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# Impact of Information Exchange on Supply chain Strategies

## School of Engineering and Information Science

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Submitted in partial fulfilment of the requirements for PhD degree

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I

# Abstract

Due to globalisation and the competition faced from Asian countries, there is an emergent need to investigate how to extend the limited capabilities of developing countries in order to survive in the market as well as reach global market. Developing countries play an important role as OEM units to provide global markets with under-brand names. Many difficulties face the industrial zones in these countries in their attempt to reach this target and these prevent them from providing their own brands. For example, many sectors in Egyptian industry are outperformed by Chinese competition and have even lost their domestic market share. Textiles are one of the most affected industries as a result of this competition. The risk of Egyptian fabrics vanishing from global markets is indicated by a huge reduction in export rate after the quota phase-out. Egyptian textile producers rely on global agreements to reach global markets. The period after the Multi-Fibre agreement shows an obvious drop in exportation rates till the Qualified Industrial Zones (QIZ) agreement was issued. Can the same scenario occur after QIZ quota phase-out? What should Egyptian fabric manufacturer do? Since the situation is alarming and may result in exporting the high quality Egyptian cotton to global markets instead of to its domestic manufacturers, the flood of Chinese fabrics in Egyptian Markets requires that the question "how to survive and compete with low-cost Chinese fabrics?" be investigated.

The aim of the research was to investigate the deficiencies experienced by Egyptian firms trying to reach global markets and maintain their domestic market share. The research conducted an exploratory-explanatory empirical study to identify the major issues facing textile fabricators in Egyptian industrial zones. Case studies and a survey outcome were matched to provide validated empirical findings. An Interpretive Structuring Modelling approach was used to indicate the stages of supply chain deficiencies based on the case study findings. The major issues causing supply chain deficiencies are defined from the case study analysis and validated using the survey approach. The outcome of the empirical study indicates that supply chain design, integration and IT infrastructure are considered as major issues that lead to the existing deficiencies of the textile industry supply chain in Egypt despite the low level assigned to their importance. At the same time, production and procurement issues are considered as dependant on poor supply chain design, IT infrastructure and unreliable forecasting despite the high level assigned to their importance. A stage-based model for supply chain deficiencies in the Egyptian textile sector was highlighted in this study to indicate dependency and driving power among internal

deficiencies. A framework, indicates supply chain deficiencies and their leading factors in Egypt, was concluded from this study. The study points out a number of external issues related to the surrounding environment and the government's role in contributing to the aggravation of the existing deficiencies. The research uses simulation techniques to test the proposed solution that might provide better supply chain performance. A System Dynamic approach is used to model a case study of the investigated industry. Different scenarios of fulfilling local and international orders have been tested. These scenarios are represented in: expansion of production capacity, reduction of inventory levels or reduction of procurement time. Since addressing the internal deficiency, which empirical study respondents' pointed out as being the most important one, could not provide an adaquate solution for the existing deficiencies, supply chain re-structuring to represent a collaborative pattern between partners was, therefore, tested and proved to have a great effect on supply chain performance. A collaborative pattern among supply chain partners indicated its positive impact on supply chain performance. The simulation experiments prove that the individual decisions of supply chain partners cannot bring about improvement to supply chain cost and responsiveness. The negative impact of an unreliable logistic system on supply chain performance was confirmed through the simulation experiments.

The study provides the managerial levels in textile organisations with a solid causal basis for the supply chain deficiencies in the Egyptian textile sector. The outcome of the work can be employed by governmental authorities to address such difficulties and accelerate the growth of this sector globally. The thesis provides the fundamentals for investigating deficiencies in developing countries that might be extended by other researchers to investigate other defective sectors in Egypt and other developing countries.

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# DEDICATION

*To my beloved strengthening great Father,*
*My Compassionate Caring incredible Mother,*
*My loving Caring Sister,*
*And my Beloved Brother.*

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# Glossary

| | |
|---|---|
| **GSP** | Generalized system of Preferences to European community |
| **OEM** | Original Equipment Manufacturing |
| **ODM** | Original Design Manufacturing |
| **SCM** | Supply Chain Management |
| **BTO** | Build-to-Order |
| **MTS** | Make-to-Stock |
| **SC** | Supply Chain |
| **SCIS** | Supply Chain Information System |
| **IOS** | Interorganisational system |
| **CPFR** | Collaborative Planning Forecasting and Replenishment |
| **ISM** | Interpretive Structural Modelling |
| **VMI** | Vendor Managed Inventory |
| **JIT** | Just-in-time |
| **SD** | System Dynamic |
| **ERP** | Enterprise resource planning |
| **TMS** | Transportation Management system |
| **UNCTAD/WTO** | United Nation Conference on Trade & Development |

# Chapter One

## Introduction

Industrial organisations attempt to gain a market share in the current competitive environment, while developing countries attempt to accelerate their performance in order to reach global market expectations and gain their market share. In order to participate in global markets, firms have the limited options of either providing domestic products that might not attain large popularity in global markets ahead of Chinese competition or playing the role of producer under foreign licence. In the aforementioned countries, firms have to justify their selection based on the pros and cons of each decision. In adapting this policy to the Egyptian textile sector, leading firms decided to sacrifice their own brand identity and carry out their role under foreign rules and brands. Global trade agreements have provided these organisations with the opportunity to access international marketplaces. However, a dilemma arises after the quota phase-out; multi-fibre agreements followed by a Qualified Industrial Zone (QIZ) agreement can provide a better chance for firms to participate in global markets especially using US safeguards in preference to Chinese products. The question that posses itself is what is going to happen following quota-phase-out and facing Chinese products? Have Egyptian firms planned for this stage?

In the Trade and Development Index (TDI) (2007) Egypt was ranked 97th while China was ranked 25th in 2006. TDI is used as a comparative study among countries to evaluate a combination of trade and development performance. According to this report, China and India show rapid growth in their economies. Studies reveal that the expectation for 2009 is that the 72% of firms in North America will depend on Chinese sources to provide their goods (Blanchard, 2007) A Study conducted by Adewole (2005) indicated that competition from alternative products from overseas had badly affected the business of SME's in the UK clothing industry, due to US safeguards towards Chinese fabrics, which limit its growth to 7.5 % of the 2005 rate (Office of Textiles and Apparel, 2004). Hence the replacement of Chinese products has become a target for developing countries to reach in developed markets. This had been translated into industrial competition between developing countries that can provide better service to global markets. These countries are trying to emulate the success of newly

industrialised East Asian countries (NICs). While countries like China, get the benefit of low cost labour and can invest more in automated plants to achieve its industrial strength, countries like Egypt-as an example of other developing countries, enjoy a low wage advantage but could not achieve such success despite its location near global markets (Magder, 2005).

Due to the fact that leading firms face challenges to increase their productivity, reduce costs and improve product quality while improving their profitability, full-package producers have placed their main operations offshore, often locating manufacturing units in developing countries. For U.S. companies, for example, a 50 percent on labour cost saving is the reason why they have moved production offshore (Blanchard, 2007). Availability of materials and reduced labour costs are the main factors which enable developing countries to capture investor's interests. At the same time, rules about product design and quality assurance are still the role of leading firms. It is for this reason that, in some cases and in order to ensure quality, developing countries do outsource product material from abroad. So the role of many industrial zones like the Egyptian one have been turned to import, manipulate and re-export materials based on international demands. This is referred to as original equipment manufacturers (OEMs) which provides products under a 'buyer' brand name. Since the industrial organisation in developing countries face many issues related to unstable economy, poor technological capabilities, limited infrastructure and lack of trust between partners (Orala, koglub and Erdisc, 2003) (Han, Kwon, Bae and Sung' 2002), these organisations, therefore, experience many difficulties to reach the global market and provide service that are of appropriate standard.

Chinese firms admit that playing the role of OEM, has enabled these firms to acquire much needed experience and develop the "brand providing" strategy (Kaibin, 2008). The driving force behind these steps is an increased profit margin; *BusinessWeek* refers to the profit of the top 100 OEMs in Asia-Pacific as only $4 billion (Wreden, 2004). China reaps the benefit of playing the role of their units as OEM for developed markets and expands the manufacturing base to provide their domestic brands globally and become ODM (original design manufacturing). (Blanchard, 2007) (Wreden, 2004). Could Egypt deploy its resources in order to take such a step?

The location of Egypt near global markets provides a competitive advantage, however, the reliability of logistics service is so important that it may lead China - with its growing logistics infrastructure - to get a larger portion of foreign investments and of the global market share. Foreign leading firms believe that to "*wait too long to develop right strategy or skill set could mean losing competitive advantages*" (Blanchard, 2007). As a consequence, developing countries have to apply "*supplier-oriented industrial upgrading*" to provide more qualified channels for global markets. (Magder, 2005)

These facts point to a number of internal and external issues that the textile industry in Egypt suffers from. The labour force has not received tangible advantages from governmental intervention despite its role as a major industry. By 2007, two of the biggest textile factories owned by the state were plagued by strikes with workers demanding higher wages. (Schemm, 2007). Governmental policies have had a great effect on the existing business climate. The Government initiated its tariff reduction decree in 2004 on imported textile based on US request and WTO commitment. The tariffs officially announced represent a weight average from 14.6 % to 9.1 % (Dean el al., 2006).The sudden tariff reduction of machinery and production inputs hindered Egyptian firms from stemming a huge flow of Chinese fabric into local markets. Furthermore, the reduction of tariff apparel from 60% to 40% in 2004 and currently to 30% in 2009 supported the rapid growth of Chinese fabric in Egyptian market and caused Egyptian fabrics to disappear. Additionally, due to the cotton export strategy of the Egyptian government, local firm's procurement of Egyptian cotton declined from 125K Egyptian Pound to 16K Egyptian Pound by 2008/2009 while imported cotton surged to reach 31.7K Tons by 2009. By 2008/2009, industrial reports of an Egyptian cotton dilemma indicates a declining rate of Egyptian cotton export rate due to the world crises, coupled with a reduced rate of deliveries to local spinners (EgyTex, 2008).

The Country's infrastructure is another barrier facing industrial organisation in Egypt. Magder (2005) indicated that the country's infrastructure poses more challenges for exporters: "*Ports and road infrastructure are generally poor, and efficiency is low. High tariff on trucks causes their price to be double the price in the United States, forcing companies to keep their trucks longer*". The Logistics system is associated with the poor infrastructure. While the lack of co-

ordination inside port operation is illustrated in containers leaving the country empty (Magder, 2005).

The move of Egyptian producers toward providing their own domestic product globally should be advanced with a restructuring process, improvement in the existing supply chain activities and dealing with the external issues in order not to end in abject failures. A large number of Chinese firms, which attempt to provide their own brand through ODM, have moved back to the OEM manufacturing phase. The competitive environment and the danger of Egyptian fabric vanishing show the need for upgrading the Egyptian textile sector's current industrial capabilities in order to acquire more foreign firm investment (Magder, 2005)**,**(Asian Development Bank, 2006).

## 1.1. Research Problem

To address the challenges faced by industrial organisations, a metric proposed by Naylor et al. (1999) will be considered to measure customer value using a number of parameters. These parameters are: service, quality, cost and lead-time. Since there is an increased awareness of customer-centric business models and of how to optimise whole chain activities instead of focusing on one entire enterprise, therefore, this matrix emphasises the importance of fulfilling customer demands accurately, rapidly and maintaining reliable delivery dates of end customers.  Can the industrial organisations in developing countries provide the rapid fulfilment of domestic and overseas demands despite their limited capabilities? Should the organisations in these countries pay attention to partner co-ordination as a prerequisite of participating in global supply chain? Enhancing collaboration between supply chain partners is considered the only way to apply customer centric models. Industrial organisations have to improve their relationships and interdependencies with the other business partners in order to respond rapidly to consumer demands. As a result, a new model of competition has been driven, which no longer has individual organisations competing with each other but with supply chain networks. (Jones and Towill, 1997), (Patnayakuni, Patnayakun and Rai, 2003), (Naylor, Naim  and Berry, 1999), (Sudhindra, 2001)

Regarding developing countries and despite the significant amount of subcomponent and final assembly that occurs there, few researchers have investigated the role and issues experienced by the mills in these countries attempting to participate in a global chain. In addition, the buy-to- order and make-to-order strategies which are applied by an OEM to fulfil customised orders and the capability of these countries to provide tailored products in accordance with international standards have emerged for discussion in further research.

Due to these gaps, the main objective of this research is the investigation of the challenges and issues faced by Egyptian industrial zones. These challenges will be explored within different supply chain strategies. The relationships between these issues will be explored as well to indicate the dependencies and the driving powers. After the initial survey work a final set of research questions are formulated:

*1. "What are the challenges that face the successful implementation of the supply chain in Egyptian Textile sector?"*

> *A-"What is the cycle of supply chain deficiency in the Egyptian Textile industry?"*

> *B-"What are the major deficiencies that lead to other supply chain deficiencies in the Egyptian Textile sector?"*

> *C- "What are the minor deficiencies that occur as consequences of other supply chain deficiencies in the Egyptian Textile sector?"*

> *D- "Do the external issues aggravate the internal deficiencies of supply chain activities in the Egyptian textile sector?"*

The research will investigate the possible solution that might be considered to improve supply chain performance. So the following question will be addressed as well:

*2. "What is the best solution that can provide the textile supply chain in Egypt with rapid responsiveness and cost reduction?"*

In order to explore such problems, the research will define an industrial sector to investigate, while different case studies in various sectors are conducted. The textile, food and steel industries represent the selection for a pilot study to choose the industry most impacted by current Chinese competition. The selection of such industries is based on their economical

strength in terms of either exports, production, or employment. The Textile industry was selected for further investigation as it is one of the most promising industries to contribute to global supply chains because of its previous record of rapidly growing proportion of world trade. Besides, a number of international investors are using Egyptian mills to provide tailored products through QIZ (qualified industrial zones) and GSP (Generalized system of preferential to European community) agreements. The QIZ framework is indicated by Egyptian producers as the major channel for more than 600 textile firm to reach US market and gain more advantages. The recent tariff reduction is the obvious role it provides.

The investigating of such sectors should provide the reasons behind the reduction indicated in the investment reports of 2006/07 and 2007/08. These reports indicate a reduced rate of new investment in the textile sector by 46% while the governmental investment in existing textile miles was reduced by 4% . (Periodic Report Jan 2008- Ministry of Investment, Egypt).

The patterns of information sharing and partnership between supply chain partners will be investigated due to their impact on supply chain performance. While real time information loses its value over time, supply chains should employ this source of information as a critical asset for supply chain integration and real time exchange. (Jones and Towill, 1997). Handfield discovered that to put information sharing into practice, a high degree of trust among supply chain partners is required (Kwon and Suh, 2005).  Kwon and Suh (2005) conducted a study to determine the effect of the relationships between the level of trust, behaviour uncertainty and informational sharing. They proved that unpredictable behaviour and information sharing highly affect the level of trust.  *Real SCM is not a software package; rather it is the collaborative management across organisational boundaries of seamless value-added processes designed to meet the needs of the supply chain's end customer.*" (Fawcett, Ogden, Magnan and Cooper, 2006).  Salman (2004) did point out that in developing countries, "Companies would not feel secure when they do share sensitive information and work together to solve business problems or invest together in common long-term benefits". Information sharing issues with global partners do exist in the Hong Kong textile industry (Lam and Postle, 2006). IT perceived benefits which were defined by Mangalaraj, P. J. (2006) that affect such decisions, are not tangible or visible to the managerial level of these firms. Ross (2003) has described five stages representing the evolution of supply chain management

development. The transition from one stage to another is a transition toward an integrated platform. It starts with logistics centralisation which focuses on internal optimisation regardless of the effect of the logistics operation and moves toward a stage where web enabled strategic collaboration does exist.

Despite the previously discussed benefits, Bentz points out that "*collaboration is hardly a new concept but it's still largely unknown to many companies*". Optimising customer service should be the motivation for partners to move from product centric to customer centric and establish a collaborative platform with business partners (Ross, 2003). Porter (1998) indicated that linkages across the chain are needed to examine cost behaviour as stand-alone activity is not enough to explain such behaviour. Linkages can provide the firm with better optimisation for activities such as procurement and assembly due to inventory reduction. Geographical nearness is not considered an alternative to overcome supply or final product delay as Adewole (2005) proved.

Blanchard (2007) pointed out cultural differences. "*There is no single set of best practice for globalization since each country has its own culture and supply chain requirement*". He pointed out that despite benefits provided by the collaboration concept, it is still unknown in low cost countries. Meanwhile, Maister pointed out the four steps driving trust in business relationship; credibility, reliability, intimacy and lack of self-orientation. (Kwon and Suh, 2005).

This research will investigate the difficulties facing industrial zones when optimising their performance. These difficulties include internal organisational activities and their partner's performance in addition to external barriers related to the governmental role and surrounding culture as well as infrastructure which affects the existing supply chain performance.

### 1.2. Study Aims

This study has investigated the current deficiencies that face Egyptian fabrics distribution either in local or global markets. The challenges that face the mass customisation approach in Egyptian industry are also investigated in this empirical study. The outcome of this study is the cycle of deficiency stages identifying the major issues that lead to each deficiency. The

research will result in a framework demonstrating the deficiencies experienced by Egyptian textile firms and their important factors. This study can provide industry leaders and industrial organisations with knowledge of existing industrial pitfalls and possible solutions to overcome these limitations. Furthermore, the study defines the role of the Egyptian firm in a global market and how to optimise their activities and accelerate their contribution.

In order to address the study questions and the aims, the following objectives have to be accomplished:

1. To investigate internal organisational activities and their deficiencies.
2. To examine organisational behaviour and performance within the supply chain.
3. To investigate relations between partners and determining whether organisational activities are executed on an individual basis or extended to an integrative one.
4. To investigate the role of IT applications inside the organisation and between partners.
5. To examine the role of logistics, its effect on organisational performance and its degree of importance.
6. To investigate the vision of the supply chain from each participant's perspective.
7. To investigate the role of OEM firms and the difficulties faced.
8. To explore the difficulties facing organisations attempting to reach global markets.
9. To differentiate between difficulties experienced in fulfilling domestic market orders and global demands.
10. To examine challenges facing a customisation approach in the Egyptian sector.
11. To examine the governmental role and the impact of the county's infrastructure on logistics activities.
12. To examine the growth rate of the industrial sector investigated and competition faced in domestic and global markets.
13. To build explanatory patterns indicating the causality of existing deficiencies and their relevance to issues inside and outside the organisation.
14. To develop a framework indicating the cycle of deficiency and its' major factors.
15. To propose solutions that might be adopted by an organisation to improve its performance.

**1.3 Research methodology**

This research uses a number of methods to address the problem and examine alternative solutions. Mixed methods are used; a qualitative method will be used to explore organisation behaviour and their activities in real world. A quantitative method is used to confirm empirical findings and to propose solutions for such problem. Mixed methods are adopted to avoid the weaknesses related to each approach and to enable the researcher to achieve an in-depth exploration by deploying scientific and quantitative tools. A case study is best fitted to be used in the preliminary stages for explorative hypotheses purposes. Structured surveys are employed as conformity tools and hypothesis testing in the later stage of the research. Simulation techniques are deployed to imitate reality and to test alternative solutions. The research does not rely on the subjective approach to reach its outcome, therefore a System Dynamics approach is used to simulate reality and test proposed scenarios for performance enhancement.

**1.4 Thesis Structure**

The thesis consists of seven chapters that are organised in three categories: research positioning, research body and research outcome. The first chapter, the Introduction, indicates the addressed problem statement, demonstrates its' importance and illustrates how the research is conducted. A literature review of theoretical concepts related to supply chain strategies and supply chain management is demonstrated in the second chapter. The study's outcomes and their relevance to this research are illustrated in this literature review chapter. This chapter emphasises the importance of the investigated problems and highlights studies conducted in similar environments and their findings, suggest possible tracks to investigate such problem, as well as promising approaches that could be adopted. The role of external factors will also be illustrated in this chapter. The selection of an appropriate philosophical aspect and the research methods are discussed in detail in chapter three: research method. Details of how the research is carried out, the case studies investigated are included in the project description. Chapter four will represent a discussion about the empirical study findings. The analysis of case study and its outcomes are included. Issues related to supply chain deficiencies in the Egyptian textile industry will be explored based on case study analysis. A problematique structure using Interpretive Structure Modelling will be used to illustrate the relationship

between these issues; dependences and driving power of each issue will be indicated as well in this chapter. A survey as a conformity tool is used for hypotheses testing. The match between qualitative and quantitative approaches is carried out to conclude the empirical study findings. A proposed framework for supply chains deficiency is structured and indicated at the end of this chapter. The simulation of existing supply chains and the proposed alternatives for performance enhancement are described in chapter five: Beer Game Simulation. The discussion of the study outcome and proven solutions for the addressed problem are included in chapter six. The role of internal organisational activities and external environmental issues, which contribute to such deficiencies are defined. That which is lacking in the Egyptian sector and is needed by foreign investors is also discussed. A summary of the study outcomes and limitations will be included in chapter seven: conclusion. Moreover, future trends are demonstrated in the same chapter. The thesis structure is illustrated in figure 1.

## 1.5 Summary

This chapter provides the overview of the conducted research. Research questions, aims and employed methods to address this question are described in this chapter. The following chapter provides a theoretical concept of supply chain strategies and the relevant model that can support this study. Supply chain management and the role of IT adoption will be discussed in detail. The following chapter represents the supply chain challenges that were highlighted by other researchers. The literature review chapter shows the theoretical basis and other contributions which are related to supply chain deficiencies and their obstacles in a different environment. The empirical study chapter presents the case studies and survey conducted in this research. The outcome of each strategy was matched to conclude a validated framework for supply chain deficiencies in Egyptian textile industry.

**Research Positioning**

**Chapter 1**
**(Introduction)**
Aims & Objectives
Problem Definition
Research Overview

**Chapter 2**
**(Literature Review)**
Supply Chain Management
IT role in supply chain
Supply chain models and
frameworks

**Research Outcomes**

**Chapter 7**
**(Conclusion)**
Summary
Recommendations & Future Work

**Chapter 6**
**(Discussion)**
Internal organisation deficiency
External environmental issue
IT role in organisational and
supply chain performance

**Research Body**

**Chapter 3**
**(Research Methods)**
Theoretical bases of used
methods
Project Description

**Chapter 4**
**(Empirical Study)**
Case Study
Survey
Validation and Match

**Chapter 5**
**(Beer Game Simulation)**
Simulate existing supply chain
Propose and test different
scenarios

**Figure 1: Thesis Structure**

# Chapter Two

## Literature Review

### 2.1. Introduction

Given the research objectives, the need to investigate existing deficiencies in Egyptian supply chains should be advanced by determining which activities should be investigated and how they should be measured. Discussion of supply chain models and existing measurement of supply chain performance and optimisation tools will be illustrated in this chapter. Issues related to supply chain strategies, the need for an integrated supply chain; the importance of information exchange, and the role of IT in supply chain activities will be investigated in detail. The chapter will also review existing barriers that face real supply chains in different countries.

