2**	**3**	**4**	**5**

6.2 Do you plan and work at present to meet future changing specifications and requirements of buyers?

Please rate the degree of importance/focus and circle the appropriate number (1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 =most important)

Factors	**Ratings**				
Training of human resource	**1**	**2**	**3**	**4**	**5**
using IT	**1**	**2**	**3**	**4**	**5**
Working together with buyers	**1**	**2**	**3**	**4**	**5**
Working together with suppliers	**1**	**2**	**3**	**4**	**5**
Installing new machineries	**1**	**2**	**3**	**4**	**5**
Sharing more information with buyers	**1**	**2**	**3**	**4**	**5**
Sharing more information with suppliers	**1**	**2**	**3**	**4**	**5**
Building trust with buyers	**1**	**2**	**3**	**4**	**5**
Making stable workers/ reducing turnover	**1**	**2**	**3**	**4**	**5**
Improving production process and efficiency	**1**	**2**	**3**	**4**	**5**

Process Integration

7.1 Do you have few strategically fixed buyers & how many?

□yes (numbers) □ no

7.2 Do you have few strategically fixed suppliers of your raw materials & how many?

□yes (numbers) □ no

7.3 Do your company, your suppliers & buyers work together (any joint team) to solve problems and develop & improve product quality & services?

□yes □ no

7.4 Do you continuously provide updated information of your production and inventory status to your buyers and suppliers?

□yes □ no

7.5 Do you work for process integration with buyers and suppliers?

Please rate the degree of importance and circle the appropriate number (1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 =most important)

Factors	Ratings				
provide related information to your suppliers on time	**1**	**2**	**3**	**4**	**5**
Provide feedback information to buyers	**1**	**2**	**3**	**4**	**5**
Work together with buyers to improve quality, efficiency	**1**	**2**	**3**	**4**	**5**
Work together with suppliers to improve quality, efficiency	**1**	**2**	**3**	**4**	**5**

Collaborative planning:

8.1 Do you have centralized coordination team/dept among your factories, production floors?

□yes □ no

8.2 Do your buyers inform you well advance if a product design or specification is changed?

□yes □ no

8.3 Do your buyers inform you well advance about the seasonal demand and fashion changes?

□yes □ no

8.4 Do you inform your buyer about your production status regularly?

□yes □ no

8.5 Do your suppliers inform you about their production status regularly?

□yes □ no

8.6 Do you inform your suppliers well advance if a product design or specification is changed?

□yes □ no

Use of IT (software & hardware)

IT on purchasing & vendor relationship

9.1 Do you negotiate & obtain price quotations from suppliers through internet?

□yes (%) □ no

9.2 Which means do you use to get samples from suppliers?

□Through internet negotiation (%) □ Through face-to-face negotiation (…%)

9.3 Do you place orders through emails & electronic media or paper orders?

□internet/email (%) □ Through paper orders (…%)

IT on operation

9.4 Do you use any specialized software in your operation?

1. Cutting section 2. Inventory or w/h 3. Production planning 4. Any other

9.5 If you use any software then name those please.

□ □ □ □

9.6 Do you use ERP software for production planning?

□yes □ no

9.7 Do you use any software for marker or cutting section?

□yes □ no

9.8 If "yes" then why do you use it?

□for reducing of waste □ quick work/shipment □ for both

9.9 Do you use any software for maintaining warehouse and ram materials?

□yes □ no

IT on buyer relationship

9.10 Do you negotiate & obtain price quotations from buyers through internet?

□yes (%) □ no

9.11 Which means do you use to get samples from buyers?

□Through internet negotiation (%) □ Through face-to-face negotiation (…%)

9.12 Do your buyers place orders through emails & electronic media or paper orders?

□internet/email (%) □ Through paper orders (…%)

Uncertainty:

10.1 How many times you could ship the exact quantity that was ordered by the buyers?

□ 80-90% □ 91-94% □ 95-97% □ 98-100%

10.2 How many times you shipped as part-shipments?

□ 1-5% □ 6-10% □ 11-15% □ 16-20%

10.3 How many times you shipped out within the range of order conditions?

□ 80-90% □ 91-94% □ 95-97% □ 98-100%

10.4 How many times your orders were cancelled after receiving confirmation?

□ 0% □1-5% □ 6-10% □ 11-15% □ 16-20%

10.5 How many times your domestic suppliers could deliver you the exact quantity that you required?

□ 70-80% □ 81-90% □ 91-95% □ 96-100%

10.6 How many times your overseas suppliers could deliver you the exact quantity that you required?

□ 70-80% □ 81-90% □ 91-95% □ 96-100%

10.7 How many times you can ship out within the initial lead time?

□ 70-80% □ 81-90% □ 91-95% □ 96-100%

10.8 How many times you applied for shipment date extension from your buyers?

□ 10-20% □ 21-30% 31-40% □ 41-50%

10.9 How many times your buyers change quantity and measurement specifications or designs after confirm order?

□ 1-10% □ 11-20% □ 21-30% □ 31-40% □ 41-50

10.10 How many times you had to delay at customs and Sea-port?

□ 1-5% □ 6-10% □ 11-20% □ 21-30%

10.11please rate the causes of your shipment uncertainty regarding quantity, quality & shipment date.

