ORIGINAL RESEARCH:

A system dynamics approach to supply chain performance analysis of the ready-made-garment industry in Bangladesh

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Abstract

The ready-made garment (RMG) industry has recently occupied the largest part of exports and foreign currency in Bangladesh and has been for more than a decade the second largest contributor to gross domestic product (GDP). Millions of poor women and men are employed in this industry. However, a supporting import quota system in the USA was stopped in 2005 which has left the RMG sector struggling against new challenges that need to be properly addressed. As the end consumers of the apparel fashion market are becoming increasingly time-sensitive, a decrease in lead time, besides quality and cost criteria, is needed to win more orders from buyers. We have examined the opportunity that lies in an integrated supply chain to provide a competitive advantage to the Bangladesh RMG sector. 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 RMG sector. A survey and individual interviews were conducted with 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 the top management may take effective decisions in order to enhance the supply chain performance in the long run.

Keywords: Bangladesh, Causal loop diagram, Integrated supply chain, Lead time, Ready-made garment industry, System dynamics analysis

Introduction

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

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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 for 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 of 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 vendors' manufacturing expertise and other R&D assets to design new products at lower costs through collaboration among trading partners.

SCM in the RMG Sector:

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 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. The primary purpose of the study is to identify the interdependence and dynamic behavior that exists among supply chain performance variables.

Methodology

A questionnaire was designed as a survey instrument. The questionnaire included both closed ended and open ended questions. We asked respondents to indicate the importance of supply chain performance variables using a five-point Likert scale. We also carried out separate depth-interviews with one managing director and owner, one general manager, one merchandising manager and one factory manager from different garment factories to construct the causal loop diagram among supply chain performance variables.

Modeling using System Dynamics:

System Dynamics has evolved mainly from industrial dynamics which 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 that's why it is 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 which are not easily measureable such as human behavior, customer satisfaction, and employee skills. Simulation of intangible factors is sometimes called strategic simulation because it doesn't 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 which 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 between stocks and flows as well as among 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).

Table 1: Definitions of 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 of 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)

Variables of the system dynamics model for RMG in Bangladesh:

After the 'multi fiber arrangement' (MFA) phased out in 2005, the Bangladesh RMG industry had to compete with all other apparel manufacturers and suppliers 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 reduced costs while buyers from Europe emphasize on high quality and fashionable products, but also 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 1).

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 respondents of the sampled factories to collect their opinions. Factors associated with each variable have been listed in the Table 2.

Table 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 to 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 on 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. 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?

Findings and Discussion

There are several loops among supply chain performance variables in the casual loop diagram (Figure 1), 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).

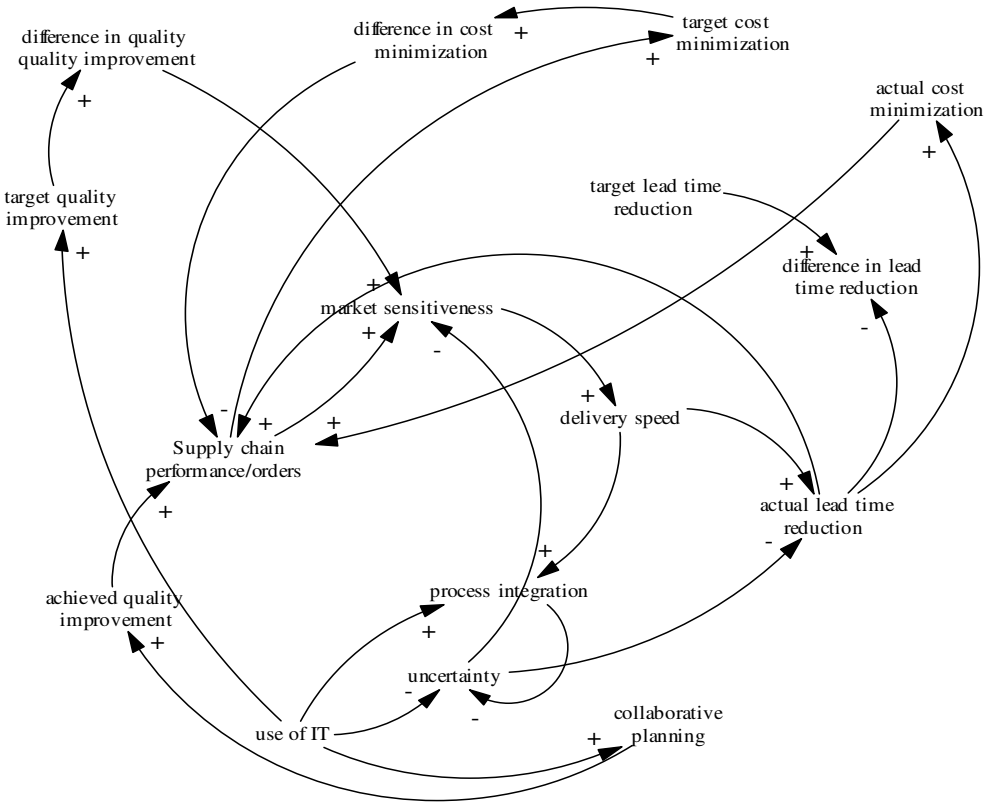

Figure 1. Causal loop diagram among variables in the RMG supply chain (see text for explanation)

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.