### 2.2. Supply Chain Concept

The concept of a supply chain is defined as processes including: procuring raw materials, manufacturing the product from these materials and delivering a finished product to the customer (Morecroft and Sterman, 2000; Schary and Larsen,1995; Blanchard, 2007: page 9-10). Others studies have criticised the linearity in the above definition. Their main argument is that supply chains not only include individual suppliers and manufacturers, but also transporters, retailers and even customers; in other words whole "dynamic trading networks" (Handfield 2003; Levi et al.,2008:page 5). So the term supply chain does not describe the image of supply moving from suppliers to the customers along a chain. Information, funds and product flows in both directions of this chain should also be demonstrated. Therefore, most supply chains are actually networks. Hence, using the terms *supply network* or *supply web* better describes the hierarchy of most supply chains. (Sunil and Peter, 2000) Some researchers define a supply chain by classifying its encompassed functions to directly or indirectly fulfilling the customer request (Sunil and Peter, 2000). Other researchers focus on the value that a supply chain generates and the required pillars/resources to support this function. They emphasise the importance of providing the product at the right time, place, and price. This depends mainly on the availability of a number of resources such as: human expertise,

processes, and technology (Leo and Kelly, 2001). Many studies insist that *Supply Chains should have the ability to rapidly anticipate changing environmental conditions* (Stanford Global Supply Chain Management, 2002). To apply the dynamic characteristic to the supply chain network, many issues should be deployed, such as quick response to changes in demand without carrying out excessive inventory, and maintain customer service level while reducing asset usage (SAP,2002).

A supply chain involves a main process starting from planning supply and ending with product delivery (Jesper,2001). Supply Chain Management (SCM) focuses on smoothing the information and product flows among the trading partners (Morecroft, and Sterman, 2000). Information flow is used as an indicator to initialise materials supply (Michael, 2000). Therefore, SCM does not only involve logistics operations but encompasses much more (Penton, 2002). SCM is the process for managing and optimising supply chain components, beginning with material supply, and ending with products delivery to end customers (Suhong, 2001), Consequently it integrates a diversity of business partners into the organisation's operations (Leo and Kelly, 2001). The key underlying parameters are to deliver merchandise with the right quantities, to the right locations and at the right time. The accomplishment of this objective will lead to high customer satisfaction level customers which will be coupled with minimal system costs (Handfield ,2003).

The best definition that would define supply chain management is one concerned with its encompassed flows and how to optimise these flows. Wartha et al (2002) define SCM as "*the planning and optimisation of the information and material flows within the supplying chain*". From the information perspective, incoming orders and purchase order forms are involved. From the physical flow perspective, delivery of components and final product is achieved through the logistics chain. Information and materials flows are major components of the supply chain that should be synchronized.

## 2.3. Supply Chain Strategies
In order to distinguish between different chain strategies, a decoupling point is deployed (Naylor, Naim, and Berry, 1999). The decoupling point divides the chain into two parts: one

responds directly to the customer order and the other is concerned with stock planning and buffers against demand variability in the supply chain. So positioning the decoupling point in different locations along the supply chain generates the different strategies.

Five strategies of supply chain operations can be distinguished. Figure 2 demonstrates these strategies. They vary from producing a totally tailored product to a standard manufactured product. Customisation approaches involve sub types; differences between these types are based on the stage at which customisation occurs (supply materials, manufacturing, and assembly process). (Blecker et al., 2004 ; Naylor, Naim and Berry, 1999).
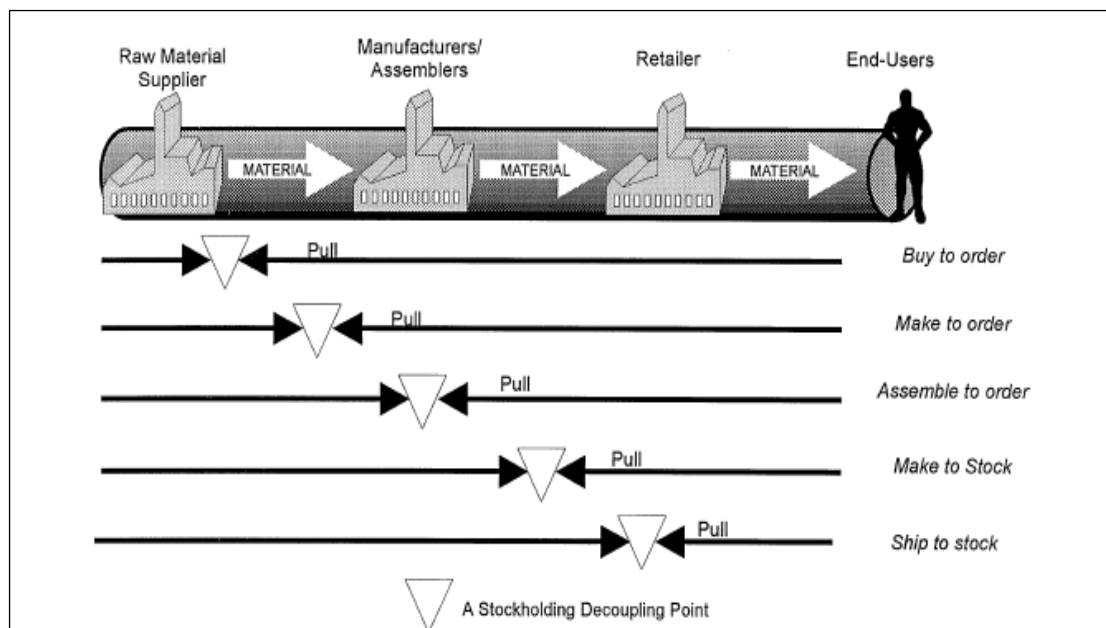


**Figure 2: Supply Chain Strategies (Naylor, Naim and Berry, 1999)**

- *Buy-to-Order* is a pure customisation strategy in which the product's modules are customised based on customer preferences. A long lead time is expected of such strategy. Customer demand in this type is highly variable; therefore there is a huge risk in holding a buffer of encompassed raw materials.

- *Make-to-Order* is often called the *fabricate-to-order* approach. Many products are fabricated from the same raw materials. This strategy involves a level of customisation both in different mixes of locations, volumes and the amount of the basic model that will be customised. The

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lead time is less than in the *buy-to-order* strategy but still exists. There is also a margin of error.

- *Assemble-to-Order*, in which customers configure the product variants from standard modules. Customisation is postponed until the assembly stage, while lead time does represent a reduced level than the previously discussed strategy, keeping a large or small buffer of inventory is risky.

- *Ship-to- Stock* is the role of retailers to adjust the product according to the customer's requirements. The *value-adding retailer* approach provides a standard product in fixed locations.

- *Make-to-Stock* strategy is used for standard products. The overall demand variability is lower than in previous types.

Adaptive products and value-adding retailer' concepts are based on standard products. They involve a mass production system with a low complexity level. The final two supply chains both represent cases where a standard product is provided from a defined range. To adapt these strategies, supply chain partners must predict their demand in advance to determine the buffer needed regarding the risk of overstocking or under-stocking.

### 2.3.1. Transition from Mass Production to Pure Customisation

To apply Mass customisation, organisations should be able to provide variations on every order within time and cost constraints. As a consequence, a number of challenges are faced when implementing mass customisation, varying from late deliveries, long response time, supplier performance and high material costs. That is why many companies experience difficulty in managing their agile supply chain (Ahlstrom and Westbrook, 1999).

Many researchers have emphasised the need for more studies in mass customisation either from the supplier or the manufacturer perspectives (Leo and Kelly, 2001). While many researchers have shown that supply chain coordination is as important issue for customisation, a few researchers have studied how logistics and production activities are actually coordinated (Fredriksson and Gadde, 2005). Supply chain coordination is an important cornerstone for

implementing mass customisation. To optimise supply chain activities, visibility and collaboration should be ensured with both suppliers and customers (Liu and Kumar, 2003). From the technical perspective, Mass customisation needs information systems that co-ordinate between partners along the chain. Porter and Millar (1985) indicate that IT adoption can facilitate providing a mass customised product. However, there is still a lacuna in the literature on how to implement information management processes in mass customisation (Silveira et al., 2001).

While delivering customised products promises greater reduction in inventory cost, *Build to-Order* (BTO) supply chains are much more complicated to manage. Differences between supply chains in *Build-to-Order* (BTO) and *Make-to-Stock* (MTS) environments have been discussed by Prasad et al. (2005). In addition, the authors examined the differences in BTO operations in developed and developing countries. The results of this study were demonstrated in a theoretical link of information complexity, operational independence and supplier integration regarding postponement strategies. Figure 3 illustrates these relationships. As the postponement strategy moves from an MTS environment to a BTO one, the information complexity increases while operational independence shows a decreased level. Integration with the supplier increases at the midstream level of the supply chain. The difference between these two strategies will be used to define its applicability in mass customisation and mass production at in developing countries such as Egypt.
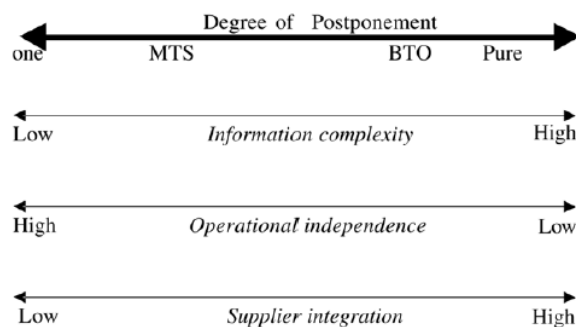


**Figure 3: Theoretical model for BTO and MTS (Prasad et al., 2005)**

Although collaboration and integration is a major issue in supply IT, its related weight differs based on the strategy followed. Collaboration effort of chain partners depends mainly on their

ability to share information and provide visibility to key business partners. Many researchers consider supply chain visibility and collaboration critical factors for optimising supply chain activities. To effectively fulfill customer orders, organisations have to consider these factors. (Sunil and Peter, 2000; Liu and Kumar, 2003; Småros, 2004). Neuman and Samuels (1996) show that although "Know your customer" is one common business rule, many producers do not pay attention to establishing an efficient channel with their retailers to ensure win-win situations. Low cost suppliers is the main criteria that retailers use in supplier selection regardless of their IT ability and readiness to share data.

Internet platforms provide the organisations with a visible channel, which can facilitate their inter-organisational activities. The Internet is "an enabling technology —a powerful set of tools that can be used, wisely or unwisely, in almost any industry and as part of almost any strategy" as Porter (2001) described. He pointed out that the internet provides the firm with a strategic value over other generations of information technology. Porter indicated the value added which the internet can provide to both the business and the marketplace as shown in figure 4. Supplier power, substitution threats, market channels and market competition are highly affected with Internet power.

To increase supply chain visibility, organisations have to exchange information with their partners over the Internet such as: inventory levels, production schedules, forecasts, promotion plans, etc. Sharing of such information can be beneficial to all supply chain partners. Benefits may include the reduction of "just-in-case" inventory, variability and lead time (Sudhindra, 2001; Småros, 2004). Information sharing is an important cornerstone for integrating a supply chain (Patnayakuni et al., 2003). An integrated supply chain combines the physical goods movement with information flow throughout the chain. Integration of the inventory across the key partners is involved.

Organisations have to decouple their material flow with the information about these materials. The management of these flows along the supply chain is needed for efficient order fulfilment. Many researchers stress the idea that maintaining efficient material flows along the chains requires managing information flow efficiently between business partners. This information

should be accurate, timely, visible to replace physical goods and readily available at the point of need.
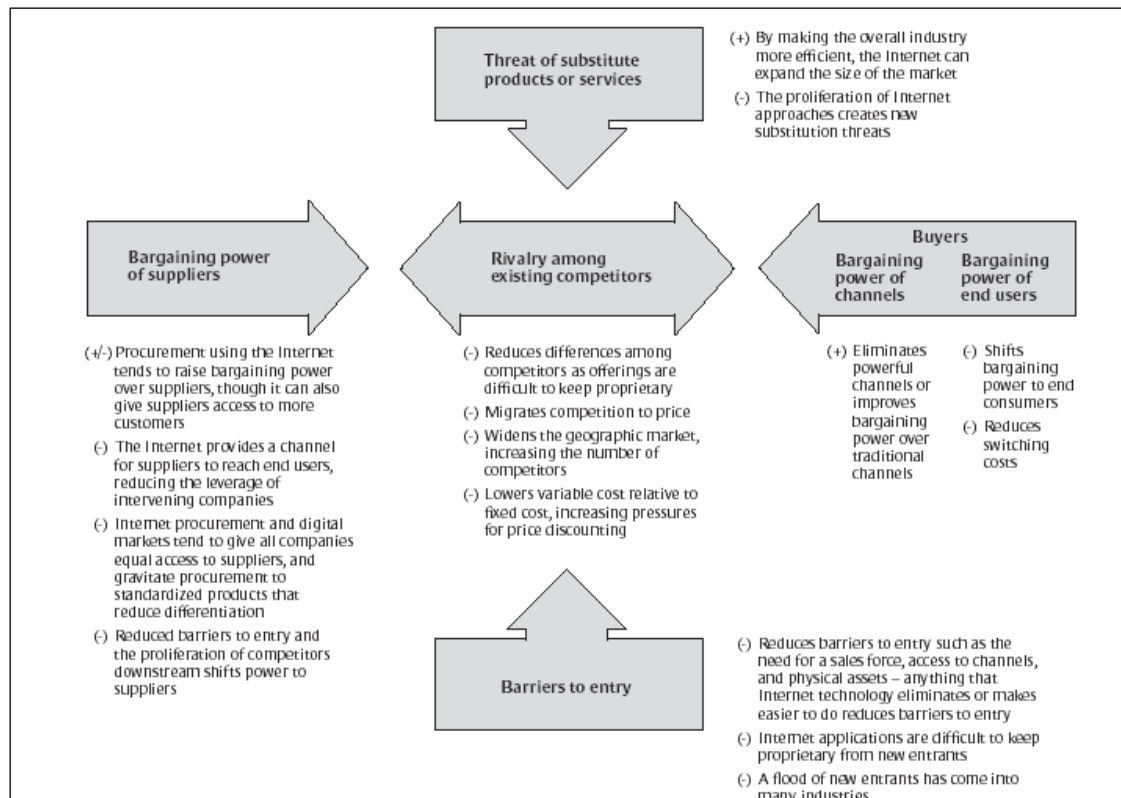


**Figure 4: How the Internet influences industry structure (Porter, 2001)**

Based on real time information, decision makers will be able to take right decisions regarding their internal operations. The management of information leads to an improved way of transaction between organisations (Patnayakuni et al., 2003; Sunil, and Peter, 2000; Singh, 1996; Småros, 2004).

Although organisations attempt continually to utilise supply chain information efficiently, a number of studies demonstrate the gap in information management methods which affect supply chain co-ordinations (Småros, 2004). This gap was demonstrated in the lack of supply chain visibility despite continuing effort to improve the whole chain visibility. (Sunil and Peter, 2000) Real-time exchange of inventory levels, forecast data and sales trends, between the different b2b participants are needed. The next section will investigate the role of

information flow in supply chains due to its importance and effect on supply chain performance.

## 2.4. The Role of information in the Supply Chain

There are many objectives that supply chain management should emphasise such as improving customer responsiveness, responding rapidly to changing demands, reducing cycle time, minimising hold inventory and reducing overall cost (Shaw et al., 2003). To achieve these objectives, key operational metrics and customer demands should be accessible, available, visible, and accurate throughout the chain (Christopher and Lee, 2004). Organisations have to exchange real-time demand changes especially when demand' variability is high. The accuracy of this business information should be the source of confidence to all SC parties and will be utilised as the base of re-planning purposes (R. Patnayakuni et al., 2003; Shaw et al.,2003).

As a consequence, industrial organisations are looking for a seamless supply chain where "players" act through an extended organisation. (Jones and Towill , 1997). This type of collaboration provides an environment to integrate partners, control data and processes sharing and therefore "*enhance effectiveness of information interchange among business partners and suppliers*" (Lau and Lee, 2000). Previous research pointed out that it is failure to achieve that affects supply chain performance. Adewole (2005) shows that previous drops in UK clothing industry were referred not only to the rapid growth of exported fabrics, but this growth was coupled with poor communication capabilities between partners due to a trust issue. Based on Fishers' (1997) claim, most organisations do not consider the pattern of demand associated with the offered product when choosing an appropriate supply chain strategy (Lam and Postle, 2006). Product is classified to be functional or innovative where each pattern of demand differs.  The next table indicates the differences between these types.

| | Functional | Innovative | |
|---|---|---|---|
| Aspect of demand | Predictable demand | Unpredictable demand | |
| Product life cycle | More than 2 years | 3 months to 1 year | |
| Contribution margin (per cent) | 5-20 | 20-60 | |
| Product variety | Low (10-20 variants per catalogue) | High (often millions of variants per catalogue) | **Table I.** |
| Average forecast error (per cent) | 10 | 40-100 | Demand for functional |
| Average stock out rate (per cent) | 1-2 | 10-40 | versus innovative |
| Average season markdown (per cent) | 0 | 10-25 | products in the supply |
| Lead-time required for made-to-order products | 6 months to 1 year | 1 day to 2 weeks | chain |

**Table 1: Functional and innovated product texture (Lam and Postle, 2006).**

Fashion products, for example, are an innovative product where volatile demand exists and requires rapid responsiveness. The above differences will be utilised in the present study to indicate the type of product investigated and to examine whether Egyptian firms adopted the correct strategy associated with that type. Whether the product's type is functional or innovated affects demand prediction, but does not reduce the importance of information. Successful supply chains use their information as a critical factor for supply chain integration (Jones and Towill , 1997). Cashmore and Lyall emphasised that value added advantage which information imposes cannot be gained unless this information is deployed (Adewole, 2005).

Through information technology development, information is utilised to signal when material flow should start, so it is considered as a source for coordination between business processes and material flows (Patnayakuni et al., 2003). While market information suffers from *delay* and *distortion* through moving along the chain, organisations attempt to reduce such order magnification and the delay that may occurs in real time exchange. (Jones and Towill., 1997). Data sharing has a significant effect on the success of a lean supply chain. Lean manufacture focuses on eliminating redundancy, reducing inventory while ensuring more revenue. Sirnivasan defined a group of principles that support the lean supply chain concept (Blanchard, 2007: page 95). These principles are: focusing on the customer's need while designing products, relying on real demand and future forecast to provide rapid responsiveness, keeping reasonable a variety of buffer, implementing partnership with a potential supplier, reducing lost time and finally providing rapid service using low inventory with low operating costs. The underlying issue behind these principles is feeding each partner

with real time information to act their part in that chain effectively and to respond rapidly to a customer order without need of keeping additional buffer.

Information Visibility is an element in supply chain excellence. Supply Chain Excellence is a process with six levels which organisation should follow to ensure the effectiveness of its supply chain (Tompkins, 2003). To achieve this, information sharing is required. Information visibility enables key partners to keep track of the ongoing supply chain processes. This will eliminate the risk of bullwhip effects or delay that may occur in manufacturing and delivery. These issues match what was investigated by many researchers to emphasise the importance of "information-enriched" supply chains (Jones and Towill, 1997). Adewole (2005) has indicated that a visible supply chain can provide better performance and competitive service to the end customer in the UK clothing sector. He indicated that existence of an effective way of data transmission through the supply chain can ensure a reduced lead time and elimination of non-value added activities throughout the chain.

Jones and Towill (1997) indicated in their research that an information enriched supply chain provides a better performance where the actual demand is fed directly to each partner of the supply chain. MIT beer game was conducted to show the effect of supply chain visibility on order magnification. The cause and effect model of the conducted experiment is illustrated in figure 5. The model points out that smooth information flow had improved order control and reduced the stock levels. The researcher concluded that deploying an electronic POS will be beneficial to chain partners and increase the information visibility through the chain.

Joshi (2000) as well proved that information visibility and collaboration had a positive effect on bullwhip reduction. To simulate the case of supply chain visibility, Joshi's model assumed feeding the customer demands to each partner and eliminating the communication delays between units. The results show that information visibility and collaboration provide 40 to 70% reductions in inventory costs. The researcher concluded with a framework to improve information visibility in supply chains. Automated object tracking and data acquisition systems were deployed in this framework using radio frequency tags and tag readers.

Information visibility is the main driver for lack of confidence in a supply chain as illustrated in figure 6. Lack of confidence is considered as an obstacle that faces SC. Information became invisible usually when an SC network included multi-echelons that do not deploy a real time system. The key partners will not be informed with the current state of demand, inventory and production plan.
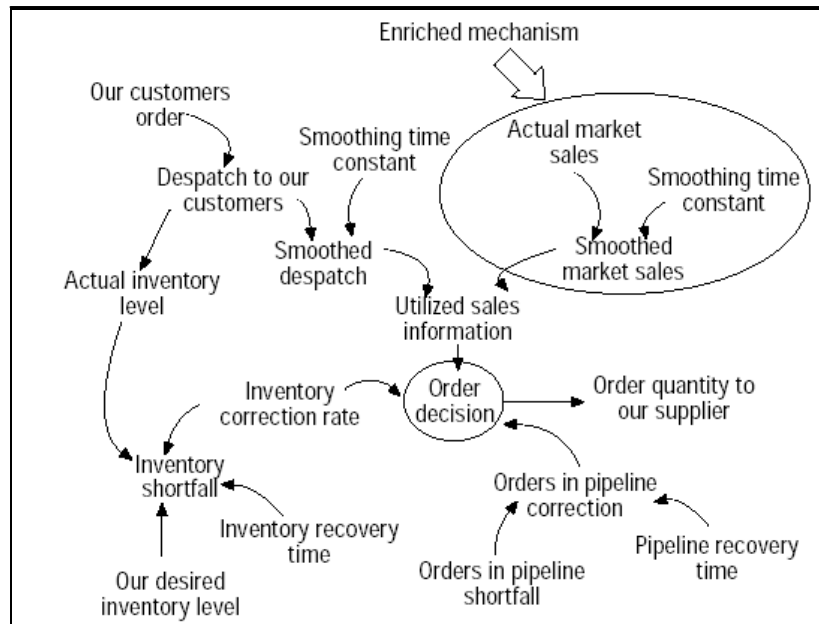


**Figure 5: Causal loop of decision support system (DSS) utilising market sales information (Jones and Towill, 1997)**

Consequently, bullwhip effect increased holding costs and late deliveries may rise. This supported the organisational needs of providing demand driven systems rather than a forecast driven one. This promising system will ensure rapid responsiveness to the customer's order (Christopher, Lee, 2004).

Jones and Towill in (1997) recommended that the most effective way to improve supply chain visibility is to feed each level of the supply chain directly with real time sales information. While this assumption can eliminate the risk of information unavailability, this mass amount of information might be considered as an overload.
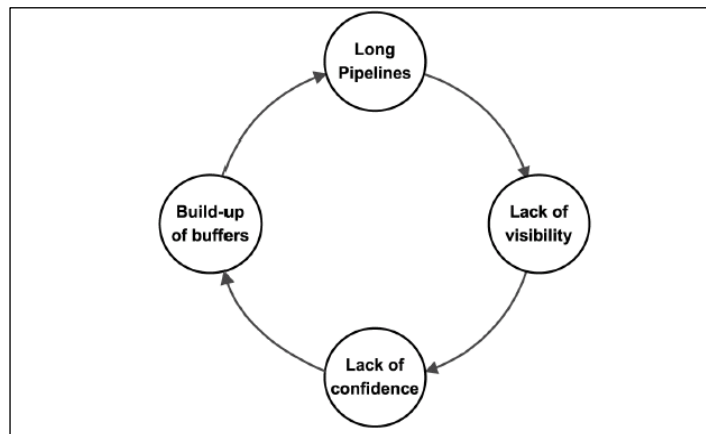
**Figure 6: The risk spiral   (Christopher and Lee, 2004)**

The redundant information will reduce the speed of the information flow and affect the expected responsiveness (Büyüközkan, 2004). So it is not about feeding each SC levels with huge amount of information but, "How to get benefit from such information″ is the question.