(1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 =most important)

Factors	**Ratings**				
Lack of Production efficiency & productivity	**1**	**2**	**3**	**4**	**5**
Sophisticated items	**1**	**2**	**3**	**4**	**5**
Suppliers' distance from your factory	**1**	**2**	**3**	**4**	**5**
Poor sewing quality	**1**	**2**	**3**	**4**	**5**
Poor fabric supplied by your supplier	**1**	**2**	**3**	**4**	**5**
Specify any other reasons please	**1**	**2**	**3**	**4**	**5**

Customer satisfaction:

11.1 What are the most critical factors for your buyers' satisfaction?

(1 = not important, 2 = somewhat important, 3 = important, 4 = very important, 5 =most important)

Factors	**Ratings**				
Low Lead time	**1**	**2**	**3**	**4**	**5**
Quality improvement	**1**	**2**	**3**	**4**	**5**
Cost minimization	**1**	**2**	**3**	**4**	**5**
Ability to sew/make fashionable and complicated items	**1**	**2**	**3**	**4**	**5**

Green & reverse Supply chain:

12.1 a) Have you obtained ISO 14000 series certification regarding environment standard?

□yes □ no

12.1 b) If "No": then are you planning or practicing rules to obtain ISO 14000 certification?

□yes □ no

12.2 What percentage of your foreign suppliers have ISO 14000 certification?

□ 0-20% □ 21-30% □31-50% □51-80% □81-100%

12.3 What percentage of your domestic suppliers have ISO 14000 certification?

□ 0-20% □ 21-30% □31-50% □51-80% □81-100%

12.4 What do you do with your rejected items?

12.5 Do you return the defective items to your domestic suppliers?

12.6 Do you return the defective items to your overseas suppliers?

Sample Questionnaire-02

1.1. Name of the garment firm:

1.2. Name of interviewee and email (if possible):

2.1 Types of garments that your company produces:

a. Woven: ……% (Average)
b. Knit: ……% (Average)

2.2 From where, does your company import raw materials (fabric)?

Country	What percentage of your fabrics from	Time to import fabrics (in days)
China		
India		
Pakistan		
Indonesia		
Turkey		
Japan		

2.3 Average lead time (**from order issue date to shipment date**) that your company takes from foreign buyers:

	Recently (days)	5 years ago	10 years ago
Woven products			
For Knit products			

2.4 Please indicate your company's raw material sourcing strategy:

	Import from overseas countries (%)	Buy from Bangladeshi textiles & suppliers (%)
Woven fabric		
Knit fabric		
Accessories		

2.5 Do your company has own textile factory to manufacture fabrics?

a. yes b. no

2.6 If you have your own textile factory then what percentage does it supply of your fabrics' demand?

Answer:…….%

2.7 Are your buyers asking to reduce lead time?

a. Yes…….b. No

2.8 If your buyers are asking for reduced lead time then what are reasons? (Tick all that you think reasonable)

□To reduce risk of being outdated/old fashion

□To make more profits by selling new designs before competitors bring in market

□ Reduce Letter of Credit or other financing/banking costs

□ Fashions are changing quickly

2.9 Comment on the following statements of **reasons for long lead time** of your company? Please rate the degree of importance and circle the appropriate number

(1 = strongly disagree, 2 = Disagree, 3 =Neutral, 4 = Agree, 5 =strongly agree)

Reasons of long/short lead time	**Opinion**				
Import of fabrics from other countries	1	2	3	4	5
Import of accessories from other countries	1	2	3	4	5
Inefficiency of loading and unloading at Chittagong sea port	1	2	3	4	5
Lack of deep sea-port in Bangladesh	1	2	3	4	5
Inefficiency of workers in the production processes	1	2	3	4	5
Political instability (Hartals, strikes)	1	2	3	4	5
Procedural complexity at customs department	1	2	3	4	5
Having own textile factory to produce fabrics	1	2	3	4	5

2.10 Do you think that you will get more orders if your company can reduce lead time by 10-15 days?

a) Yes b) No

2.11 How much more order could be gained if lead time is reduced by another 10-15 days?

a. 0-10% b. 11-20% c. 21-30% d. more than 30%