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).

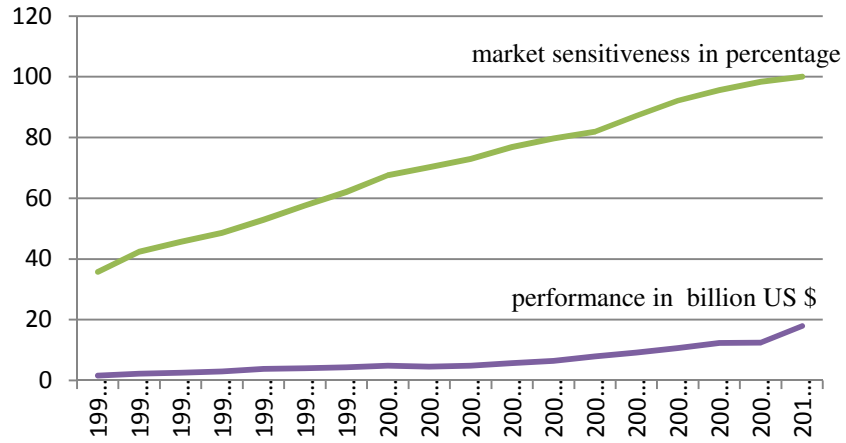

Figure 2. The relationship between market sensitiveness and supply chain performance

Since fabrics 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.

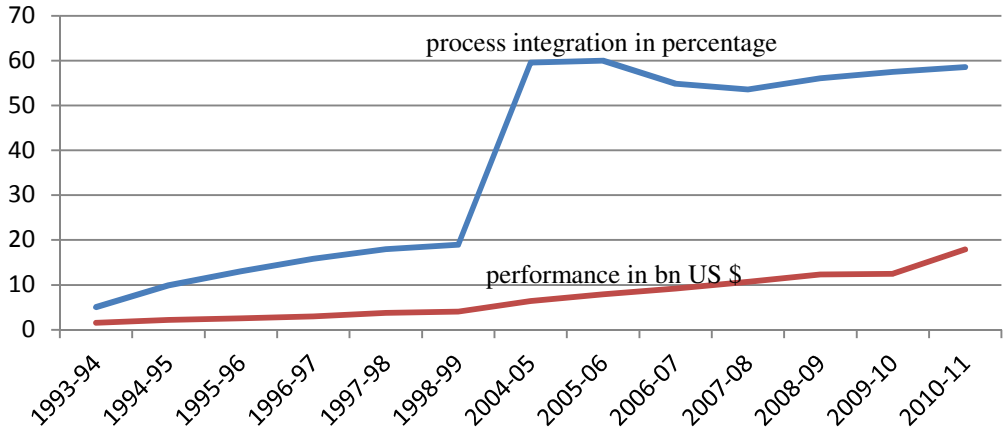

Figure 3. The relationship between process integration and supply chain performance

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).

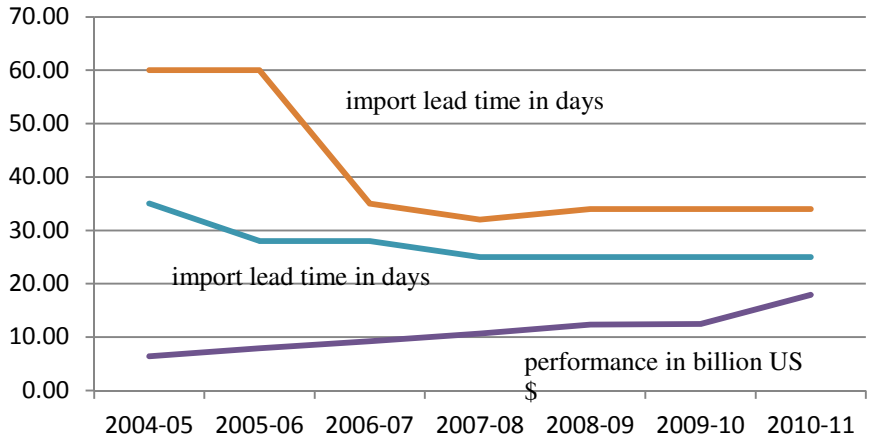

Figure 4. The relationship among import and export lead times and supply chain performance

Limitations of research:

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 affect supply chain performance. These variables are not considered in our research. Customer satisfaction was also excluded from our research though 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. 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 because its exact impact on supply chain performance was difficult to identify. 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.

Conclusion

The cost, quality and lead time are the most important result variables to sell garments to the buyers. While other competitors from different countries are providing garments with the same quality and at reasonably low costs, reduced lead time becomes the 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. If lead time is reduced, then not only waste in different processes and departments along the garment supply chain partners can be minimized but also cost may decrease because the inventory cost and capital investment decrease. 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 like pattern making, cutting, sewing and finishing, etc. may 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 agreed that lead time reduction can help increase industry's competitiveness and sales accordingly. To emphasize on the point, we have included a separate section about lead time reduction strategy in the questionnaire to collect suggestions from the respondents.

This model helps to maximize the scope of attaining optimum solutions in the supply chain since it shows 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 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.

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 fires and accidents in Bangladesh garment factories. So, it should be taken into consideration in the future 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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