Dell is considered to be a successful example of implementing information visibility (Handfield , 2003). To provide a lead time of five days while maintaining a small buffer of inventory, component suppliers have to hold a level of inventory to reduce their cycle times. Dell utilises a web-based hub to exchange component availability, capacity, web-based orders and forecasting between Dell and their suppliers in both directions.

Another problem faces information flow while being transferred in a sequential order throughout the chain. Fluctuation and amplification of demand from the downstream to the upstream appear. It misleads the managerial levels and can lead to incorrect decisions concerning product production and inventory level (Christiaanse and Kumar, 2000). For instance, the manufacturer might be misled by amplified order information and respond with excess material processing which results in additional cost. These costs will be represented in unplanned supply costs, additional manufacturing costs, excess inventory holding and shipment cost (Lee et al., 1997). Demand amplification was first explained by Forrester in 1961 (Lau et al., 2002). Lau et al (1997) emphasise that lack of information sharing is considered as a source of these forms of fluctuation and amplification of order and inventory.

Lee et al. (1997) agreed that sharing order information would be beneficial to the manufacturer and would reduce the level of data amplification but they point out that the amplification issue could not be resolved while there are different sources of forecasts being shared. Due to the difference in forecasting methodologies, which would aggravate demand amplification, a centralised demand forecasting process should be handled between multiple supply chain partners. Since the organisations are reluctant to share their information and different forecasting sources do exist for each partner, actual demand information will be distorted. Distortion increases while moving upstream; so "bullwhip effect" occurs. To illustrate this amplification of demand signal and fluctuation of the inventory level, "beer game" is commonly used by researchers. (Christiaanse and Kumar, 2000).

The discussion held by Christiaanse and Kumar (2000) revealed that the traditional supply chains deficiencies and delays could be eliminated by re-designing the supply chain and modifying its coordination structures. The distortion effect *can easily be avoided if alternate communication and coordination paths are designed and implemented*. This redirects us to the role of IT application and its promising advantages.

## 2.5. IT role in Information management

Supply chain information is an essential ingredient to be integrated with the physical one. It will enhance the performance of the entire supply chain network. The role of current supply chain systems is to provide an infrastructure that enables the exchange of data between the various value chain components as shown in figure 7 (Lau and Lee, 2000).
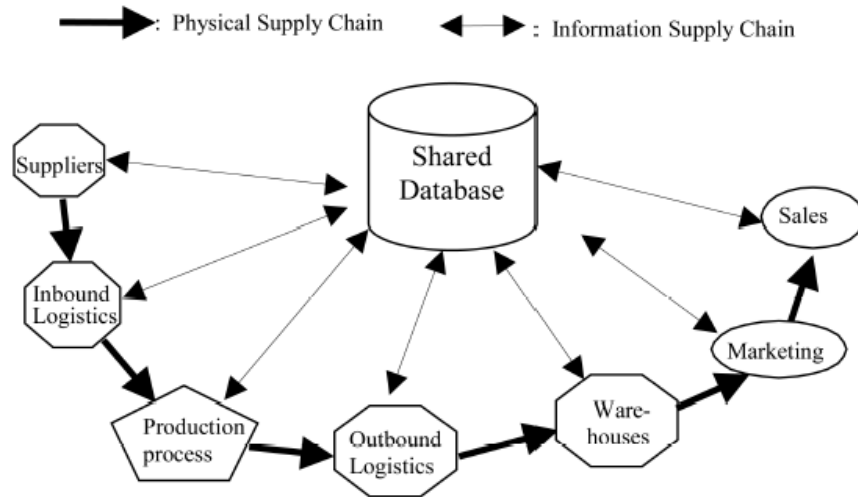
**Figure 7:  Internet based global supply chain (Lau and Lee, 2000)**

Information technology in SCM is used as a central point of contact to streamline order processing, increase awareness with customer demand and thus support supply chain collaboration. Conducting a sophisticated analysis of these data will provide a greater understanding of current supply chain performance and indeed will lead to accurate decisions regarding production and inventory holding (Auramo et al., 2005), (Gibson, 2000).

A supply chain information system (SCIS) is critical for supply chain excellence as its definition indicates. Lau and Lee (2000) define it as "*a mechanism for coordinating and monitoring of the operations within the supply chain*". Information-based activities are used to visualise physical chain operations. This integration will ensure a replacement of physical trucks and warehouses with real-time information about it (Anderson and Lee, 2000).

The internet provides a medium that allows supply chain activities synchronisation in order to optimise supply chain performance (Lankford, 2004; Anderson and Lee, 2000). The primary advantages of utilising the Internet in supply chain management are: faster speed of response, decreased cost, increased flexibility, and overall shortened supply chain cycle. Copacino defined an "e-synchronized supply chain", which links different supply chain partners with an internet enabled hub to allow a coordinated planning, real-time exchange of information, and performance reporting (Lankford, 2004). Not only does the design of E-business solution indicate the relevance of each supply chain process with its needed information, but also the adoption of such system will optimise information flow along the chain. The real time

information provided by e-business applications enables collaborative decisions between partners (Auramo et al., 2005). ICT and e-business infrastructure facilitate the communication between partners especially in global chains (Daly and Bruce, 2002).

ICT supports collaboration between partners and results in new approaches such as E-collaboration. E-Collaboration depends on Internet technologies to facilitate smooth exchange of electronic data between partners. Wang (2005) described it starting that "*It is being used to integrate previously separate aspects of the supply chain and to enhance the value delivered to consumer by providing a series of practical improvement concepts to unlock this value*". That's why an increased level of information visibility and sharing along the supply chain is coupled with the need for efficient communication. Adopting such approach enables participants to gain promising benefit from collaborative planning forecasting and replenishment tools.

Collaborative planning forecasting and replenishment approaches were investigated by Liu and Kumar (2003). They define initially the importance of an adopted pattern for information sharing. They define a three-part typology for interorganisational information systems (IOS) communication as represented in figure 8: sequential, reciprocal, and hub-and-spoke. Sequential information sharing is commonly used in traditional supply chain activities. The information sharing links the collaborative processes together into a sequential chain. In reciprocal information sharing, information flow is bidirectional and each partner may communicate with several others. Hub-and-spoke information sharing provides the supply chain with an electronic marketplace to facilitate interactions between partners. Regarding the research aims of this study, information sharing patterns in the Egyptian sectors will be explored. The initial indicators based on the literature survey point out that although ICT adoption can support supply chain activities by providing an aggregated hub to facilitate collaborative activities, awareness of collaboration benefits and advantages that can be achieved behind IT adoption has not captured the interest of firms in developing countries.
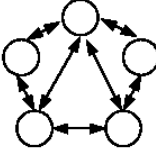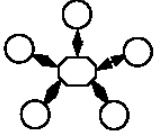
| Information Sharing | Sequential | Reciprocal | Hub-and-Spoke |
|---|---|---|---|
| Structure | ○→○→○→○→○ | (diagram) | (diagram) |
| Level of collaboration | Between neighboring partners only (one-way) | Two-way, multiple partners | Two-way, centralized |
| Coordination Mechanism | Information flow upstream, goods downstream | Multiple information flows | Intelligent hub |
| Technologies | EDI | Networking, email, videoconference | Web services |
| Examples | Traditional supply chain, 3PL | VMI | CPFR, Private Trading Exchanges, Consortia Trading Exchanges |

**Figure 8: information sharing structure (Liu and Kumar, 2003)**

Liu and Kumar (2003) investigate a number of approaches related to 3PL, Vendor Managed Inventory, Collaborative Planning, Forecasting and Replenishment, and the supply network. Collaborative Planning, Forecasting and Replenishment (CPFR) is a joint effort between a manufacturer and its trading partner to plan and carry out the activities needed to deliver the final product (Henry, 1997). CPFR is used to manage the instability and uncertainty associated with demand and supply by establishing a collaborative pattern and enhancing communication means between business partners. Supply chain partners develop collaborative plans for future events, and then use an exception-based process to handle any deviations. CPFR reduces the effect of forecast uncertainty through using the real time exchange of information. Sharing of production planning, order demand and inventory levels provide the supply chain with better performance. The CPFR process begins with setting an agreement with partner, planning, forecasting and order generation as follows (Henry, 1997):

**Step 1: Front-end agreement:** The supply chain participants agree on the used measures, adopted systems and shared resources. Partners commit to information sharing and reach a pattern for ordering between partners.

**Step 2: Joint business plan:** Partners reach an agreed plan for inventory replenishment and marketing strategy regarding each product.

**Steps 3-5: Sales forecast collaboration:** Demand forecasts are being shared. Partners set a collaborative plan and solve out the exceptions by adjusting plans in case of unexpected demand.

**Steps 6-8: Order forecast collaboration:** Trading partners share their inventory replenishment plans, then figure out unhandled exceptions in such buffering plans.

**Step 9: Order generation/delivery execution:** Data regarding POS, shipments are being shared. Scenario of overstock, inventory shortage and forecast are being solved out at this stage.

Vendor managed inventory is an approach of interorganisational communication where the supplier has access and replenishes the client's inventory to maintain a certain inventory level. The vendor could track a client's inventory and shipments to decide whether the client needs more supplies. Inventory reduction and reduced time of order cycle are the main preserved values from VMI (Michiel and Harold, 1993). VMI enables the client to keep the same buffer of inventory while handling the incoming orders (Småros,2004). Bullwhip effect is positively affected with the adoption of VMI; therefore VMI is considered as a means of optimising the supply chain performance, thus improving the supply chain's efficiency.

Liu and Kumar (2003) conclude that to enable collaboration inside the chain, the architecture for information sharing in addition to schema for shared data, a model of information flow should exist**.** Despite the perceived benefits behind such approaches, most firms are reluctant to share information electronically and a manual method is commonly deployed (Auramo et al., 2005).

Whiteley (1996) indicates that the flow of information between organisation boundaries can ensure an efficient customer response. EMAP proved that the use of CAD/CAM can provide textile producers with obvious benefits concerning rapid production through collaborative decision (Adewole, 2005). To enable smooth material flow along the chain, Yin and Khoo (2007) propose using a distributed system for intelligent coordination and scheduling to ensure supplying requirements for each supply chain unit efficiently. Deploying such system provides a hub for coordination to facilitate interactions between partners. There is a need to couple IT

implementation with business process re-engineering to emphasise the strategic benefits of IT adoption (Auramo et al., 2005).

Yin and Khoo (2007) discussed an instance of IT tools and how their deployed capabilities enhance SCM. Broader study of exist IT application and their classification were conducted. A study conducted by Auramo et al. (2005) has discussed different types of IT usage and its drivers in SCM. According to the study, three IT usages are represented in SCM: Transaction processing, supply chain planning & collaboration and order tracking & delivery coordination. The authors relate each type with a number of drivers that lead to its adoption. These drivers may focus on operational levels such as: operational cost reduction and speeding up transfer of information or it may address strategic and holistic levels such as: managing unpredictable demands and merging In-transit delivery. The outcome of the study is demonstrated in figure 9. The relevance of IT usage and its driving factors will be beneficial to analyze the performance of Egyptian firms and their objectives behind IT adoption.
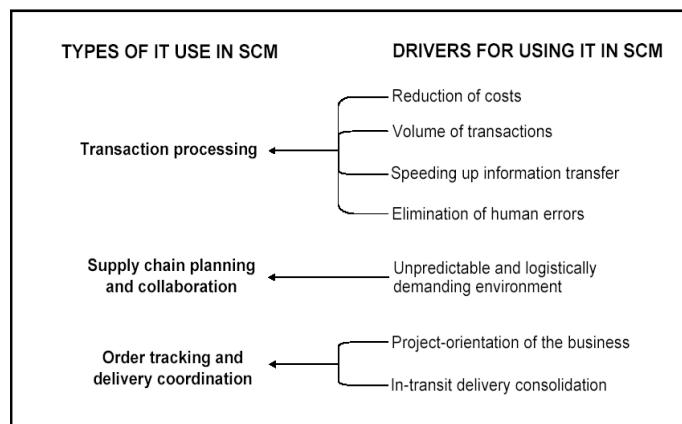


**Figure 9: Relationship between IT usage and its drivers**
**(Auramo et al., 2005)**

Another type of IT adoption category is defined by Mangalaraj et al. (2006). He classifies firms regarding IS adoption into organisations, which had the intention to adopt or already had adopted IS in SCM. In both situations where the firm invested in IT adoption or collected information about perceived benefits behind such adoption, expected benefits of IT adoption, attributes of the innovation, organisational characteristics, and environmental characteristics

affect such decisions of IT adoption or enhancement. These factors will be considered in this research to indicate the readiness of IT adoption in industrial organisations.
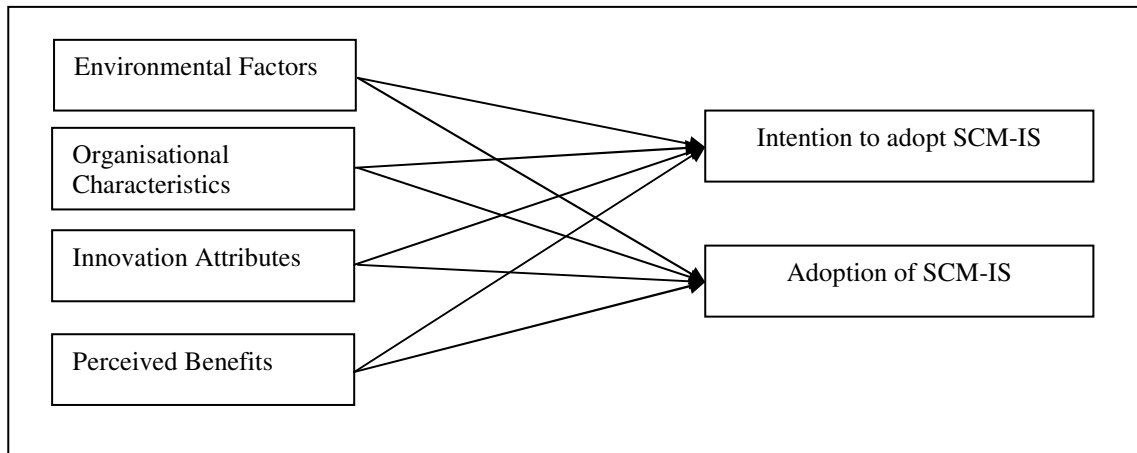


**Figure 10: Firms classification based on IT adoption (Mangalaraj et al., 2006).**

### 2.5.1. Needs for more IT capabilities

Many researchers have discussed different methods to enhance information sharing within the chain. Many studies attempt to overcome issues behind the lack of IT adoption by exploring current IT capabilities and their promising benefits in supply chain performance while others attempt to analyse the shortage of IT applications. Stank et al. (1999) conducted a survey to indicate the correlation between IT adoption and the level of implemented Collaborative Planning Forecasting and Replenishment (CPFR). Stank et al's (1999) study concluded a number of goals behind adopting CPFR such as reduced cost, reduced amount of inventory held and few stock-out. The study indicates that perceived benefits behind IT adoption is more tangible when it is associated with a high level of CPFR implementation. Accurate, timely and real time availability of information can be ensured from IT implementation based on the Stank et al. study. A study of Småros (2004) focused on rating information needs from different perspectives of the chain partners. In addition, it measured the ability of current IT systems to meet these needs. The study reveals that current supply chain information systems have not yet provided the required level of information visibility and sharing from different perspectives. Figure 11 provides the results of these need/ability comparisons.

30

**Figure 11: External Information Needs and IT Capabilities (Småros, 2004)**

Other researches refer to the shortage of IT in providing the promised level since that SCM applications are based on distributed database applications. The main limitation underlying these is "*their inability to predict complex interactions of incoming requests with the current states and parameters (request, response times, etc.) of the chain nodes*". (Wartha et al., 2002).

Another conducted survey has defined and ranked barriers that face IT implementation in supply chain management. Regardless of common obstacles related to cost and dispersion between partner's capabilities, these barriers include issues related to culture effect such as low level of integration, lack of trust between partners and resistance to implement IT. Jharkharia and Shankar (2005) used Interpretive Structural Modelling (ISM) to define the relationship among these barriers and show the interrelationships of the barriers, driving powers and their dependency. The results of this study are demonstrated in the next table.

| SN | Barriers in the IT-enablement of a supply chain | Mean score | Standard deviation | Rank |
|---|---|---|---|---|
| 1 | Disparity in trading partners' capability | 3.09 | 1.21 | 1 |
| 2 | Resistance to change to IT-enabled SCM | 3.01 | 1.30 | 2 |
| 3 | Low level of supply chain integration | 2.96 | 1.22 | 3 |
| 4 | Threats of information security | 2.83 | 1.18 | 4 |
| 5 | Lack of trust in supply chain linkage | 2.82 | 1.15 | 5 |
| 6 | Fear of information system breakdown | 2.76 | 1.27 | 6 |
| 7 | Low priority by the management | 2.70 | 1.42 | 7 |
| 8 | Fear of supply chain breakdown | 2.64 | 1.23 | 8 |
| 9 | Lack of funds | 2.54 | 1.35 | 9 |
| 10 | Poor IT infrastructure facilities | 2.52 | 1.39 | 10 |
| 11 | Lack of awareness about use of IT in supply chain | 2.34 | 1.18 | 11 |

**Table 2: barriers in the IT enablement of supply chain**
**(Jharkharia and Shankar, 2005)**

The availability of modern information and communication technologies (ICT) enables the capture and share of information in addition to supply chain redesign (KUMAR, 2001; Christopher and Lee, 2004). Numerous limitations have been found in existing solutions (Lau and Lee, 2000). Different types of limitations exist according to Lau and Lee (2000). Cost issues are major limitations for SMEs to implement IT applications. The technical limitations of IT systems need to be considered. These limitations could be related to integration issues where there is a need to acquire new packages and fulfill certain user requirements which existing solutions could not fulfill. Limited system scalability is considered as a barrier for firm expansion. Another limitation is related to system usability and design. Managing IT systems as well is an important issue to avoid its failure. Originations have to consider these issues to fully utilise an IT system. This best usage will lead to a significant impact on supply chain cost and generated value. So the current systems have to deal with demand uncertainty by providing more responsiveness and reducing cycle time. Companies have to emphasise the role of information technology to enhance supply chain performance.

Although it is impossible to achieve an effective supply chain without IT adoption, there are a number of literature surveys that deal with IT in SCM (Gunasekaran and Nagaib, 2003). To fully integrate an end-to-end supply chain, an integrated information system that enables information sharing, is required along the chain. Many researchers point out the necessity for a comprehensive IT survey in SCM that can identify its importance as a critical success factor

for supply chain integration. Further researches are needed to discuss how information technology can design and enhance the implementation and effectiveness of a supply chain. From a technical perspective, there is a need for research to provide an architecture framework to formulate data interchange systems along the chain (Lau and Lee, 2000). Beside IT roles in SCM, supply chain design and optimisation should be examined. Many researchers addressed existing deficiencies in SCM to define optimal supply chain models, design and better utilisation of information systems. Investigating these models will provide a number of theoretical concepts that could support the addressed problem. A number of such studies will be explored in the next section to investigate their relevance to research objectives. Highlights the limitations of each contribution will be discussed. In addition, the research will demonstrate the significant issues related to supply chain analysis, design and re-engineering.

## 2.6. Supply Chain Models

The need for supply chain analysis, design and modelling becomes necessary to explore supply chain deficiency for re-engineering purposes. These deficiencies are represented in high cost, long product cycles, and lack of information sharing between organisations. To define the efficiency of existing supply chain systems, performance measures are set. These measures are categorised as qualitative or quantitative. Quantitative performance measures are those measures described numerically. These have been categorised into cost, profit and customer responsiveness. Qualitative performance measures are not based on a single direct numerical measurement. Measures such as: integrating information and material flow, flexibility and supplier performance are considered as qualitative measures. Decision variables are used to optimise one or more performance measures such as inventory levels, the number of echelons, buyer-supplier relationships, product differentiation and the number of product types held in inventory. Previous supply chain models have been reviewed by Beamon (1998) and summarised in Table 3. The table illustrates for each model: the modelling methodology used, adopted performance measure and decision variable used to enhance the performance measure. According to this survey, the majority of researchers focus on cost as a performance measure and inventory level as a decision variable while a number of other performance measures have not been addressed yet. The table indicates four types of models: a deterministic analytical model, stochastic analytical model, economic model and simulation

model. The deterministic model was employed to build an algorithm to schedule the production and distribution operations (Williams, 1981). The model investigates how to reach the optimum cost effective activities to fulfil incoming orders. Williams (1983) established another algorithm to define the batch size in production and distribution activities concurrently at each echelon. The model aims to reduce the cost associated with the held inventory and the processing expenses. The deterministic model was used as well to define the inventory levels and the lead times needed to provide the optimum cost (Ishii, et al.,1988). The model aims to overcome stock out and dead stages where inventory amount reaches critical stages in each node. Cohen and Lee (1989) employed the economic order quantity (EOQ) technique to develop a model illustrating an optimum resource utilisation. The model targets the net profit of production and marketing activities. A deterministic model was used to optimise supply chain cost and facilities (Cohen and Moon, 1990). This model is called the Pilot model, which investigates cost components and discusses which production and distribution node should be operated. Newhart, et. al. (1993) developed a model to optimise the inventory level by reducing the safety stock. The model adopts two stages, the first one aims to reduce inventory buffer along the supply chain using heuristic model and the second one targets how to minimise the inventory buffer while addressing the incoming demands and overcoming lead time instability. Tzafestas and Kapsiotis (1994) developed a mathematical model for supply chain optimisation and followed that model with adopting a simulation technique to examine the scenario of manufacturing facility optimisation, Global Supply Chain optimisation or decentralised optimisation.

In order to enhance supply chain performance, Voudouris (1996) established a model to enhance supply chain responsiveness. The model examines system flexibility utilising inventory resources and activity resources. Arntzen, et. al. (1995) built a mixed integer programming model to define the best allocation of facilities to produce multiple products and deliver these products using different transportation nodes. Regarding the Stochastic analytical model, Cohen and Lee (1988) developed a model to allocate the supplies of each supply chain echelon. The author initialised a model of cost efficiency in four activities: material control, manufacturing, warehousing and distribution. Different attempts to optimise supply chain behaviour are examined by different researcher. Svoronos and Zipkin (1991) developed a model to optimise the cost of the safety inventory held. The author considered a multi-echelon

supply chain assuming a base stock and inventory replenishment for each facility. Lee and Billington (1993) developed a stochastic model to control the material flows and calculate the needed stock to provide a certain level of service. As alternate policy, the researcher proposed what the service level is that can be accomplished based on an adopted ordering policy. Lee et al. (1993) developed a stochastic model for inventory replenishment based on a periodic review. The author considered differentiation between markets such as environment and languages to propose how to handle the internal activities. Lee et al. (1997) established another stochastic mathematical model to explain the bullwhip phenomena and demand distortion. The researcher investigated four issues causing the bullwhip effect; these issues are represented in: demand signal processing, rationing game, order batching, and price variations. Pyke and Cohen (1993) developed a mathematical model to illustrate how to integrate the supply chain stages. The model defined lot size and re-order interval related to replenishment policy and level of ordered products.

Lee and Feitzinger (1995) developed an analytical model to figure out the optimal production step for product differentiation. The researchers conclude with a cost estimation for each configuration. The cost issue composed freight, inventory and processing cost. The economic model was used by Christy and Grout (1994) to model the buyer-supplier relationship in a supply chain. The authors developed a relationship matrix to define the different scenarios that may occur. The matrix considered *process and product* specificity. The supplier-buyer relationship is defined based on the matrix.

Towill (1991) and Towill, et. al. (1992) used simulation techniques to determine how to reduce demand amplification. Different scenarios are considered which are represented in: merging the distribution into the production stage, integrating the flow of information along the chain, adopting the just-in-time (JIT) inventory policy, improving the movement of intermediate products and materials by modifying the order quantity procedures and modifying the parameters of the existing order quantity procedures. To eliminate the distribution echelon and just in time adoption were the best scenarios to overcome demand instability. Wikner, et. al. (1991) used these simulation experiments to conclude how to enhance supply chain performance and how to reduce the demand amplification as well. The

authors examined five strategies, which included decision rules, delay reduction, information flow integration and divided the demands into actual demands and others considered for safety. The author indicated that integrating information flow and dealing with demand as the actual and safe solution is the most effective strategy to be adopted.

A numbers of studies have provided a holistic perspective of supply chains such as the *21st Century Logistics* framework. This framework, which was introduced by Michigan State University proved its *"robustness across environments"* since different samples of U.S. and Australian, New Zealand firms are compared. It includes six firm proficiencies which are represented in figure 12. These proficiencies are characterised into operational, planning, and behavioural processes. Regarding the operational process, firm competencies include customer integration, internal integration, and supplier integration. *Customer integration* is accomplished by providing customised services based on customer preferences. To achieve that, customer segmentation, rapid response to unique preferences and flexibility can ensure such integration. *Internal integration* includes connecting activities needed internally to fulfil customer orders. Cross-functional activities, developing policies for synchronous activities and continuous improvement are needed to accomplish such integration.

*Supplier integration* includes coordination of supplier related activities with internal activities. Agreement on a common vision linked and co-ordinated with associated operations is mandatory to establish an integrative platform with the supplier. Based on the planning process, capabilities such as technology & planning integration in addition to measurement integration are included. *Technology & planning integration* indicates the need for information systems that aggregate various activities needed to provide a rapid responsiveness.

Smooth information flow, exchange information in real time and the capability of integrative platforms are interfering issues which control technology integration. Information systems enable the seamless transactions inside the organisation boundaries and between supply chain

| | Deterministic Analytical | Stochastic Analytical | Economic | Simulation | Cost | Customer Responsiveness/ Backorder | Activity Time | Flexibility | Production/Distribution Scheduling | Inventory levels/Ordering (Batch) Size | Number of Stages | DC . Customer Assignment/Location | Plant . Product Assignment | Buyer . Supplier Relationships | Product Differentiation Step Specification | Number of Product Types Held in Inventory |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Altiok and Ranjan (1995) | | X | | | X | X | | | | X | X | | | | | |
| Arntzen, et. al. (1995) | X | | | X | X | | X | | X | X | | X | X | | | |
| Camm, et. al. (1997) | X | | | | X | | | | | | | X | | | | |
| Christy and Grout (1994) | | X | X | | X | X | | | | | | | | X | | |
| Cohen and Lee (1988) | X | | | | X | | | | | X | | | | | | |
| Cohen and Lee (1989) | X | | | | X | | | | | X | | | | | | |
| Cohen and Moon (1990) | X | | | | X | | | | X | | | | | | | |
| Ishii, et. al. (1988) | | | | | X | X | | | X | X | | | | | | |
| Lee and Billington (1993) | | X | | | X | | | | X | X | | | | | | |
| Lee and Feitzinger (1995) | | X | | | X | | | | | | | | | | X | |
| Lee, et. al. (1993) | | X | | | X | X | | | | X | | | | | | |
| Lee, et. al. (1997) | | X | | | X | | | | | X | | | | | | |
| Pyke and Cohen (1993) | | X | | | X | | | | | X | | | | | | |
| Pyke and Cohen (1994) | | X | | | X | | | | | X | | | | | | |
| Newhart, et. al. (1993) | X | | | | X | X | | | | X | | | | | | X |
| Svoronos and Zipkin (1991) | | X | | | X | X | | | | X | X | | | | | |
| Towill (1991) | | | | X | X | X | | | | X | X | | | | | |
| Towill, et. al. (1992) | | | | X | X | X | | | | X | | | | | | |
| Towill and Del Vecchio (1994) | X | | | | | X | | | | X | | | | | | |
| Tzafestas and Kapsiotis (1994) | X | | | | | | | | | X | | | | | | |
| Voudouris (1996) | X | | | | | | | X | X | X | | | | | | |
| Williams (1981) | X | | | | X | | | | X | | | | | | | |
| Williams (1983) | X | | | | X | X | | | X | | | | | | | |
| Wikner, et. al. (1991) | | | | X | X | | | | | X | X | | | | | |

**Table 3: Supply Chain Models (Beamon, 1998)**

partners which lead to shorter order-to-delivery time. Electronic information exchange supports partner collaboration and facilitates information sharing. *Measurement integration* refers to the development of measurement systems that facilitate segmental strategies and processes. Measurement integration is based on measuring both activity-based cost and cost/profit associated with each entity, establishing cross-enterprise matrix and associating the supply chain performance with financial measures. Concerning the behavioural process, *relationship integration* indicates the need to establish an integrated platform with suppliers and customers for collaboration. Role and guidelines regaling partnership should be clarified in advance. Willingness to exchange the data is a mandatory issue for partnership success.

Closs and Mollenkopf investigated the applicability of this framework to case studies in Australia and New Zealand. They found out that firms in different environments attempt to improve their capabilities in order to enhance their logistics performance. Although the importance of competencies differs based on the deployed environment, the model supports the logistics competency (Closs and Mollenkopf, 2004).



Fig. 1. The *21st Century Logistics* framework.
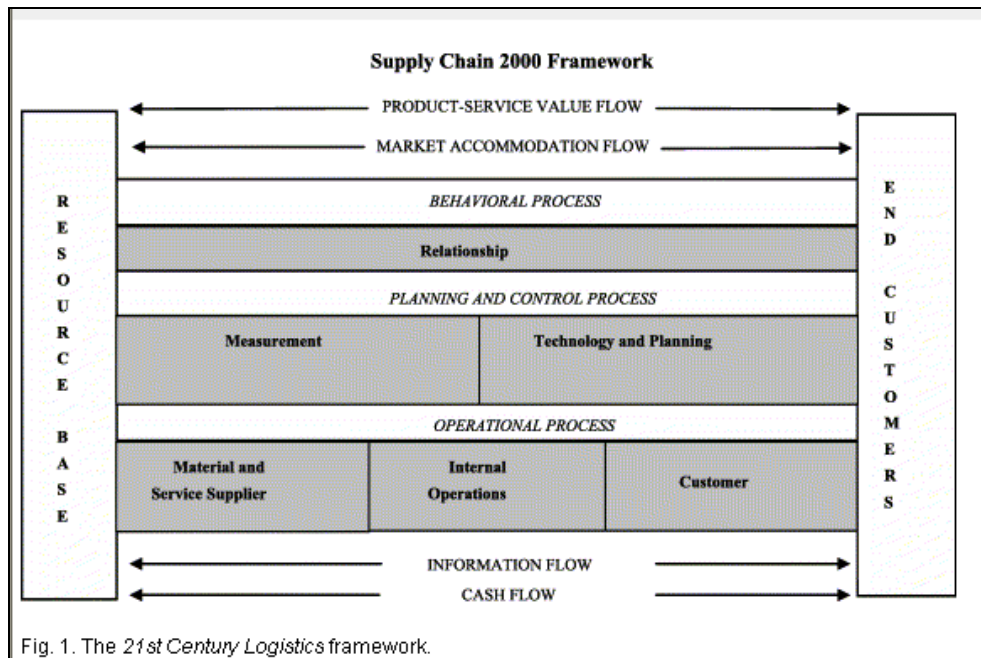
**Figure 12: 21st Century Logistic Framework (Closs and Mollenkopf, 2004)**

The logistic framework considered the main supply chain components regardless of its design and structure. There are a number of considerations that should be followed to design a supply chain. Sharifi (2006) proposes five steps to be considered:

1. A supply chain should target the demand requirement.
2. A set expected pattern of supply chain performance based on requirement analysis.
3. Define performance measurement of supply chain based on required pattern of supply chain activities.
4. Convert the conceptual supply chain model and its performance measurement into business processes.
5. Design supply chain components regarding existing requirements.

Sharifi (2006) emphasised that starting from market analysis to set performance measures is mandatory for a supply chain success. Another perspective of the supply chain was illustrated by Lambert and Cooper (2000). They defined a framework that is composed of three interrelated elements: supply chain network structure, supply chain business processes, and the supply chain management components – as represented in Figure 13. A supply chain network structure represents the involved firms and the links between these firms. Business processes are the core activities of procurement, manufacturing and product delivery. The management components are managerial issues to be integrated and managed across the supply chain.
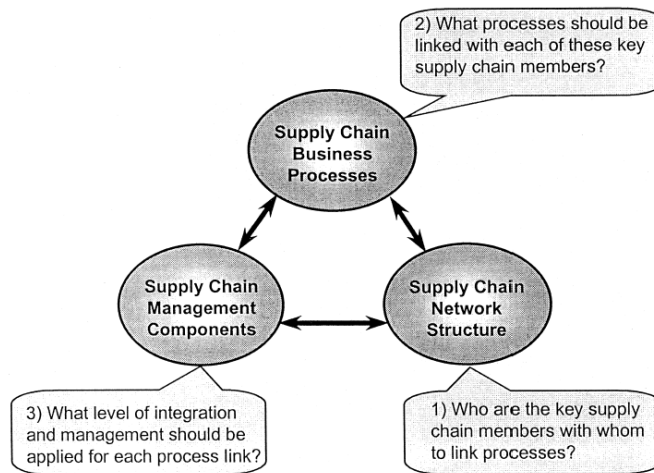


**Figure 13: Supply Chain management frameworks: Elements and key decisions (Lambert and Cooper , 2000)**

Management components are divided into physical and managerial groups as illustrated in Figure 14. The physical components encompass many elements as follows:

- *Planning and control, are needed to set and solve any deviation in the organisational performance in the supply chain.*
- The *work structure* is concerned with the management of ongoing processes across the organisations.
- *Organisational structure,* is mandatory to manage the cross functional activities.
- *Product flow facility structure* refers to the movement of physical material and products along the chain.

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- *Information flow facility structure* represents the need for updated information flow to represent real time transaction.

The managerial and behavioural components are mandatory to re-direct organisational patterns to match supply chain objectives. These components include:

- *Management methods* that indicate the philosophy and strategy followed to manage supply chain co-ordination.
- *The power and leadership structure,* which affects the partner's commitment in the supply chain.
- *Culture and attitude*, i.e. the difference in culture should be taken into consideration due to its importance and its effect on the organisational performance and the workforce.

Product and information flow structures are identified as sub-types of management components. The *product flow structure* represents the procurement, production and delivery of product to customers. As for the *information flow structure,* information type and whether it indicates the real time are mandatory for efficient supply chain.

Although a number of valuable and essential components are discussed in that framework; relationships between these components were neglected so their dependencies were not illustrated. For instance, the need for synchronised supply chain flows (product flow and information flow) has not been demonstrated in this framework. Therefore, the main underlying issue for inter- and intra- organisational systems was not resolved by the proposed framework. Information flow should trigger initialisation and movement for the physical flow. In addition, the applicability of the proposed framework in different countries was not considered. For instance, in the developing countries factors like culture and unwillingness to share data by managerial levels affected collaboration and communication methods negatively inside and outside organisation boundaries (Basmaci, 2003). That is why stand-alone components proposed in the above framework cannot ensure an appropriate level of supply chain integration and optimisation.
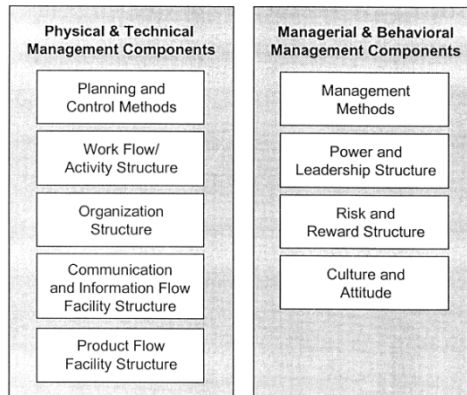
**Figure 14: Supply Chain Management: Fundamental Components**

**(Lambert and Cooper, 2000)**

Basmaci (2003) proposed that Collaborative Planning Forecasting and Replenishment approaches could not provide the managerial level with an understanding of how to implement a successful collaboration strategy. Basmaci pointed out the importance of the framework developed by the International Trading Organisation. According to this framework, firms have to plan to investigate how to improve their proposed value. A collaborative supply chain framework emphasises supply chain planning and continuous improvement. Details of each step are demonstrated in the following and represented in figure 15:

**1. Stage 1: Develop an Overall Understanding of the Supply Chain**

At this stage, there is a need to visualise supply chain entities. The managerial level in each organisation has to be aware of which vital player in their supply chain to deal with.

**2. Stage 2: Position the Organisation within the Supply Chain**

Managers evaluate the proposed value of their organisation to supply chain partners and whether it contributes to the chain. The need for investigating further capabilities or process improvement should be considered by mangers to enhance the proposed value.

**3. Stage 3: Build the Supply Chain Infrastructure Needed for Success**

Defining the important customer is required at this stage prior to establishing a long term partnership. CPFR, VMI or any promising approach can be deployed in such partnerships. The same applies to suppliers. Firms have to determine critical suppliers to mandate for a

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smooth internal operation. Information sharing strategy should facilitate transaction with these partners.

**4. Stage 4: Create and Communicate a Common Supply Chain Vision**

Aligning the organisational culture is mandatory for further collaboration. A common vision could avoid conflicts arising in the objectives of each partner. A definition of the "company's supply chain vision" could be more beneficial. It is the manager's role to promote such vision inside the organisation. Resolving gaps between individual objectives is needed to activate such collaboration.

**5. Stage 5: Cultivate Integrative Mechanisms**

This step deals with the management for effective collaboration by defining obstacles. SC information sharing, SC performance measurement and cross-functional processes and management represent a collaboration mechanism that can be deployed to ensure an integrated platform between partners.

**6. Stage 6: Constantly Re-evaluate and Continuously Improve**

A monitoring process and rapid change to cope with the marketplace are needed. To adopt a technological solution and industrial opportunities could provide supply chain with better access gain to the market. Continuous comparison with competitors is needed. A market scan is mandatory to define possible communication channels, understand current demand patterns and customer preferences.

This framework could provide an organisation with a better chance to fit into a supply chain, to operate and get better access to the market. Integrated platforms of supply chain partners could ensure an optimised performance. The major challenge facing organisations to adopt this framework is their ability and willingness to act as an entity in a system. Without a commitment from the managerial level to share their information and to be involved in collaboration with partners, the applicability of implementing such framework will be diminished. Supply chain integration impacts the ability to compete. Kim (2009) proved this by investigating SCM differences in Korea and Japan to correlate between SCM practice,

competition capability, level of supply chain integration and a firm's performance. The study found out that supply chain integration was accomplished by Japanese organisations a while ago and this integration indicated a high correlation between SCM practice and competition capability. Supply chain integration is a critical cornerstone for optimising supply chain activities.

Based on the Yin and Khoo (2007) study, supply chain optimisation and management have different levels as represented in figure 16. To optimise the supply chain performance, a firm may address long term or short term objectives. The figure indicates different objectives of supply chain optimisation in form of strategic and operational levels. The strategic objectives focus on supply chain design, simulation and demand planning for long term benefits, while the operational objectives are more related to production scheduling, stock management and transportation management. Existing patterns of organisational behaviour in developing countries indicate independent behaviour inside the entire chain where information sharing is still not utilised (Blanchard, 2007). The main criticism that might face this classification is that one objective is being addressed as long term for an organisation while it represents a short term target for another. For instance, capacity planning can be related to operational levels for daily production activities while it might represent further planning for a capacity extension to another.

**Develop Overall SC Understanding**

Map SC: Organizations, technologies, and capabilities
Determine SC value proposition.
Determine value proposition & success factors at each level.
Determine where SC leverage & profitability are located.
Identify critical value-added processes & technologies
Evaluate linkage to end customer
Specifically define "As-is" value-added roles of SC members

**Position Organisation within SC**

Re-evaluate organization's value proposition from SC perspective
Identify the organization's core competencies.
Define critical processes to support core competencies.
Role Shift where appropriate i.e.,move to "To-Be" roles

**Build Customer Success Infrastructure**

Classify customers according to importance & measure profitability
Establish appropriate customer relationships
Implement SC partner development initiatives
Build good relationships with important customers

**Build Supplier Success Infrastructure**

Classify suppliers - materials & service
Establish appropriate supplier relationships
Implement SC partner development initiatives
Build good relationships with important suppliers
Establish mechanisms for transactional relationships

**Create & Communicate Common Vision**

Establish vision & mission statements which affect organisational policies & procedures
Promote internally & garner broad-based commitment
Share externally with key SC partners
Make available to entire SC
Measure alignment among core "partners"
Identify, communicate, and resolve critical gaps

**Cultivate Integrative Mechanisms**

Consensus effort to identify internal & external barriers
Prioritise specific initiatives to build key integrative mechanisms
• Alignment mechanisms • Cross-functional processes
• SC performance measurement
• SC information sharing • Alliance management techniques

**Constantly Re-evaluate - Scan & Plan**

Monitor market & competitive conditions
Conduct periodic environmental & technology scans
Periodically evaluate industry and SC structure
Re-evaluate SC fit
Benchmark value-added: competitors, best in class & customers
Establish continuous improvement programs

**Figure 15: Supply Chain Collaboration Framework  (Basmaci, 2003)**

This pattern indicates that firms in developing countries focus mainly on short term benefits. The current study investigates the validation of such outcome in the Egyptian industrial sector.



**Figure 16: Supply chain optimisation and management (Yin and Khoo, 2007)**

Supply chain optimisation depends on a number of issues. Researchers have been divided into two groups to define leading factors behind supply chain optimisation. While a number of researchers such as Cohen and Moon (1990) and Newhart et al. (1993) assume that a cost function and minimised product types held in inventory can provide an optimised model for a supply chain, others argue that smooth collaboration between partners is the clue to reduce total operational costs and develop an optimised model. Tzafestas and Kapsiotis (1994) carried out supply chain optimisation under different scenarios varying from manufacture facility optimisation, to global supply chain optimisation to decentralised optimisation. Correlations among stages of supply chain have been assumed by the authors to demonstrate the effectiveness of other factors on the chain. This cannot be considered as a simulation of reality where collaboration between partners experienced difficulties and cannot be considered as a default assumption.

The SCM maturity model which was represented by Trkman et al. (2007) indicates that collaboration among partners represents a higher stage of SCM maturity. The SCM maturity model represents the following levels:

- Level 1 – Ad hoc. It is the level where supply chain processes are not well-defined by partners. This impacts cost and responsiveness badly.

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- Level 2 – Defined. While SCM processes are clear to partners, organisational processes still adopt the traditional way of doing business. Order fulfilment rates and supply chain costs are much better than at the previous level.

- Level 3 – Linked. At this level, collaboration with suppliers is established. More responsiveness and cost reduction are indicated in comparison with the previous stage.

- Level 4 – Integrated. Organisational processes are re-structured to fit in the integrated platform of the supply chain. Forecasting and scheduling activities may be extended to become collaborative activities. The SCM cost records a significant reduction.

- Level 5 – Extended. Collaboration between companies is the highest. The supply chain competes in this case rather than individual organisations.

SCM maturity levels will be used to investigate SCM in the Egyptian industrial sectors to define which level relates to the existing SCM. Derived from the fact that supply chain optimisation and information integration are interrelated issues as represented by the SCM maturity levels, a number of researchers have commented on the importance of analysing information flows in supply chain (Decelle et al.,2006). Most of the studies conducted to investigate how to optimise information flow have used simulation techniques as a research methodology due to its' limited purpose (Beamon, 1998).

Simulation techniques were used by Towill (1991) and Towill et al. (1992) to evaluate the effects of deploying five different strategies on demand amplification. Integrating information flow throughout the chain is one of these strategies; but is considered to be a less efficient one on demand amplification than the JIT (Just-in-Time) strategy (Beamon, 1998). JIT depends mainly on a buyer-supplier relationship where information sharing and communication between partners is essential. That is why separating JIT from information sharing is a major critique to this model; JIT strategy is dependent on information integration between these partners. Therefore, implementing a successful JIT strategy cannot be assured without a smooth information flow. Information flow is the mandatory issue that affects demand implication. This matches what Wikner, et. al. (1991) found out. They examined five supply chain improvement strategies. The implementation of the five different strategies was carried out using simulation. The objective of simulation experiments was to show the effect of each

strategy on reducing demand fluctuations. Improving the flow of information at all levels through the chain was the most effective strategy.

Another common approach used by researchers to investigate the information role is a System Dynamic approach (SD). SD was originally called Industrial Dynamics which is defined as "*the study of the information- feedback characteristics of industrial activity to show how organisational structure, amplification (in policies), and time delays (in decision and actions) interact to influence the success of the enterprise. It treats the interactions between the flows of information, money, orders, materials, personnel, and capital equipment in a company, an industry, or a national economy*". Different perspectives of supply chains were investigated by Jones and Towill (1997) using a System Dynamic approach such as supply chain integration and time compression.

Dutta and Roy (2003) used SD to examine the impact of information flows on supply chain performance. The model was developed to measure *demand amplification* in the supply chain. The model demonstrated that "*information-based feedback loops underlie the mechanics of the demand amplification behaviour*". That is why the authors emphasise the importance of defining the pattern of information flow while designing supply chain information systems. Information patterns highly influence supply chain performance. A study by Ham & LaLonde (1996) determined that many consequences may occur if a delay occurs in information handling. For instance, last-minute orders, order changes, mechanical failures, picking and packing errors, coordination failures and data corrections are considered as types of delay that lead to "information friction". A number of factors that lead to supply chain deficiencies have determined to be excluded as such as: manual data entry tasks translators used for data conversion and numbers of firms involved. (Decelle et al, 2006). The authors proposed that high-frequency information flows should be automated and transferred within standard formats to ensure optimal supply chain performance. In addition, the elimination of data redundancy and ensuring system availability should be assured. A theoretical model was proposed in the study of Decelle et al (2006) to a merge knowledge management approach. The implementation of the proposed model from technical perspectives was not discussed in detail, which may argue the applicability of its implementation.

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From a technical perspective, in-depth studies investigated the effect of information visibility on SCM and a framework incorporating RFID adoption was proposed by Joshi (2000). Joshi proposed a framework to improve information visibility in supply chains by reducing delays in information flow. This author assumed that availability of correct information and a partner's willingness for collaboration are mandatory to optimise the supply chain performance. The study examined such issues using a System Dynamics model of the supply chain under different conditions of information visibility and collaboration. The research used FORECAST and SMOOTH functions in different simulation scenarios for the beer game to investigate each pattern of behaviour. FORECAST function in Vensim provides forecasts of the future value based on its past behaviour. SMOOTH function provides an exponential smoothing of input that depends on the delay time entered. The study proposed a framework real time tracking through deploying radio frequency identification technology. Although the use of these technologies can eliminate some time delays and reduce the possibility of error in data entry, cost barriers and environmental issues should be considered to justify such investments. In addition, the study focused on the distribution network and did not consider the supplier's impact on the chain, which has a great impact on supply chain performance. Assuming a smooth replenishment of supplies cannot simulate the reality so information visibility cannot be totally assured while part of the chain has not been considered. The Joshi Beer Game (2000) will be adapted and utilised in this research to investigate the Egyptian industrial sector.

**2.7. Supply Chain Deficiency in Industrial Sectors**

Due to globalisation and the competition that faces producers, the need to optimise supply chain activities reduces related cost and provides rapid responsiveness that becomes mandatory in order to survive in global markets. Therefore many researchers investigated issues that cause supply chain deficiency and evaluate the reasons behind such performance in different industrial sectors worldwide. While investigating current deficiencies in Egyptian industry is the major addressed problem, there is a need to review previous studies which investigate the industrial sectors and define issues raised as obstacles facing supply chain optimisation. Similarity or differences with an existing environment under investigation will be discussed.

A large portion of the current studies focused on the textile industry due to greater Asian competition and resulting decline of the textile sector in other countries. The growth of the textile sectors in different developed or developing countries was reduced due to the rapid growth of Chinese fabrics. Consequently, researchers were redirected to examine causes behind this and to investigate how to improve supply chain performance there.

The UK clothing industry has been affected by global competition, the traditional way of doing business and affecting the obvious power of material supplies (Adewole, 2005). Lack of collaboration and trust between partners are obstacles that face SMEs there, although managers realise the importance of information sharing and its' effect on organisational performance and rapid order processing. Adewole proved that a lack of information-sharing imposes a barrier for SMEs in the UK clothing manufacturing sector. The high cost of electronic technology prohibits the investment in further techniques that would enable information sharing. Adewole concluded that IT is not just a tool for large organisations. The perceived benefits behind it should be understood by SMEs to capture the interest of managerial level there.

Investigation of supply chain collaboration and its affecting factors was conducted by Bagchi and Ha (2005). They defined four major factors of supply chain integration in European firms. These are represented in: collaboration in supply chain design and operations with key customers, collaboration in supply chain design and operation with key suppliers, relationship quality monitoring with supply chain partners and the length of relationship with supply chain partners. The result of their study demonstrate that collaboration in supply chain design and operations with key suppliers is the most critical factor in supply chain integration that affect supply chain performance obviously. At the same time, the length of relationships with supply chain partners shows negative effects on supply chain performance.

Previously discussed models had been created to investigate the applicability of certain supply chain strategies regardless of the characteristics of the applied environment. The environmental factor had a great effect on the applicability of certain strategies or tools. Based on the fact that weight of environmental factors differs based on the growth rate of the country, the relevance of supply chain models to a specific environment needs to be discussed.

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Factors related to cultural issues are critical and should affect supply chain collaboration and integration. For instance, developing countries have some sort of special requirements for supply chain integration. Few studies have aimed to investigate supply chains in developing countries. Besides, there is a lack of a comprehensive survey to define how to accelerate supply chain performance in these countries. Therefore, a number of studies that had been conducted in the environment of developing countries will be discussed in this section.

Voordijk (1999) investigated three supply chains in Eritrea. These chains are associated with raw cotton for the production of textiles, leather and drinks. The study defined obstacles that faced materials supply, manufacturing and distribution in these chains. The study recommendations for further improvement are listed in table 4. Issues related to external environment are decoupled from internal deficiencies to represent such obstacles. Voordijk indicates the necessity of a governmental role to enhance the supporting infrastructure in place and ensure smooth supply chain operations.

Communications between supplier and producers do not exist in the investigated industrial sector, in addition to old machinery with an average age of 25 to 30 years and a lack of business planning or management skills. A need for a satisfactory business climate and good supporting infrastructure aggravates supply chain performance and does not support existing deficiencies. The above obstacles will be investigated in this study to indicate whether Egyptian producers suffer from the same issues.

| Basic conditions | Roles of main actors |
|---|---|
| **Well-developed infrastructure**<br>1. Transport system<br>a. Rehabilitation of existing roads<br>b. Adequate maintenance program<br>c. Building of new roads | Planning and programming of road building and maintenance by the government<br>Private domestic contracting industry for building and maintenance |
| 2. Telecommunication network<br>a. Reconstruction of the network<br>b. Training technical staff<br>c. Regulatory reform of telecommunications industry | Joint ventures between domestic and foreign operators in provision of training and telecommunications services<br>Medium- and long-term planning and regulation by government |
| **Enabling environment**<br>1. Sound industrial policy<br>a. More autonomy for public firms<br>b. Elimination of obstacles constraining domestic and foreign investments | The government has to develop sound competition policies, efficient investment approval procedures in order to attract foreign investments |
| 2. Educational system for skills development<br>a. More resources toward primary education<br>b. Supplying skills for the Civil Service and the public and private firms | Greater role of the private sector in the provision of schooling<br>Involvement of the Civil Service and the private sector in vocational and technical education |
| **Firm level**<br>1. Purchasing materials<br>a. Supply of inputs<br>b. Less bureaucracy inside firms when materials have to be purchased | Improving local supply networks by information provided by the Chamber of Commerce<br>Introduction of more internal linkages between departments within firms |
| 2. Manufacturing capabilities<br>a. Investments in new machines<br>b. Technical assistance | Production and investment agreements with foreign manufacturers<br>Provision of training by the Chamber of Commerce |
| 3. Export and distribution<br>a. Marketing skills<br>b. Linkages with the foreign markets | Joint ventures with foreign buyers<br>Contacts with expatriate entrepreneurs |

**Table 4: Basic conditions for logistics and manufacturing improvements**

The Indian automotive sector also suffers from similar common factors. Based on the Saad and Patel study (2006), a huge number of producers (over 300 small and medium sized firms servicing 24 automobile companies) are involved in Indian automobiles while the integration concept is still not fully utilised. A high tariff on imported components is a limitation to import advanced technologies and at the same time limited capabilities and unreliability of

domestic built components does not support overcoming that. Adopting international quality standards and pay more consideration to components suppliers are still missing.

Although Indian companies enable collaborative activities with their supplier, continuous measurement and improvement of performance should take place to improve and allow adoption of supply chain integration. Elimination of non-value added levels from organisations is needed to enhance the productivity. Supplier selection should be based on quality, delivery and lead time criteria. Saad and Patel (2006) conclude that comprehensive understanding of the supply chain concept is still needed. Applying the supply chain management concept to environmental factors in the Indian environment is considered as an issue for further investigation.

Cultural issues should be considered to optimise supply chain activities and is a determinant of partner collaboration. A study was conducted in the Turkish textile industry that indicated a lack of confidence, willingness to share data and lack of measurement for both collaborative activities and partner participation are barriers that interfere with collaboration efforts there (Basmaci, 2003). Trust between partners affected activities efficient commutation channels interfere with the integration process of supply chain activities (Kwon and Suh, 2005). The managerial level should be devoted and committed to collaborative activities and propagate that inside the organisation (Fawcett et al., 2006). Organisational culture plays a vital role in that "*Issues of trust and risk can be significantly more important in supply chain relationships, because supply chain relationships often involve a higher degree of interdependency between companies*" (La Londe 2002: page 10).

| Barriers to SC Collaboration | Percentage of "4" or "5" Answers |
|---|---|
| Lack of confidence to the partners | 96.8% |
| Unwillingness to share information | 96.8% |
| Lack of consistent collaboration performance metrics | 93.5% |
| Difficulty of calculation of each partner's contribution to the collaboration | 90.3% |

**Table 5: Information sharing barriers (Basmaci , 2003)**

Supply chains do not represent a group of sequential processes; common vision of that correct concept should be promoted between partners. A study conducted by O. M. Fawcett, (2006) indicated the lack of managerial level commitment towards supply chain management. Both top and functional managers commitment are needed for supply chain success. Propagate the culture of a collaborative activities and team orientation could ensure an optimised performance. Perceived value of such collaboration is demonstrated in lead time reduction, improved customer service and efficient business processes. Fawcett (2006) pointed out the lack of studies that emphasise the importance of commitment levels which partners should express. Managerial role and commitment toward supply chain vision will be investigated in my research due to its effect an SCM success.

Another type of study focussed on part of the chain or discussed the applicability of implementing one of the supply chain tools. As an example of these studies, a study conducted by Orala, et al (2003) examined the applicability of JIT in developing countries. This empirical study was based on the Turkish prefabrication sector. The study identified barriers facing successful implementation of the JIT approach, these factors include: poor market conditions, unstable economic environments, high costs of technology, training, maintenance, low costs of labour and cultural values. The empirical study found out that uncertainties in demand and market conditions were the two primary barriers for productivity enhancement. While the success of JIT applications requires stability in both supply and demand, government policies have a great effect on the demand stability in developing countries. Study findings have stressed on critical issues regarding the environment in the developing countries. It demonstrated that companies were unwilling to invest in new technologies. In addition from technical perspectives, low labour costs were key obstacles for automation.

Another study was made of a Korean distribution system (Han, Kwon, Bae and Sung, 2002). The driver for this study was the decision of Korean government to open up the retail market for international investments in 1996. The study defined some characteristics of the Korean distribution system such as: non-existence of a competitive infrastructure which is considered a pre-requirement for successful supply chain integration, lack of trust between manufacturers and retailers having influence collaborative supply chain activities in Korea, the lack of deploying recent technologies and information systems in Korea such as a cross-docking

system. In addition, the study demonstrated the effect of grey markets which sell untaxed items through unofficial distribution channels on international stores sales. Therefore, well-equipped supply chain integration stores cannot guarantee a high sales rate in Korea. Actually, this study has demonstrated many obstacles that are highly visible in other developing countries and face operators' collaborative activities there. In addition, end customers in these countries are concerned with the lowest price products rather than other competitive advantages. Therefore, to meet customer requirements there, the company strategy has been redirected to focus on price reduction rather than quality and fast delivery terms.

For recommendation, these authors have suggested a number of issues required for supply chain integration in Korea, which include: promoting benefits behind supply chain integration to managers and indicate its effect on overall supply chain performance. To accomplish this aim, trust between suppliers and retailers should be ensured for successful supply chain integration. Han et al. (2002) concluded with the need for establishing a well integrated information technology infrastructure to enable supply chain synchronisation. Dell is a common example of IT success in establishing collaboration with a supplier. A Multi-vendor hub was adopted to ensure the supplies needed for a two hour production schedule (Blanchard, 2007). Dell would be able to maintain their procurement while there is no need to hold an inventory buffer. Dell replaced the actual inventory with real time information flow regarding production schedule and incoming orders. Technology adoption had not proved its positive effect on the manufacturers' role, while the retailer captured the perceived benefits behind its adoption. Wal-Mart retailer integrated Radio Frequency Identification (RFID) technology in its activities to ensure a rapid replenishment of stock. The RFID data is available to their suppliers within 30 minutes through an extranet website. The outcome indicates that RFID-enabled stores were 63 percent more effective in replenishing out-of-stocks than using the traditional way of stock replenishment. This proves that to enable information visibility across the chain could provide the chain with rapid order fulfillment (IDTechEx, 2005).

The same result applied to a Hong Kong supply chain. Lam and Postle (2006) had pointed two major studies which were conducted in Hong Kong industry. The first one investigated collaboration between partners in 1996. This study indicates a number of barriers facing Hong

Kong SCM, which is represented in figure 17. Lack of information sharing is a major barrier as indicated by other studies in different countries. 4% of the study participants expressed that SCM is "quite knowledgeable", 27 % of the study participants showed that they "heard the term, but that's all", and over 52 % expressed that they had "never heard of it". The second group focussed on how to drive industrial expertise into global markets in 1997. The study concluded that rapid procurement and replenishment across the chain could accelerate Hong Kong growth in global markets.
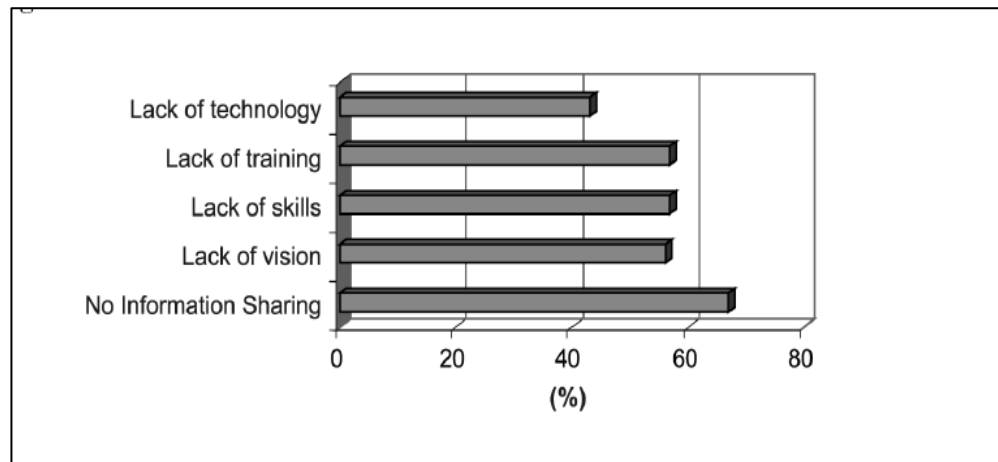


**Figure 17: Barrier to implement SCM in Hong Kong  (Lam and Postle, 2006)**

The textile industry in Hong Kong represents a contradictory example of supply chains, where supply chain integration and disintermediation are employed. More than 105 clothing manufacturing firms in Hong Kong were surveyed. The outcome of such a study shows that textile firms in Hong Kong focussed on internal activities and did not pay attention to logistics systems despite their importance. "*Misunderstanding is a big issue in translating specifications from English into Chinese*" as indicated by Chen's study in 2005 and leads to an information sharing issue. In brief, the Hong Kong textile industry suffers from long lead times, forecasting errors in addition to their distance from global markets. (Lam and Postle, 2006).

The Egyptian textile and apparel industry has been investigated by Magder (2005) based on its economic strength in terms of a large number of firms, being a labour intensive industry and

within important export records. With the end of the MFA, countries such as Egypt have been faced with highly competitive Chinese products. To face this competition and participate in international marketplaces, Magder (2005) has proposed a supply chain model with reduced lead times and demonstrated its effects with a profit increase. Lead time impact is demonstrated in a magnitude of 0.5 percent per week change on average. Magder's model has utilised the geographical proximity of Egyptian firms to focus more on products where shorter lead times are worth more. Magder has figured out that shorter lead times had greater impact in short selling seasons. The textile industry is not a static one, and the fashion industry is characterised with rapid changes in customer demands and preferences. Quick response can provide the chain with rapid movement of products from production to delivery. The issue underlying this is whether "quick response provides benefits for both partners or does it provide cost saving for one and more expenses for the other?" (Daly and Bruce, 2002).

A numbers of environmental factors related to country infrastructure and logistics systems, which affect industrial productivity and export rates, have been indicated in this study. Providing high quality products to foreign markets is the main issue facing these firms. The environmental factors are additional challenges for the Egyptian industrial zone to reach international marketplaces, these factors include: poor supporting infrastructure and reliability of logistics activities. While the Magder study has proposed the importance of lead times to Egyptian firms, it defined critical factors originating in supply chain deficiencies. It attributes this responsibility to firms, governmental policies and basic infrastructure. The study provides valuable solid background to start from and investigate the addressed problem statement in the Egyptian sector.

The Magder study leads us to discuss issues related to IT infrastructure and e-readiness for ICT in the developing countries. Although Porter and Millar (1985) indicated that IT is an efficient tool that can provide organisation with cost or differentiation advantages, realisation of its perceived benefit and willingness to adopt changes in business processes are not well expressed by firms in developing countries. From the technical perspectives, the IT capability and e-commerce trend should be addressed especially while we are addressing countries with limited infrastructures.

Humphrey et al (2003) indicate in their report barriers for B2B interaction in developing countries. As represented in table 6, the authors assess each barrier and its relevance. While transport and technology resistance were awarded high ranking and are considered as critical barriers, they do consider ICT infrastructure as non influential one to B2B transactions.

| Obstacle | Assessment |
|---|---|
| Poor ICT Infrastructure | Not as relevant as often assumed |
| Poor transport infrastructure | Very Important |
| Weak or absent legal and institutional infrastructure | Not as important as often assumed |
| Weak trust infrastructure for certification and effective redress | Open e-marketplaces are not assuming the risks and expenses need to generate trust. The off-line trust infrastructure is a higher priority |
| Lack of preparedness. Awareness and need for training and capacity building | Training and capacity building should not be driven by broad-brush ICT and B2B e-commerce strategies |
| Enthusiasm, resistance and cynicism | Getting the balance between 'old' business parties and appropriate 'new' B2B e-commerce solutions is a high priority for both younger and older managers of producers firms. |

**Table 6: Obstacles of B2B e-commerce and assessment (Humphrey et al, 2003)**

On a micro level, Rizk (2004) summarised the situation of Egyptian e-readiness based on previous quantitative and qualitative macro studies. Egypt represents a modest degree of e-readiness. Additionally, Rizk assessed the e-readiness of SMEs in the textile sector and large organisations for comparison purposes. The study outcome -which is demonstrated in the table 7 indicates that the degree of readiness showed an increased level for larger organisations.

In contrast, a study conducted by El Sayed et al (2003) about how Egyptian society responds to rapid technological change and development globally, indicates a positive reaction of Egyptian firms toward IT adoption and implementation. This study used one case study which can hardly be globalised to indicate Egyptian industrial business in general.

| | | Small | Medium | Large |
|---|---|---|---|---|
| **Connectivity/E-infrastructure** | Level | L | L | L |
| | Type | L | L | H-M |
| | Software Ownership | L | M-H | H |
| **ICT use in Transitions** | Awareness | L | L | L |
| | Use | L | L-M | M |
| **ICT use in Marketing** | Awareness | L | L | L |
| | Use | L-M | L | M |
| **ICT use in Production** | Awareness | M | H | H |
| | Use | L | M | M-H |
| **ICT use in Management** | Awareness | M | H | H |
| | Use | L | M | H |
| **Barriers to ICT use in Marketing** | | *Awareness/Personal* | *Personal/ Awareness* | *Awareness* |
| **Barriers to ICT use in Production** | | *Personal/ Awareness* | *Personal* | *Budget* |
| **Barriers to ICT use in Management** | | *Personal/ Awareness* | *Personal* | *Budget/Technical Difficulties* |
| **E-readiness \*\*** | Connectivity/ E-infrastructure | L | L-M | M |
| | ICT Awareness | L-M | M | M |
| | ICT use | L | L-M | M |
| | Overall \*\*\* | L | M | M |

**Table 7: Primarily E-readiness Assessment (Rizk (2004)**

Success of one case in one sector does not ensure the success of other firms or ensure replication of such success to other sectors. There is a need for cross-industry investigations to indicate the readiness of ICT in industrial sectors.

Another study of IT barriers in developing countries was made by Salman (2004). He investigated IT-based management in developing countries, with special reference to Bangladesh. Regarding Tjaden's differences between industrial and information ages which are demonstrated in table 8, developing countries are supposed to be in the information age rather than industrial age. They must therefore overcome certain barriers. These countries need to establish basic platforms for e-commerce launching. A numbers of issues are related to the traditional industrial age which still exists, such as: a lack of basic business automation, poor management skills and lack of e-commerce integration. Salman's (2004) study has provided state-of-the-art IT perspectives in developing countries. The author identified micro and macro recommendations of the impact of the level of automation and IT applicability in these countries. The research will utilise the results of this study to investigate the IT platform in the case studies of the current research and define the level of IT implementation.

| Industrial Age | Information Age |
|---|---|
| Mass Production | Mass Customisation |
| Labour serves tools | Tools serve labour |
| Labour performs repetitive tasks | Labour applies knowledge |
| Command and control structure | Common control structure |
| Capital intensive | Knowledge intensive |
| Capitalists own production means | Labour owns productions means |
| Capital is primary driver | Knowledge is primary driver |

**Table 8: Differences between industrial and information ages (Salman, 2004)**

## 2.8. Summary

Joining a global supply chain provides a number of arguments in developing countries. Issues ranging from poor infrastructure, cultural effects, labour cost and management methods have been inferred to affect supply chain performance in developing countries. The main objective of this research is to investigate supply chain deficiency in one of the developing countries due to its special requirements. Egypt is considered as a good example of a developing country, where a high inflationary economy, technological dependence on the developed world and its cultural differences from developed countries are demonstrated (Magder, 2005). Egypt could capture the interest of foreign investors as demonstrated in Table 8. But with Asian competition, can the Egyptian products survive in global markets? According to the Logistics Performance Index (LPI) which was issued by the World Bank (Table 9), Egypt suffers from a deficiency in international shipment, custom and poor infrastructure. LPI provides an assessment ranking that can help foreign investors in taking their decisions. IT infrastructure, shipment arrangements and duration are included in this measure.

By 2004, Egypt had taken steps to reduce tariffs on imports as a mean to encourage investment and industrial sectors there. Further agreements such as QIZ are concluded in an attempt to accelerate the growth of Egyptian products in global markets. But the question proposed now is, what is going to happen after the quota phases out? An obvious decline of textile fabrics occurred after the Multi-Fiber agreement that is why there is no guarantee that geographical proximity and low operating costs could help Egyptian industry out of this drop after QIZ. There is a need to address a current performance deficiency in order to improve the competitive advantage of Egyptian products.

| Country | Year | Number of affiliates |
|---|---|---|
| Bangladesh | 2002 | 13 |
| China | 2002 | 363,885 |
| Egypt | 1999 | 99 |
| Jordan | 2002 | 13 |
| Mauritius | 2002 | 35 |
| Mexico | 2002 | 25,708 |
| Morocco | 2002 | 194 |
| Tunisia | 2002 | 2,503 |

*Source:* UNCTAD, *World Investment Report* 2003.

**Table 9: Foreign Affiliates located in the economy (Magder, 2005)**

This research will investigate whether internal deficiency exists, its relevance to environmental or cultural issues, and how to improve the organisational performance. This lead to the following research question: *"What are the challenges that face the successful implementation of supply chains in Egypt?"* Defining factors which had great influence on supply chain optimisation and integration in these environments is the main target of this research.

Methods of defining these factors will be represented in the next chapter. The proposed methodology will be based on an empirical study followed by a discussion about how to translate these empirical data into an ISM model to indicate dependency. Validation and testing the effect of these factors on supply chain performance will be accomplished using simulation techniques. Simulation experiments will be fed with real data instead of using researcher assumptions to validate the entries.

| Overall LPI | Score | **2.37** |
|---|---|---|
| | **Rank** | **97** |
| | **Conf** | **0.24** |
| **Custom** | Score | 2.08 |
| | Rank | 122 |
| | Conf | 0.62 |
| **Infrastructure** | Score | 2 |
| | Rank | 121 |
| | Conf | 0.4 |
| **International shipments** | Score | 2.33 |
| | Rank | 111 |
| | Conf | 0.6 |
| **Logistics competence** | Score | 2.38 |
| | Rank | 95 |
| | Conf | 0.55 |
| **Tracking & tracing** | Score | 2.62 |
| | Rank | 72 |
| | Conf | 0.66 |
| **Domestic logistics costs** | Score | 2.83 |
| | Rank | 94 |
| | Conf | 0.49 |
| **Timeliness** | Score | 2.85 |
| | Rank | 96 |

**Table 10: Logistics Performance Index (LPI) (World Bank 2007)**

# Chapter Three

## Research Methodology

### 3.1. Introduction

The research methodology is of two parts: a theoretical basis for the chosen methodology section and a project description, which indicates how the study is being carried out. The theoretical basis provides the underlying theoretical background related to the knowledge claim and strategy section. The project description represents the study structure, case study context and conducted pilot studies and concludes with a re-structured design of the case study using the pilot study outcome.

### Part One: The Theoretical Basis

The following part gives the justification of the selection. its relevance to the investigated problem is included. Applied strategies used by previous studies in the same area are discussed to indicate their strengths and weakness. In addition, Further details about conducted methods, collection techniques and data triangulation are discussed.

### 3.2. Research Question

A review of previous supply chain studies and discussion of the existing supply chain framework emphasise the gap in research on how to investigate methods to accelerate third world capabilities in order to reach global markets. Egyptian sectors lack such research and do suffer from an obvious decline in some of its sectors. Therefore, the necessity to investigate supply chain deficiency in a country such as Egypt emerges, being as it is an example of a developing country that struggles to survive competition with Asian products.

The main objective of this research is to define the challenges facing the implementation of successful supply chains in Egypt and propose solution that might improve supply chain performance. The co-dependency between these challenges will be demonstrated in order to define the major issues leading to supply chain deficiency and their principal factors. Based on the above, the main research questions are:

*1. "What are the challenges that face the successful implementation of the supply chain in Egyptian Textile sector?"*

*A-"What is the cycle of supply chain deficiency in the Egyptian Textile industry?"*

*B-"What are the major deficiencies that lead to other supply chain deficiencies in the Egyptian Textile sector?"*

*C- "What are the minor deficiencies that occur as consequences of other supply chain deficiencies in the Egyptian Textile sector?"*

*D- "Do the external issues aggravate the internal deficiencies of supply chain activities in the Egyptian textile sector?"*

*2. "What is the best solution that can provide the textile supply chain in Egypt with rapid responsiveness and cost reduction?"*

In order to address these research questions, a promising industrial sector in Egypt which is suffering from obvious decline has been chosen for a number of issues to be investigated. Supply chain activities, such as the IT role in these supply chain activities, degree of supply chain integration, information visibility and partner collaborative activities are investigated. External factors related to cultural issues, the role of supporting infrastructure and managerial expertise are also included as well. The Conducted methods and strategy used to explore these issues are discussed in next section.

### 3.3 Research design

To move from broader assumptions toward defining methods to be conducted, Creswell (2003) aggregated and re-formulated Crotty's (1998) framework into three steps for designing a research programme:

- Define knowledge claims adopted by researcher;
- Define strategies that can be employed due to their appropriateness to the research question.
- Define methods of data collection and analysis.

The following section represents each of these steps in details

### 3.3.1 Knowledge Claims - Philosophical Perspectives

The researcher in the early stage defines his philosophical perspectives, therefore an assumption regarding the research outcome is issued and the mean of reaching this outcome should be identified as well. Creswell (2003) points out that "*The researcher makes a claim about what is knowledge, how to know it, what values go into, how to write about it and the process of studying it*". With reference to the information systems researches and their classification of knowledge claim, a summary of these categories will be discussed in the next section to indicate which one is most suited to addressing the problem statement.

Clarke (2000) classified research traditions in information systems in general, and e-commerce in particular, into three main categories: 1) conventional scientific research (or positivist). This is where a researcher starts using a theory then proposes a hypothesis that should be tested to provide feedback for the proposed theory. 2) Interpretivist research, assuming that reality can be interpreted in a variety of ways depending on a number of factors in addition to the researcher's perspective. 3) Engineering research, where research focusing on electronic commerce has an engineering rather than a scientific orientation while it is more concerned with technology. Clarke extended the Orlikowski and Baroudi (1991) classification where they proposed three categories of research epistemology based on examining large amounts of information systems research. These categories are: positivist, interpretive and finally critical in which the role of social critique arises. An examination of the above classification with regards to the research objective indicates different epistemologies in the research. The Exploration of the reality using a qualitative approach such as a case study is necessary in the early stage of this research. This imposes an interpretive epistemology for the research programme (Falconer and Mackay, 1999). Test hypotheses for generalisation purposes and for propose solution is required at a later stage of the study which interpretive could not provide. Employing a quantitative method for conformity and generalisation imposes positivistic epistemology. The above classification did not pay enough attention to mixed methods research design. The reason behind this fact might be the small sample of IS mixed methods research, which represent 3.2 % of investigated studies. In contrast, Creswell (2003) paid considerable attention to the adoption of mixed methods as a method of data triangulation between quantitative and qualitative approaches. The mixed method would ensure that

research findings do not suffer the limitation of participatory study added to the fact that it is not based on theoretical assumption.

The inductive logic of a qualitative study has been criticised by Popper (2008). According to this logic, the researcher starts with an empirical study to collect a real dataset and ends by generalising the research findings. Popper points out that an inductive study cannot be considered as justified since it is developed on experience. Popper (2008) states the there is a need to define certain "principles of induction" since that statement is "logically justified by another statement". The research will include a combination of empirical and mathematical approaches to avoid the subjectivity related to the qualitative approach. The quantitative approach will be used in my research for conformity and validation purposes in accordance with Creswell classification.

According to Creswell, knowledge claimed is an assumption related to reaching the outcome of such a study and the knowledge acquired through it. Different alternatives are indicated as knowledge claim according to Creswell (2003). The classification of knowledge claims will be discussed in the following section to conclude which type of knowledge assumption is adopted in the research:

1. Postpositivism is defined as "science" or "scientific" research. It is the deterministic philosophy of investigating causes that determine an outcome. The Postpositivist cautiously measures the reality in the real world cautiously. A researcher initiates the study with a theory and then uses the data collected to accept or reject the theory.

2. Constructivism is based on the subjective involvement of researchers; researchers are believed to have a holistic perspective, which represents the complexity of reality instead of assuming a small set of ideas. They place themselves in the research and employ their backgrounds to interpret the situation. A participant's perspective has an obvious role to help define the implications.

3. Participatory approaches assume that the investigation should propose an action agenda to address the change needed and argue a constructivism approach for this purpose. The cooperation of participants is based on this approach and such participation extends to involve data collection and data analysis phases. A visual

illustration of the addressed issue coupled with participants and actions needed are developed.

4.  Pragmatic approaches where knowledge is captured based on the situation, actions and effects rather than the theoretical assumptions applied in postpositivism. A mixed method which is a combination of closed and open ended measures is commonly employed to understand the problem statement pragmatically.

With regards to the above discussion, it is believed that exploring issues associated with the problem statement and adopting an alternative method for conformity is more appropriate to providing a consolidated and validated outcome. The mixed method was proposed by Creswell (2003) and Sekaran (2003) as a more reliable method. While there is lack of research of the investigated environment, proposed absolute theoretical assumptions (Postpositivism approach) could not simulate reality or provide a proper solution. Brannen (2005) indicated that mixed methods provide an advantage in the exploration of issues that may not be illustrated in theoretical work and encourage thinking 'outside the box'. Duncan and Harrop (2006) point out that the research should use at least "two languages", a technical language should be used alongside more comprehensive one to simplify the messages. Therefore, the authors indicate that the adoption of mixed methods could ensure the investigation of research enquiry with by different means. Mixed method has proven its strength in the following (Johnson and Onwuegbuzie, 2004):

- The use of multiple methods could help the researcher with interrelated research questions.
- The result of the first method can be employed to design the second methods.
- The Mixed methods approach provides corroboration and convergence for the conducted study.
- A mixture of quantitative and qualitative approaches provides the research with both theory and practices regarding the developed theory.

Sekaran (2003) indicates the need to conduct an exploratory study as there is little information or a lack of research. "What" and "How" to investigate the research is based on its intended consequences (Creswell, 2003). Since the investigated research question is important in this

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research, a pragmatic approach is the best method to be employ.  The exploratory nature of this research imposes the use of multiple methods to explore and confirm findings and outcome. Employing the mixed method approach could ensures that the research conducts an in-depth investigation of issues experienced by industrial organisations in Egypt, which require the participant's vital involvement and explanation. Decision makers in the investigated case studies and a number of participants related to supply chain activities have been interviewed in order to explore the difficulties they face. The external factors related to business climate and governmental policies are examined as well so as to demonstrate how way they reflect on the organisational performance. A Survey is conducted as a conformity tool for the purpose of generalisation. Investigating such issues and reaching consolidated findings is not enough unless the proposed solutions are being tested. The research will rely on quantitative methods to propose solutions according to empirical study findings and test their impact on supply chain performance. Since culture and resistance to change are important issues to be considered especially in developing countries as indicated from literature (Salman, 2004), the research could not rely only on a participatory approach, which may misinform its findings and lead to concluding with subjective results. Therefore, techniques of cause and effect are deployed to indicate the consequences of the proposed solution. Deploying both qualitative and quantitative methods provides a comprehensive investigation of the addressed issue.

### 3.3.2. Research Strategy

Defining philosophical assumptions leads us to the following stage that involves the investigation of the relevant research strategies that are the most relevant to this assumption. Pragmatism approach adopts multiple methods of qualitative and quantitative tests (Creswell, 2003). Qualitative research is "*like deep sea explorers, qualitative studies may pull up unexpected items for us to gaze on*" (Burns, 2000 Page. 13). In-depth exploration supply chain activities and the experienced deficiencies is a priority of this study. Proposing solutions that might improve supply chain performance will be generated based on the commonly used techniques of cause and effect. Based on Yin (2003), Case studies and surveys will be employed to address the question "what are supply chain deficiencies in Egyptian industry?" and "how does the deficiency of each activity influence supply chain performance or other

activities". To overcome the limitation of each strategy, multiple strategies are employed. Triangulation is achieved by multiple strategies to find the correlation in between. A collection of qualitative and quantitative data sequentially is the essence of the mixed method approach, which is adopted for pragmatic knowledge claims (Creswell, 2003). Yin (2003) defined the survey as an instrument which is not capable of explaining causal effects in reality whereas case studies are much more effective in exploring a situation and providing an in-depth description of an investigated context. While there is a lack of research regarding industrial performance deficiencies in promising Egyptian sectors, a qualitative exploratory approach such as a case study could expose the main investigated issues and provide a descriptive view of a situation to be generalised at a later stage (Morse,1991). Therefore, a case study followed by the survey a larger number of firms. It is recommended that research findings be confirmed from different sources Creswell (2003). Since the need for exploring issues that will be investigated comes before the conformity stage in this research, a qualitative case study has been adopted as the first priority. Matching data comes from both approaches occurring in the data interpretation stage while the case study represents a hypothesis definition stage and a survey instrument to test such hypotheses in large scale trial. The study adopts a sequential exploratory strategy which imposes initial qualitative data collection and analysis followed by quantitative data collection and analysis. Creswell (2003) claims that this approach is useful when researcher "*need to explore phenomena and but also want to expand on qualitative findings*". Sekaran (2003. page 118-125) classifies research based on its purpose into exploratory, descriptive and hypothesis testing, current studies do intend to explore existing deficiency and use the hypothesis testing approach to generalise the findings. A simulation technique is used to examine the effect of the proposed solution on supply chain performance measures. Simulation techniques are more suited to being employed to put the theory into practice than real life implementation. Testing the proposed solution on a real supply chain is hard to accomplish due to several issues. Culture and resistance to change are the main barriers that face testing proposed solution using field experimentation. Experiment could provide more control over tested environment to identify the causal relationship between the factors (Denscombe and Martyn, 1998), implementing such experimental design and running the experiment is rarely approved by decision makers in the industrial firms. Cause and effect relationships are represented in this research using computer simulation and modelling.

Simulation is used to represent the real environment and causal relations could be defined since the control is represented. A simulation technique is used as a decision making tool which can provide the participant with the best solution for current deficiencies (Sekaran, 2003).

### 3.3.3 Research Methods

Given the research question and in order to investigate supply chain deficiencies in the Egyptian industrial sectors, a causal study is proposed to indicate the causes of performance deficiency. Causal study is defined by Sekaran (2003. Page 126) as a type of investigation that defines the reasons behind certain problem. Research methods employed in this research employs open-ended interview with a predetermined instrument methods to achieve the study purpose. Creswell (2003) point out the need for open-ended and close-ended questions to emerge in mixed methods. Using multiple methods can help avoid the weakness related to each method individually. Clarke (2000) categorises the research techniques based on their nature whether they are empirical or not. According to this classification, this research adopts different type of techniques. Empirical techniques are used for exploring phenomena and collecting real datasets. A case study replies on multiple sources of evidence followed by a structured questionnaire for conformity employing empirical techniques. These techniques relate to a scientific and interpretivist boundary. Simulation techniques, since they represent a formal model of reality to test action that can hardly be tested in real life, is classified as a Non-Empirical technique depending on imitation or on a conceptual view. Feeding simulation techniques with the real datasets, which result from the empirical study eliminate this limitation and represent a more realistic and validated solution.

Conducting in-depth interviews coupled with examining archival records, observation and conformity surveys ensures the validity of the findings. But how, in effect do different data analyses come to the same conclusion? (Denzin, 1970). Mixed methods are commonly used for one of the following Hammersley (1996) purposes (Bryman and Bell, 2007):

- Triangulation: using quantitative research in order to support the qualitative research results and vice versa.
- Facilitation: when one research strategy is used to assist the research using another research strategy.

- Complementarily: this is applied when the two research strategies are employed with the goal of fitting together different aspects of an enquiry.

Brannen (2005) had discusses further meanings of data triangulation based on literature in that it takes several forms in addition to that of conformity, these forms are represented as follows:

1. Elaboration or expansion: the use of one approach contributes to the comprehensive understanding of another.
2. Initiation: the researcher uses an approach for exploratory purposes and to issue new hypotheses.
3. Complementarily: each approach adds to the study results and both help to reach meaningful findings.
4. Contradictions: the findings of each approach are contradictory and represent conflict in the findings.

By combining qualitative research with quantitative one aims in this research programme to target initiation and complementarily purposes. Since the qualitative research does extremely well in explaining complex social phenomena, and in establishing a theme or applying the participant's point of view, the quantitative research deals better with larger quantities of data and helps in reaching a generalization of the results. The exploratory case study is used to structure the study hypotheses, which in turn are confirmed using structured survey. This argument justifies the adoption of both approaches for hypotheses initiation. Additionally, It proves that qualitative analyses is used to complement the quantitative results and provide an in depth explanation of quantitative findings. According to the Clarke study, exploratory research should be conducted where a lack of research exists. An open-ended study is needed to acquire knowledge. System dynamic techniques are used to conduct simulation experiments, test the proposed solutions and define which of these leads to optimal supply chain performance. So the simulation technique will be used to validate the empirical study findings on a quantitative basis. Details of each methodology and deployed evidences will be discussed later in this chapter.

### 3.4. Research Structure in Supply Chain Field

The research follows the structure proposed by previous supply chain studies for supply chain modelling. This structure entails exploring real supply chains using the qualitative approach and validates the findings with a quantitative approach. According to Laurikkala el at. (2002), several stages have to be considered when designing and modelling supply chains. Starting with the real supply chain and identifying its encompassed business objects followed by data analysis in order to visualise the conceptual models. The role of quantitative methods is decided at this stage in order to test and validate findings. Mathematical, simulation models or control theory techniques are utilised. Re-design of the quantitative model might arise to match reality and validation issues. Figure 18 shows the research structure of supply chain modelling.
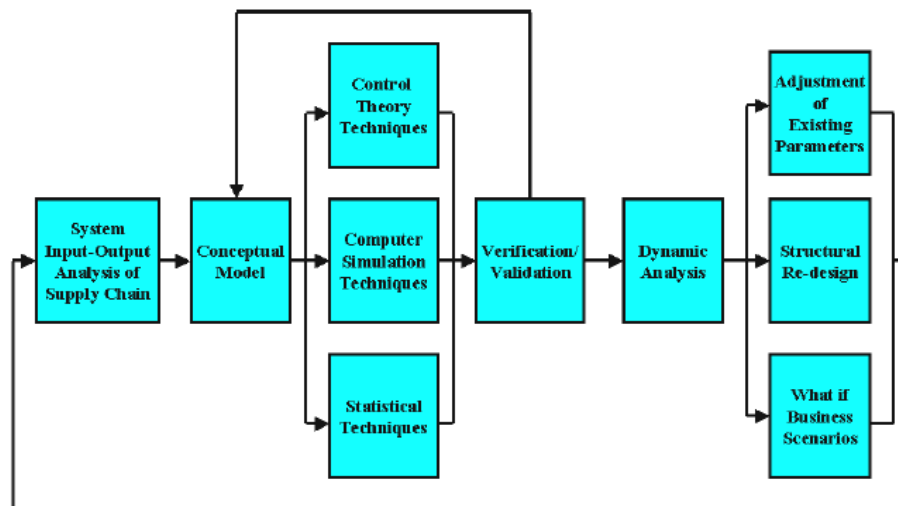


**Figure 18: Research Structure for Supply Chain Modelling**
**(Laurikkala, Vilkman, Ek, Koivisto, Xiong, 2002)**

Naim and Towill (1994) propose a similar structure in the "Cardiff Framework for Supply Chain Design". The Cardiff framework, presented in figure 19, provides researchers with a procedure to model a supply chain using qualitative and quantitative approaches. The analyses of real datasets to develop conceptual model is employed at the quantitative stage. The set up of a mathematical or simulation model is applied to test the conceptual model. Model validation is needed to ensure the simulation of reality.

Based on the above, the research adopts the structure proposed by Naim and Towill (1994). A qualitative approach will be employed to define supply chain deficiency issues and their leading factors. Figure 20 represent the adopted structure for the research. The research structure starts an exploratory case study strategy.
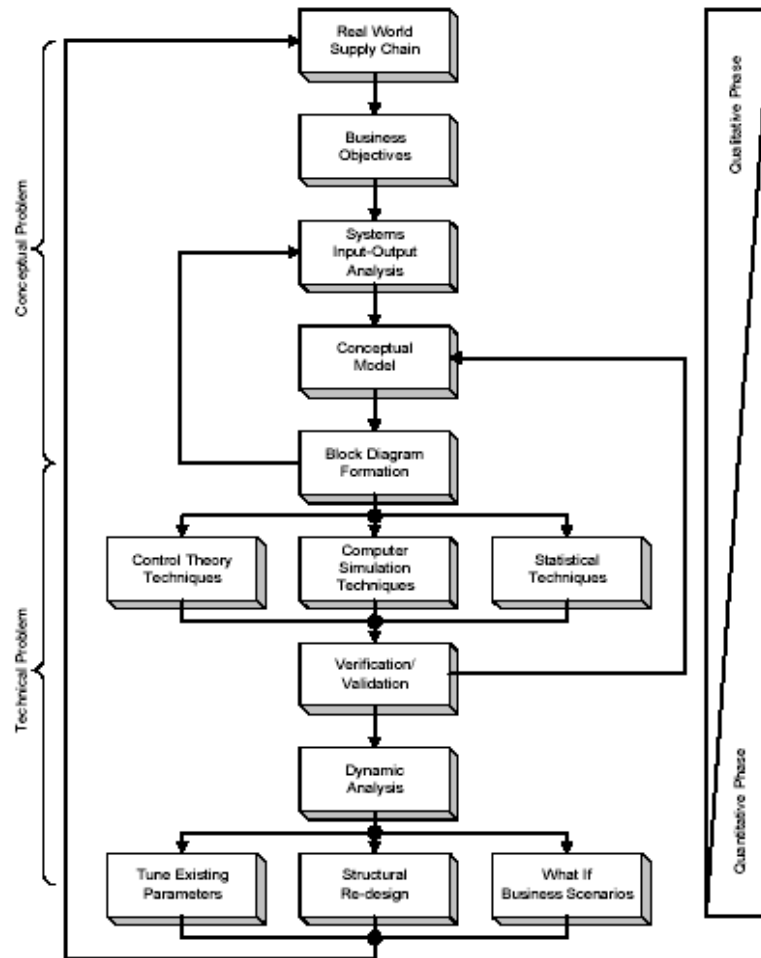


**Figure 19: Cardiff Framework for Supply Chain Design**
**(Naim and Towill, 1994)**

Based on the empirical findings, Interpretive Structural Modelling is used in this thesis to indicate dependencies between issues and their driving power. A stage-based model to demonstrate the discussed deficiencies followed by the development of a conceptual framework is carried out based on the case study findings. This framework represents the major issues that lead to the current deficiencies. Conducting a survey on a larger scale is employed as a conformity strategy to re-structure the proposed framework. The Proposed

actions that could be taken to improve supply chain performance are tested using simulation techniques. The iterative process will be employed to reach the optimal solution and achieve a better supply chain performance. Further details of conducted strategies are discussed in the following sections.
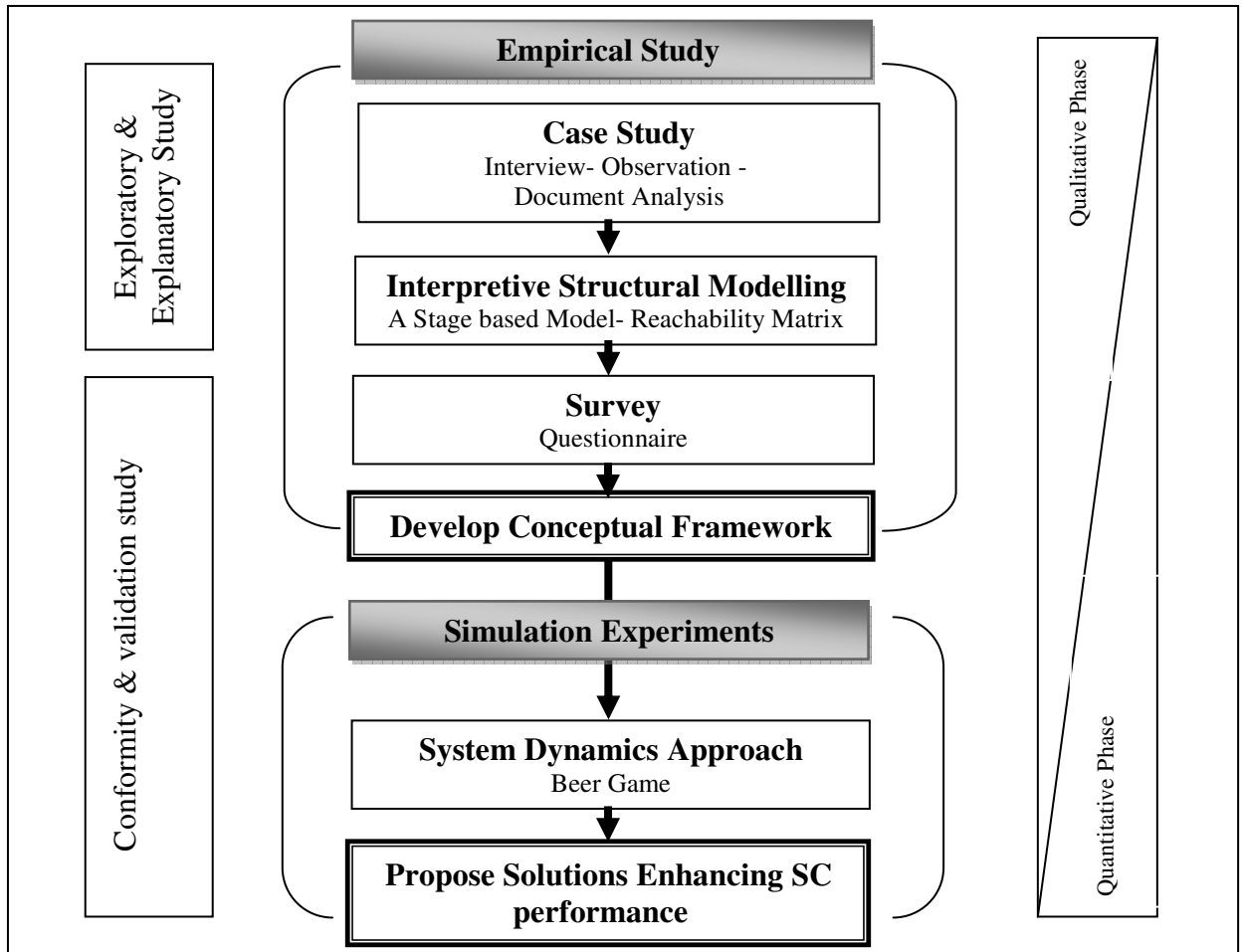


**Figure 20: Research Structure used in this Thesis**

## 3.5. Conducted Research Strategies

The research adopts three main strategies to explore, confirm empirical findings and test the proposed solutions.

### 3.5.1 Case Study

Case study research is a commonly employed qualitative method used in information systems (Alavi and Carlson, 1992). Yin (2003 Page. 13) defines a case study as an empirical study that: "*investigates a contemporary phenomenon within its real-life context, especially when*

*the boundaries between phenomenon and context are not clearly evident*".   A case study is appropriate to adopt at the earlier stages of research due to its' exploratory nature. Myers (1999) defines the difference between case study research and ethnographic research as "the extent to which the researcher immerses himself or herself in the life of the social group under study".  Ethnography focuses more on human and social issues which is appropriate for social or cultural field investigation. The poor credibility of case study is major issue which have to be considered as strategy limitation for generalisation issue (Oates, 2006).

Yin (2003) identifies six sources of evidence for collecting data in a case study. These are: documentation, archival records, interviews, direct observation, participant observation, and physical artifacts. Multiple sources of evidence are required to ensure the validity of the study (Tellis, 1997). Collecting data from multiple sources could ensure data validation and as well as overcome the bias related to single method use (Polit and Beck, 2003 Page. 431). The study conducts a number of semi-structured and un- structured interviews with decision makers and middle managerial levels to capture more details about supply chain activities in these organisations. Additional evidence is provided by the Analysis of records and documents relevant to such activities provides additional evidence. Multiple case studies in an industrial sector have been investigated to arrive at the supply chain issues that reduce organisational performance in the investigated sector. Replication logic is applied using multiple case studies to ensure external validity while multiple data source are used to ensure construct validity (Yin, 2003 Page 34). This avoids the criticism of the case study methodology that relies on a single case and cannot be generalised (Tellis, 1997). Different samples of textile producers regarding organisational size, applied strategies and domestic or global market contributors are considered as case studies participants.

A definition of the logical sequences that can bind empirical data and the expected outcome to a study's question is required when designing the case study. (Yin, 2003 pp.21)

**3.5.1.1 Case Studies Components**

Five components of case studies research design are proposed by Yin (2003, pp. 21) and (Burns, 2000 Page. 464):

1. Fundamental questions.
2. Propositions, if any.
3. Unit(s) of analysis.
4. Logic linking the data to the propositions.
5. The criteria for interpreting the findings.

- A study's questions and unit of analysis:

The current research in hand is an exploratory case study. According to the definition of exploratory type of procedure, the nature of the research question is related to the "what" question. The study uses a generic research question to define the challenges that face Egyptian industries. This type of research question justifies choosing an exploratory type for this study (Zainal, 2007). Sub-questions using "how" are mandatory in order to explain the cause and effect relations and interrelations between activities. These questions investigate how IT can deploy, a logistics system, the deficiency of other activities and the external factors that affect supply chain activities and cause problematic issues. Since the unit of analysis in a case study could be an individual, a community or an organisation under investigation (Tellis, 1997), supply chain activities and organisational behaviour is the unit investigated in the research and is investigated in multiple case-studies.

- Study propositions,

The study proposes that: *Lack of seamless Information flow is a major issue which leads to other supply chain deficiencies.* This study will investigate accuracy of such a proposition besides exploring any hidden proposition that might defect supply chain performance in Egypt.

- The logic linking the data to the propositions.

Yin suggests that every investigation should have an analytic strategy which is: a *"pattern-matching*, *explanation-building* or *time-series analysis"* (Yin, 2003 pp. 26-27). Regarding the current study, defining supply chain issues and explaining their influence; and relevance to research proposition enables the use of an explanation-building entails. Explanation building

means identifying causal relationships to support the theoretical proposition. (Burns, 2000 Page. 473). The analysis is carried out by building an explanation for the supply chain deficiency issues and their leading factors using the iterative process based on Burns (2000 Page. 473) recommendation. Explanation-building is an iterative process which relies on comparison between proposition and findings and reforming the proposition on alterative bases. Since this study investigates multiple case studies, explanation building will be in the form of cross-case synthesis (Yin 2003 Page. 133) instead of that of an individual case. Providing empirical evidence from a set of cases to test a theoretical proposition is the core of the analysis process. This strategy is used to generate a hypothesis and propose issues for further investigation (Yin, 2003, P. 120). These hypotheses have been tested using the survey instrument. Several pieces of information from the same case study are related to the research proposition.

- The criteria for interpreting the findings,

Since the main objective of this study is to explore deficiencies faced by industrial organisations as well as build an explanatory pattern to examine existing organisational behaviour, therefore, explanation building involves testing the rival causality to link developed explanations with the proposition (Burns, 2000 Page. 473). The rival proposition has been used for comparison where the statistical data is not available (Yin, 2003 pp.27). The statistical data which indicates the importance of experienced deficiencies is analysed to determine the major and obvious issues from the respondents' perspectives.

### 3.5.1.2 Used Evidence Types
Multiple types of evidence are used for data triangulation which ensures construct validity. Construct validity guarantees that the researcher did not reach findings subjectively (Tellis,1997). In the context of data collection, triangulation serves to correlate data gathered from different sources (Cresswell, 2003 P.196). When different sources of evidence address the same facts, the facts are supported by more than one source enabling the achievement of convergence of evidence (Yin, 2003 pp. 99).

Interviews are one of the most important sources of case study information (Tellis, 1997). An interview can take one of several forms. By using an open-ended interview, the interviewer is able to acquire more information about respondents (Burns, 2000 Page. 467). Since the interview is considered as a guided conversation, it is more appropriate to be used initially rather than as a structured instrument. Due to the confidentiality of data collected, it is better obtained via dialogue (Yin, 2003 pp. 89). Cultural issues tend to make companies more reluctant to reveal their business issues and their deficiencies in the form of a structured survey; this makes an interview the best alternative to be used.

Informants are asked to report insight facts related to their supply chain performance and activities. Additionally, a participant's perspective and their explanation regarding current deficiencies are taken into consideration. Face-to-face interviews reveal "invisible" issues that are important to the researcher's view (Cresswell, 2003 Page. 187), this limitation is overcome by using multiple evidence. While open-ended interviews can provide an in-depth investigation for investigated situation, focused interviews have been employed to follow the line of inquiry (Tellis, 1997). Open-ended interviews are used to capture knowledge related to a deficiency existing in organisational performance in addition to the effect of environmental and cultural factors. A semi-structured interview was adopted for conformity and explanatory issues related to influence between issues and their driving power. Conducting interviews in the early stages of the current study enabled the researcher to acquire sensitive information which was difficult to capture through a structured questionnaire.

Direct observation is evidence that occurs when the investigator makes a site visit to conduct an interview. Ad hoc observations were made during an interview or while gathering other evidence as recommended by (Burns, 2000 Page. 468). This provides some sort of data validity to the research programme and enables the researcher to gage the effect of cultural issues and resistance to change on theoretical propositions.

Documents, archival records and physical artifacts were collected by the researcher during site visits as vital sources of data. These documents are represented in: administrative documents, annual reports, Forecasting charts, organisational records, computer output, system manual,

exportation records, CAPMAS (Central Agency for Public Mobilisation and Statistics, Egypt) information and other similar physical evidence.

### 3.5.2 Interpretive structural modelling (ISM)

ISM is a well-established methodology to define correlations between a group of factors (Sage, 1977). ISM methodology was employed to impose order and direction on complex relationships between issues that affect supply chain performance. Supply chain experienced deficiencies are manipulated using the ISM approach to represent interrelationships, the driving power and dependencies between issues. (Sage, 1977) (Jharkharia and Shankar, 2004). Interpretive Structural Modelling was first proposed by J. Warfield in 1973 to analyse complex socioeconomic systems (Gorvett and Liu, 2007). The ISM computer-based application is fed with the opinion of a group regarding of elements and formation of its relations. ISM is commonly used to handle "Interactive Management" (IM). Interactive management is used deal with complicated issues where a systematic way of problem solving is not applicable. The outcome of the ISM approach is a logical structure which can represent relations between issues in forms of negative influence "problematique Structure", or the structure may represent the positive relations between proposed improvements "Enhancement Structure". "Intent Structure" correlates a group of objectives or goals that are interrelated in a positive manner (Benjamin, 1997).

The ISM approach establishes a comprehensive meaning of interrelation between the elements using the following steps (Jharkharia and Shankar, 2004):

1. Define the elements which are related to the problem statement using survey or any group problem-solving technique.
2. Develop a relationship between each pair of elements;
3. Initialise a structural self-interaction matrix (SSIM) which illustrates the relationship between each pair of the system.
4. Establish a reachability matrix from the SSIM, and check the matrix for transitivity – indirect relations between the elements.
5. Represent the relationships which are confirmed in the reachability matrix in a form of graph.

6. Establish an ISM-based model which demonstrates the elements and their relationships.

7. Restructure the model to reflect the theoretical basis of addressed problem.

The ISM approach is commonly used to rely on group brainstorming or any techniques of a group problem-solving to establish the structuring process. Conducting a survey is considered to be a supportive tool to facilitate the structuring process and identification of the relations (Jharkharia and Shankar, 2004). Consequently, by defining supply chain issues from case study findings, a participant is asked to rank issues with top priority regarding their business relevance. ISM software computes the indicated weight score associated with each issue. ISM software was employed in this research as it is the only software does the structuring process related to ISM methodology. The researcher refers to field expertise to indicate relationship between issues using a contextual relationship structured by ISM software. Problematique structure is developed using the research objective. This structure shows "a *graphic representation of indicate how a set of problems are related to one another through aggravation or other forms of negative influence*". (Benjamin, 1997)

Based on this structure, a reachability matrix is generated by ISM. Dependences and the driving power can be illustrated by this matrix. It indicates dependant and independent elements. The major issues lead to supply chain deficiencies will be identified based on their importance power. Both issues with major and minor effects are tests using survey techniques for conformity and generalisation purposes.

### 3.5.3. Survey

A Survey is used as an instrument to provide a "*quantitative description by studying a sample of the population*" (Cresswell, 2003 p.153). According to Yin (2003 p5), a survey is research strategy that can be employed to deal with the "what" and "how" forms of research question. While many researcher claim that case study evidence cannot be sufficient for generalisation purpose (Burns, 2000 p. 474), conducting a survey is used at a later stage of the research as a conformity tool. While a survey is best used in positivistic and quantitative research, it is not best fit for qualitative investigations (Vaus, 2002 Page.5). "Questionnaires are an efficient data

collection mechanism when researcher knows exactly what is required and how to measure the variables of interest" (Sekaran, 2003). They are one of the more reliable methods to be used whereas surveys are used to test proposed hypotheses. A Hypothesis is a relationship between two variables that is expressed in the form of a testable statement (Sekaran, 2003 Page. 103). In this study, hypotheses test whether each proposed issue aggravates or contributes to supply chain deficiencies as a major or minor factor. Moreover, the sequence of occurrence is also tested using these hypotheses. Hypotheses, which are initialised from a case study outcome, are confirmed by the structured instrument to indicate their conformity. Based on hypothesis testing, the correlation between the investigated problem and leading factors allows the degree of importance for each issue to be confirmed. The difference between organisations regarding adopted strategies or sector are considered during hypotheses generation. Null hypotheses in addition to an alternate one are tested.

The survey design uses Cresswell's (2003) recommendations. The length of the survey is designed to capture the interest of the managerial level and ensure a rapid turnover. The questions were tested to overcome ambiguous wording (Vaus, 2002 Page.). The survey was translated into a participant's native language to avoid language barriers. Since response rates are affected by different issues such as: content, structures of question and conduction method, these factors have been considered for a re-structure process based on participant feedback (Vaus, 2002 p.97). A logical sequence of questions is initialised with a broader one and end specifically as Sekaran (2003 Page. 242) recommends. Conducting a survey in interview form is more appropriate to avoid misunderstanding.

The survey employs multiple scales. The scale is a tool used to differentiate and categorise the individuals (Sekaran, 2003). A combination of interval, ordinal and nominal scales is employed in this survey as well as open-ended questions. Regarding Sekaran's (2003) discussion of different scales, the ordinal scale is adopted to provide rank ordering while the interval one is used to indicate magnitude of differences in participant's view among organisations. The interval scale is used to indicate which issues lead to supply chain deficiency and their degree of importance. A likert scale of (1-5) is used by the respondent to indicate their perception of the addressed problem. An ordinal scale is used to identify the rank

associated with each issue and its role in the deficiency cycle. Respondents are asked to rank each issues based its occurrence level in the deficiency cycle. A nominal scale acquires information about the associated sector, adopted strategy and production capacity. Industrial organisations have been questioned to indicate the adopted supply chain strategy (Mass production, mass customisation or mixture of both them) and the sector it relates to. The difference and similarity of deficiencies between different strategies and sectors can be identified based on such data. Moreover, closed and open ended questions are also used. A forced choice question is used to ensure a response during self-administrated responses besides employing open-ended question to capture a participant's view (Vaus, 2002 Page. 99). The researcher considers respondent motivation and type as affecting factors whether to adopt open or closed ended questions (Vaus, 2002 Page. 100). The data was collected at one point in time.

Sampling includes different sizes of organisations; both SMEs and large companies. Firms having export records or serving only domestic markets, participating in global agreements, public or private are all considered. Mass production, mass customisation and combined strategies are used as subgroups. These subgroups in different industrial zones were surveyed. That is why stratified random sampling is used where subgroups are defined based on common characteristics and followed by random sampling. Since random sampling means that each individual has equal opportunity of being selected from the population to indicate a representative sample (Cresswell, 2003 p. 167) (Fink, 2005 p. 45) (Sekaran, 2003 p. 270), therefore, stratified sampling is more efficient than simple random sampling. Disproportionate sampling is adopted based on the percent age of each subgroup in selected sector. This type of sampling does represent major meaningful segments in the population. The target audience of this survey was selected from managerial levels as they have a holistic view of the firm and can answer questions related to its performance and deficiencies experienced. Random sampling provides the best chance for generalisation (Sekaran, 2003 page.270).

The researcher can generalise the survey outcome about the population. A survey is used to confirm and therefore generalise the experienced deficiencies that face individual organisations in each sector.

The confidentiality of the collected data may interfere and result in smaller numbers of participants. That is why dealing with each segment according to its actual representation of the population can overcome this issue and represent reality. Since a willing participant provides the research with a potential outcome rather than unwilling one who may mislead the study, therefore, the quality issue is the main consideration to represent reality.

Based on Creswell's (2002) suggestions for data validation, a triangulation between quantitative and qualitative data is performed to investigate the extent to which they provide the same facts. Based on this, major and minor issues that affect supply chain performance are defined. Major issues are tested by simulation experiment to indicate their effect on supply chain performance. Therefore, simulation techniques can be considered a further conformity technique. Testing possible solutions and their impact on the supply chain helps to refine the research proposition and reach optimal performance, while Numerical techniques allow exact representation of science. Therefore, a System Dynamics approach is the most appropriate research methodology to be employed. Simulation experiments help to investigate the dynamical effects in large non-linear systems such as the one under investigation (Disney, Naim and Potter, 2002).

### 3.5.4. Simulation Techniques

A simulation approach has been used to test empirical findings. Regardless of the fact that simulation is the handiest technique to be employed as an OR model (Perros, 2003), simulation adoption is more relevant to satisfy the research objectives. Simulation techniques are commonly used to predict the behaviour of the supply chain (Naim and Towill, 1994) (Jones and Towill, 1998). A simulation experiment is the most appropriate method used to test the proposed solutions in this research and determine their impact on supply chain performance. A statistical approach in a supply chain focuses on the statistical insights about the impact of demand properties such as standard deviation and correlation. The causes and effects of system structure on performance are not obtained in-depth by the technique. The continuous control theory "*illustrates extremely well dynamical effects and feedback, but cannot incorporate sequencing and lot-sizing issues*" (Disney, Naim and Potter, 2002).

Simulation techniques are applicable to a wide range of problems. SCM performance can be better predicted using simulation methods (Wartha , Peev, Borshchev and Filippov, 2002).

Simulation is a technique to devise supply chain optimisation (Umeda and Lee, 2004). The strength of simulation is to enable the users to capture the dynamic behaviours in investigated system. Use of simulation helps to reveal the limitation related to the mechanism of synchronising information-flow with material- flow.

System Dynamics (SD) methodology is a type of simulation that captures the interaction between material flows and information flows. SD is considered as methodology for studying and managing complex feedback. Feedback refers to the situation where each variable affects the other through a chain of causes and effects (Kirkwood, 1998). Studying such chain of cause and effect predicts how the system will behave (System Dynamics Society, 2007). System Dynamics was first introduced by Forrester (1960) to understand the impact of supply chain dynamics on business performance (Jones and Towill, 1998). The System Dynamics approach has been applied to logistics and supply systems to model issues such as the impact of reducing delivery times and improving customer service quality.

### 3.5.4. 1 Why System Dynamics?

A System Dynamics approach is best suited to represent how organisational structure, time delay and demand amplification affect the performance of industrial organisations in Egypt. It also demonstrates the interaction between information and material flows. Since the simulation is best fitted to capture the dynamic behaviour of the investigated system as discussed in section **3.5.4.,** this research adopts the simulation technique to examine the entire deficiencies of supply chain activities in Egypt. Employing simulation techniques provides insight into synchronised information flow with material flow. While this research illustrates the effect of each existing deficiency and the proposed solutions on the overall supply chain performance, holistic view of supply chain activities is needed using the Beer Game technique. Moreover, this research attempts as well to demonstrate the effect of individual decision on overall performance. Presenting level of aggregation associated to information and material flow across the supply can better be demonstrated using system dynamic approach. System Dynamic will be used to capture the human interaction and the effect of time delays on existing supply chain performance. The effect of individual and collaborative managerial policies on overall supply chain performance will be demonstrated using the beer game. The

impact of frozen external issues on organisational performance will be investigated as well using beer game. Traditional beer game was adapted to indicate existing deficiencies based on observations of supply chains in the participants. The use of SD rather than WITNESS, a discrete simulator, is concerned with the level of aggregation used. In this case insufficient data was available for such a detailed examination. Referring back to the discussion in section **3.5.4** which indicates that limitations of other approaches. Since a statistical approach can provide only insight investigation of specific delivery while the Continuous control theory could not employ lot sizing and sequencing**.** These causes and effects of system structure can be best represented using the system dynamic approach. Therefore, the Beer Game is used to represent a production–distribution system.

Regarding the research focus, the impact of issues that influence supply chain performance can be investigated by representing the interactions in these systems and examining the systems behaviour. Systems Dynamics (SD) methodology is used to represent these interactions due to its aptness to the research purpose. The research will follow the System Dynamics methodology, which involve (System Dynamics Society, 2007):

1. Define a problem,
2. Initialise a dynamic hypothesis illustrating the cause of the situation,
3. Develop a simulation model to demonstrate the problem,
4. Tests the model to ensure reality representation,
5. Manipulate alternative solutions that could solve such problem

### 3.5.4.2 Basic Concepts of System Dynamics

Hypothesis generation is based on empirical findings; while the impact of the re-structured theoretical proposition is tested using simulation techniques as follows (Kirkwood, 1998):

1- Building Causal Loops

Develop a cause and effect diagram that represents complex system interactions. The chain of causes and effects illustrates a closed loop where system components influence themselves in a way.

2- Stocks and Flows:

Demonstrate interactions between system components over time using a stock and flow diagram. The stock represents the accumulation of something while the flow is the movement or flow of the "something" from one stock to another.

3 -Equations behind the Model

Build equations that indicate the rate of flow between stock and set up initial values for each stock to run the experiment.

4 - Run Simulations

After running the simulation, the patterns of behaviour are interrupted to analyse the outcome. Focusing on one or more indictor for system performance such as cost, revenue and sales represents system pattern of behaviour. There are four patterns of behaviour (exponential growth, goal-seeking, s-shaped growth and oscillation).

To represent the case of this research using a system dynamic approach, a Beer Game model is used. The "Beer Game" is a commonly used simplification for the supply chain (Joshi, 2000). The beer distribution encompasses a supplier, a factory, a distributor, a wholesaler, a retailer and the end customers. The game is initialised when customers place orders on a weekly basis to the retailer who in turn forwards the order along the chain. Each partner fulfils the order from a kept inventory buffer. Inventory replenishment is handled on a weekly basis to preserve safety levels. Delay stems from ordering, shipping, production and communication between supply chain partners. The existing supply chain deficiency is represented. And different scenarios for supply chain improvement are considered.

Different performance indicators will be considered. According to behaviour patterns, Supply chain performance can be evaluated and the impact of each driven solution will be predicted. Testing possible alternative will be employed to achieve better supply chain performance.

The above segment of the chapter provides the theoretical bases for methods selection and guideline about its implementation. The following segment provides more details about methods implementation and the conducted pilot study.

**Part Two: Project Description**

Based on the previous discussion regarding the employed methodology, this part will include a closer view of how the research was carried out indicating research design and structure. It includes defining of Egyptian sectors that have a significant impact on the Egyptian economy and at the same time have a role in the global supply chain are included. Industries that suffer from successive reduction are indicated based on a literature survey. These reported industries will be investigated in a pilot study. The details of conducted pilot studies in chosen industries are explained in the context of chosen organisations context. The re-structuring of case study design will be based on the pilot study output. The chapter ends with a determination of which industry will be further investigated and explored in the next stage.

**3.6. Research Structure**

Given the research objective, which entails further investigation of current supply chains in Egypt, a numbers of issues have to be explored. These issues are related to supply chain activities, supply chain structure; IT role in supply chain management, managerial expertise, the role of country's supporting infrastructure on supply chain activities and the impact of cultural issues.

The research deploys several approaches to collect data and validate the study outcome. Table 11 offers further details regarding the research structure. The problem is defined based on a literature survey. This stage ends with the proposed research question. A case study approach is used to collect the qualitative data while interpretive modelling is used to model this data. Supply chain deficiency issues and their leading factors are defined based on case studies analysis. ISM software has been used to indicate dependencies and the driving power of these issues. A Stage-based model has been derived followed by a proposed framework that indicates the extracted issues and their leading factors. The framework that demonstrates the study outcome was developed based on case studies analysis. A survey was used to validate the result of case studies. The framework is re-structured to tune the survey results. A textile supply chain with current deficiencies is simulated using a real dataset. Possible alternatives that might improve supply chain performance have been considered and tested to figure out the different impacts. An iterative process was employed to reach the optimal solution and

achieve better supply chain performance. Following section includes a summary of each adopted methodology.

*Problem Definition*
1. Literature Review (supply chain strategies, technical and non-technical issues related to supply chain, and supply chain models).
2. Define study theoretical proposition, question and relevant data to study focus.

*Case Study Methodology*
3. Develop a case study protocol that indicates a number of case studies; evidence used and the applied analytical strategy and conduct a pilot study.
4. Conduct interviews and analyse the qualitative data.
5. Define supply chain deficiencies issues at Egyptian industries and their leading factors.
6. Use SPSS to define issue weight based on participant's perspective.

*Interpretive Structural Modelling*
7. Build a problematic structure to represent the relationship between these issues.
8. Interpret the reachability matrix, define dependencies and driving factors.
9. Generate an ISM-based model for supply chain deficiencies stages in Egyptian industries.

*Framework Structuring*
10. Build a framework that indicates supply chain deficiencies and their leading factors.

*Validation using Survey*
11. Conduct a survey at textile industry in two major industrial zones.
12. Analyse quantitative data (survey result).
13. Validate the framework developed based on case study analysis
14. Restructure the supply chain deficiencies framework.

*Proposing solutions using system dynamic approach*
15. Simulate current supply chain deficiency using a system dynamic approach.
16. Define the proposed solutions to enhance supply chain performance.
17. Run different simulation experiments to demonstrate the effect of each proposed solutions on supply chain performance.
18. Define the possible solutions to improve supply chain performance.

**Table 11: The Structure Adopted in the Research**

### 3.6.1. Case studies

A pilot study was conducted to test the proposed case study design and refine its structure. The pilot study was conducted across major industries in Egypt. Nine cases were included in the pilot study. Based on the pilot outcome, the industry that suffers the most supply deficiency and has obvious profit reduction was chosen to be the study focus. The textile industry was investigated, so six case studies were explored to define supply chain deficiency issues and provide the interpretation of deficiency issues. The outcome from case studies was modelled using ISM methodology. A problematic structure was developed to define the relationship

between factors and its driving power. A model that indicates supply chain deficiency stages was built based on a cause and effect structure. The framework that represents deficiency issues and their leading factors was proposed. The hypotheses proposed by the case studies outcome were tested by survey for the purpose of validation.

### 3.6.2. Survey

The survey is conducted in the form of a self-administered procedure to help the respondent to understand the survey structure and by email. Over 150 questionnaires were distributed at two different industrial zones; 32 firms agreed to participate. The outcome of the survey analysis is used for validating case studies outcome. The proposed framework has been re-structured based on the validation outcome. Possible actions that might be taken by managers are proposed to be simulated in the following stage.

### 3.6.3. Simulation

A current supply chain with deficiencies is simulated. The possible actions that might be taken are adopted to reflect their impact on supply chain performance. Reduced inventory, increased production capacity, reduced delivery time and smooth information flow are adopted. Cost and lead time performance measures are used as indicators for supply chain improvement with each experiment. The most effective actions are defined based on various simulation experiments. Recommendation for improved supply chain performance will be concluded from this research programme.

## 3.7. Major Industrial Performance in Egypt

Egypt is considered a good representative of developing countries; with its high inflationary economy, technological dependence on the developed world and its distinctive cultural differences from developed countries. The research focuses on three major Egyptian industries to define which one can be considered as the study focus. These industries are: basic manufacturing (Steel and Alloy production as an example), the textile and apparel industry, and the food industry. These promising sectors were chosen due to its economical strength, exportation rate, and to their being labour intensive industries. (International Trade Centre (ITC) UNCTAD/WTO, COMTRADE data, 2002, 2003, 2004) The comparative advantage of

Egyptian industries is demonstrated in Table 12. The table indicates the comparative advantage of each sector measured revealed by comparative advantage. The revealed comparative advantage is "*an index used in international economics for calculating the relative advantage or disadvantage of a certain country in a certain class of goods or services as evidenced by trade flows*" (Ginzburg and Simonazzi, 2005). According to the trade performance report, while fresh food and basic manufacturing sectors have shown a positive change in world market share around 6%, textile has shown a reduction in 2003 of 1.28% and is expected to shrink after the Multi Fibre Arrangement (Trade performance report, Adapted from ITC – COMTRADE, 1999-2003). The International Trade Statistics by Product Group illustrated Egyptian export rate between 2001 and 2004. While Egyptian exports have shown a rapid increased rate in the food industry, by 2004 flat-rolled products and steel bars, textile yarn and fabrics shown a decreased export rate. This encourage many spinning, weaving and textile firms to join the recent Qualified Industrial Zones (QIZ) agreement as a way to increase its export rates and benefit from duty free charges.

| Sector | Revealed comparative advantage (Balassa index) |
|---|---|
| Clothing | 3.49 |
| Minerals | 3.42 |
| Textiles | 3.21 |
| Fresh food | 2.71 |
| Basic manufactures | 1.36 |
| Leather products | 1.04 |
| Processed food | 0.85 |
| Chemicals | 0.62 |
| Miscellaneous manufacturing | 0.39 |
| Nonelectronic machinery | 0.18 |
| Electronic components | 0.11 |

**Table 12: Revealed comparative advantages in Egypt**

**ITC (2002), COMTRADE data**

### 3.8. Pilot Case Study

A pilot is a small experiment used to test the proposed design prior to a large scale study (Yin, 2003). A pilot study helps to improve the quality and efficiency of the following study by defining the deficiency in the existing design and assisting in the development of relevant lines of questioning. A satisfactory procedure can be developed for the formal data collection based on pilot study. The variation of industrial performance is tested using the pilot study. Nine cases studies have been conducted: three in textile fabrication (customised and standard

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produced fabrics), two in basic manufactories (steel and alloy production) and four at food manufacturing (fresh, dehydrated, processed food). Both mass production and customisation strategies are represented in the conducted case studies. The collected empirical data focuses on the supply chain activities of each industry, IT's role in supply chain management and the problems faced by each firm. Interviews with decision makers, individuals associated with the forecasting process, managing materials, manufacturing operation and marketing activities were held. The context of case studies is demonstrated in Table 13.

The main objective behind conducting pilot studies is to define which industry the study should focus on and to refine the case study design. The researcher investigated three major industries in Egypt. The case studies were chosen from various industrial sectors within different industrial zones to avoid common factors that might affect a certain zone and not affect the other. This random selection ensures more confidence in the study outcome and enables the generalisation of results. Based on the preliminary interviews during the pilot study, it is clearly obvious that weaving, spinning and textile sectors are suffering from successive profit reduction coupled with a loss of market share in both local and international markets (Trade performance report, Adapted from ITC – COMTRADE, 1999-2003). The main reason behind this is that competitive Asian products have not only reached international markets but have also met the preferences of Egyptian consumers. Based on respondents, un-planned governmental regulation and constrains have had a negative influence the textile sector more than any other sector. Egyptian fabrics can barely survive in the face of Asian competition and this may lead, in future to a dramatic disappearance of local or international markets. It is for the reason that textile firms are attempting to overcome governmental constraints and get the benefit of free duty by joining global chains and trade agreements. The critical situation of the spinning, weaving & textile sectors leads us to focus on it.

### 3.9. Why Study the Textile Industry?

- The textile and clothing industry indicates the highest comparative advantages (3.5-3.2) amongst other Egyptian industries as illustrated in section 3.7.
- Textile and apparel provides 25% of Egypt exports and employ about 30% of Egyptian labour forces (950 thousands workers) (EgyTex, 2009).

- Despite the high potential of Egyptian cotton globally, the Egyptian textile industry is rarely involved in its refining such as high staple Egyptian cotton (Giza 85).

- Large quantities of Egyptian cotton are exported due to governmental policy while the producers procure their needs of cotton from overseas.

- Due to globalisation and high competition faced from Asian countries, the textile industry in Egypt is the most affected one among the other sectors. It is demonstrated by an overwhelming flow of Chinese fabrics into the Egyptian markets while domestic' producers are competing to gain a limited market share. A reduction from 40 to 25 companies was noticed as well in the sector investment by 2007-2008 (Periodic report Jan 2008- Ministry of Investment, Egypt).

- Textiles and apparel have shown a very low export rate in 2006 in the Multi-Fibre phase out, while a gradual increase was demonstrated after initiating the QIZ agreement. The producers in this industry depend mainly on global agreements as channels to reach the global market, while existing marketing expertise and product quality cannot ensure global reach.

## 3.10. Re-structured case study Design

The interview was redefined based on the outcome of the pilot study. Further investigated case studies are conducted based on the pilot study results. Interviews are to be used as a method of data collection due to the sensitivity and confidentiality of the required empirical data. Cultural issues are conductive to making companies reluctant to reveal their business issues in the form of a structured survey. Open-ended interviews and semi structured ones will be used to provide in-depth gathered data, more detailed of supply chain deficiency and its invisible issues. The main objective behind these case studies is to define the supply chain deficiency issues in the chosen industries and their leading factors. The key aspects of case study interviews are discussed in Table 14. Production capacity and supply chain activities at upstream and downstream levels have been investigated. Adopted production strategies, procurement and replenishment approach, supplier collaboration, IT role in supply chain activities are the main aspects for further investigation and are discussed in the findings chapter.

| Company | Sector | Public/ Private Sector | Production Size | Industrial Zone | No of Plant /Mill | Applied Production Strategy | Marketplace |
|---|---|---|---|---|---|---|---|
| Misr El Amria Spinning & Weaving Co | Spinning, Weaving & Textile | Private | 15 Million US Dollar/Yr | Alexandria | 3 spinning Mills 3 weaving Mills 1 Processing Plant 4 Confection Unit | Mass Production & Mass Customisation | 60% exported to International marketplace and 40% market at Local Marketplace |
| El-Arabia & Polivera for spinning & weaving Co (UniRab) | Spinning, Weaving & Textile | Public | 300,000 Egyptian Pound | Alexandria | 1 spinning Mills 1 weaving Mills 1 Processing Plant 3 Confection Unit | Mass Production | 80% Local Marketplace 20 % international marketplace |
| Canadian for Spinning, weaving & textile Co | Textile | Private | 500 Ton/Yr | Sadat City | 1 dyeing unit 2 mercerizing unit 2 Confection unit | Mass Customisation | 95% exported to international marketplace 5 % market at Local Marketplace |
| ArcoSteel Co | Steel & Alloys | Private | 140,000 Ton/Yr | Sadat City | 6 manufacturing unit | Mass Customisation | 25% Local Market and 75% international Market |
| Ezz El Dekalia | Steel | Private | 5.3 million Ton | Sadat City | 2 steel melting plant 4 bar mill plant 1 steel bar mill 3 DR plant 1 rod mill plant | Mass Production | - International Market: **58%** of Flat Product exported, 23% of long product exported. - Local market: 77% of Flat Product. 42% of long product |
| El Aguizy International for economic development | Fresh & Frozen Food | Private | 4000-8000 Ton Frozen 8000- 1000 Ton fresh | Sadat City | 3 Frames 4 Packing house 2 MT/hr Individual quick freezing (IQF) | Mass Customisation | 99% international Market, 1% local market |
| Faragalla Group | Processed & frozen Food | Private | Meat Factory: capacity 150 MT/Day Bakery Factory: capacity 25 MT/Day Frozen Vegetables Factory: capacity 10 MT/Hour | Borg El Arab | 4 factories for beef processing and chicken processing 1 Vegetables processing factory 1 Canning factory | Mass Production | International & local Marketplace |
| United for Import & Export | Herbs , spices and dehydrated vegetable | Private | Drying area: 5000 sqr m Processing area: 450 sqr m | Fayoum | 3 processing units: 2 units for conventional production and 1 for organic | Mass Customisation | 100% International Market |
| Paste & Juice Co | Processed Food | Private | 6000 Unit/Month | Sadat City | 1 Paste Factory 1 Juice Factory | Mass Customisation | 20% local market 80% international market |

**Table 13: Case studies context**

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## 3.11 Summary

The research combines both qualitative and quantitative approaches as suggested by other researchers. A real dataset has been collected through a case study using multiple evidences. The data is analysed to indicate current supply chain deficiencies. ISM software is used to indicate the weight of each issue and develop a problematic structuring. The structuring process ends with a stage-based model that is used to explain these deficiencies and indicate issues of high driving power. The Survey is used as a conformity tool for case study findings. Powerful issues which impact the supply chain obviously will be simulated using the system dynamic to predict its impact. The system dynamic approach is the most applicable approach for the research purpose due to the complex nature of the supply chain environment. The pattern of behaviour is interpreted to ensure the performance enhancement. The simulation tests the number of alternative that could provide better supply chain performance.

| **1- Company Profile** |
|---|
| - Summary of company activities, and No of branches |
| - Define the main products and production capacity |
| **2- Forecasting Process** |
| - Describe the procedure used in the forecasting process |
| - What are the sources that the company relies on for future forecasting? |
| - Describe the procedure followed by your company to convert forecasting figures into production schedule |
| - Which type of information system is used in forecasting? |
| **3- Procurement Process** |
| - How many suppliers does your company deal with and where are they located? |
| - What are the main criteria for choosing raw material suppliers? |
| - Which type of raw materials does your company need? How much does your company keep of each type? (amount of inventory buffer) |
| - Describe the Procedure followed in the procurement process |
| - Does your company use information system to handle the procurement process? If so which type of IS is used? |
| - What is the rate of returned materials (error rate)? |
| - Does your supplier have access to raw material inventory? |
| - Does your company follow just in time material delivery? |
| - Which type of problems is faced during the procurement process? |
| - When does your company initialise the procurement process? (before or after customer order)? |
| - Identity the level of demand variety and whether there is high risk to keep huge volume of particular material |
| **4- Manufacturing process** |
| - Which type of production strategy does the company follow? |
| - Describe the sequence of manufacturing processes |
| - How many manufacturing unit/ mill do you company have? Specify each one activities |
| - Do your company enable customer interference during the manufacturing process for product modification? |
| - Which type of information system is used in manufacturing process? |
| - Do number of worker match the production capacity? or its differ from session to other |
| **5- Logistics** |
| - What is the estimated time of supplies delivery? |
| - Can the delivery time be reduced to reach more optimal time? |
| - Identify the importance level of delivery process (critical factor to production process– important but is not critical to production process- low priority) |
| - Define the reliability level of current used logistics system |
| - Does your company use third party logistics or rely on its own logistics system? |
| **6- Distributions** |
| - How many distributors do your company deal with or do you have your distribution points? Where are they located? |
| -  Do distributors have access to finished product inventory? |
| - Do you use any type of Information system to handle distributor orders? (automated system, manual system),  If so, which type of IS is used? |
| **7- Opinions and Recommendation** |
| - Identify issues related to manufacturing, procurement, logistics and distribution activities. |
| - Identify the importance level of each issue, its occurrence sequence and the relationship between them. |
| - Define factors that lead to these problems. |
| - Suggested solutions, recommendations for these problems |

**Table 14: Interview Key Concepts**

# Chapter Four

**Empirical Study Findings**

## 4.1 Introduction

This chapter shows the results of the empirical investigation using a multiple research strategy. The conducted strategies are: case studies, which were used for supply chain deficiency exploration and the conducted survey used to validate the case study outcomes. Each strategy output is illustrated separately. Comparison between quantitative and qualitative analysis is demonstrated at the end of the chapter. The reasons for using multiple research methods are also indicated.

This chapter encompasses three sections: the first one relating the conducted case study analysis which concludes with the proposed framework for supply chain deficiency evaluation. The second part is concerned with the survey outcome and testing hypotheses drawn from the case study stage. The third section focuses on qualitative and quantitative data comparison in order to validate the research outcome. The proposed framework for supply chain deficiency will be restructured based on data match.

### Part One: Case Studies

Case studies have been conducted in six textile organisations for the purpose of investigating supply chain activities. These cases are associated with spinning and weaving in the textile sector. The three textile case studies, which were included in the pilot study, were further explored in this stage. The selection criteria of these cases were based on choosing a sample of large business and SME, mass customisation and mass production adopted strategies, private and public sector firms. The context of the newly explored case studies is demonstrated in the table 15.

Observations during site visit have been carried out and are indicated in the findings and discussion section (4.3). Document analysis has been carried out using company reports, brochures, CAPMAS report, production & export rates, the technical manual of the applied system as well as income and revenue reports.

| Company | Sector | Activities | Public/ Private Sector | Production Size | Industrial Zone | Applied Production Strategy | Marketplace |
|---|---|---|---|---|---|---|---|
| Al Roybaia Fourtex Co | Spinning, Weaving & Textile | Produce Cloth for Jeans | Private | 20,000,000 m² | Sadat City | Mass Production | Local & International Marketplace |
| Alkan Mannai Textile Co | Spinning, Weaving | Produce Spin Cotton | Private | 600 tonne./yr | Sadat City | Mass Customisation | 25% Local & 75% International Marketplace |
| Egyptian carpet yarns. | Spinning, Weaving | Produce all types of Spins | Private | 4,800 tonne./yr | Sadat City | Mass Production | Local & International Marketplace |

**Table 15: Case Studies Context**

Table 16 summarises the internal activities of each case for comparison issue. The description of each activity and discussion about each case study outcome is represented in the next section. The description encompasses different organisational activities such as forecasting, procurement & logistics, manufacturing operations, distribution and marketing activities. The IT role in supply chain activities is included in the next section.

| Company | Forecasting | Production Activities | Distribution Activities | Logistics | Inventory buffer | Procurement | Supplier-Collaboration | IT system & Infrastructure |
|---|---|---|---|---|---|---|---|---|
| Case Study 1 | - Number of Customer Contacts through the internet. <br> - International market survey <br> - Produced Quality improvement and new design pattern. <br> - Previous sales rate. <br> - CAPMAS statistics. | - adopt Mass Customisation (Build-to –order) approach. <br> - High material wastage. <br> - High production cost. <br> - Lack of trained labour. | - rely on agents for international marketing. <br> - does not deal with local distributors | - own logistics system for local delivery. <br> - use country supporting infrastructure for international f*reight shipment* | - Yearly buffer from major supplies-cotton. <br> - three months buffer for minor materials | - Fixed deal with numbers of local suppliers. <br> - Tender system for imported supplies. <br> - keep fixed amount of in | - Deal with frequent suppliers. <br> - focus on inventory replenishments without information sharing or access to each inventory. | COBOL-based used in finance, payroll, costs and inventory units |
| Case Study 2 | - CAPMAS statistics. <br> - Previous sales rates. <br> - International industry reports. <br> - consuming rate of the developed countries. | - adopt Mass Customisation (Build-to –order), mass production approaches. <br> - works as original equipment manufacturers globally. <br> - high production cost. <br> - high material wastage. <br> - No predefined standards for quality assurance. <br> - lack of periodic machinery maintenance. <br> - Limited labour skills for machinery re- configuration to produce tailored products. | - direct marketing to international customers. <br> - Own on their distribution point in addition to local distributors | - own logistics system for local delivery. <br> - use country supporting infrastructure for international f*reight shipment* | - Yearly buffer from major supplies-cotton. <br> - Six months buffer for imported substance. <br> -three months buffer for other | - tender system for imported and local supplies <br> - Selection of material supplier is based mainly on the least price, sometimes the best quality is combined with the price. | - does not deal with frequent suppliers to establish collaborative channel with. <br> - focus on inventory replenishments without information sharing or access to each inventory. | Oracle ERP modules for inventory management and procurements. |
| Case Study 3 | - International market survey <br> - Previous sales rate. <br> CAPMAS statistics. <br> - previous deal with clients' demand | - Adopt mass production strategy. <br> - sometimes, works as original equipment manufacturers locally <br> - High production cost. <br> - use aged and non productive machineries. <br> - Lack of trained labour. | - deal with Number of local distributors | - use third party logics for local shipment. <br> - limited use of the country supporting infrastructure in international f*reight shipment*. | - Yearly buffer from major and minor supplies. | - tender system for imported and local supplies <br> - Selection of material supplier is based on least price only. | - does not deal with frequent suppliers to establish collaborative channel with. <br> - focus on inventory replenishments without information sharing or access to each inventory. | Manual system using limited ICT support |

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| Company | Forecasting | Production Activities | Distribution Activities | Logistics | Inventory buffer | Procurement | Supplier-Collaboration | IT system & Infrastructure |
|---|---|---|---|---|---|---|---|---|
| Case Study 4 | - Previous sales rate.<br>- CAPMAS statistics. | - Adopt mass production strategy.<br>- High production cost.<br>- Lack of trained labour. | - Own on their distribution point in addition to local distributors | - own logistics system for local delivery.<br>- use country supporting infrastructure for international f*reight shipment.* | - Yearly buffer from major supplies- cotton.<br>- Few months buffer for minor supplies based on supplies availability. | - Fixed deal with numbers of local suppliers.<br>- Tender system for imported supplies. | - deal with frequent suppliers.<br>- focus on inventory replenishments without information sharing or access to each inventory. | Visual basic system used in payroll and finance departments |
| Case Study 5 | - Previous sales rate.<br>- CAPMAS statistics. | - Adopt mass production strategy.<br>- High production cost.<br>- Lack of trained labour. | Own on their distribution point in addition to local distributors. | - use third party logistics for local shipment.<br>- use country supporting infrastructure for international f*reight shipment.* | - Yearly buffer from major supplies- cotton.<br>- three months buffer for minor materials | - Fixed deal with numbers of local suppliers.<br>- Tender system for imported supplies. | - Deal with frequent suppliers.<br>- focus on inventory replenishments without information sharing or access to each inventory. | Manual system using limited ICT support |
| Case Study 6 | - Previous sales rate.<br>- Existing Customer contacts. | - Adopt mass production strategy.<br>- High production cost. | - Own on their distribution point in addition to local distributors | - use third party logistics for local shipment.<br>- use country supporting infrastructure for international f*reight shipment.* | - Yearly buffer from major supplies- cotton.<br>- couple of months buffer for minor/local materials | - tender system for imported and local supplies.<br>- Selection of material supplier is based on least price only. | - does not deal with frequent suppliers to establish collaborative channel with.<br>- focus on inventory replenishments without information sharing or access to each inventory. | Manual system using limited ICT support |

**Table 16: Case Study Evidence**

**4.2 Supply chain activities**

**4.2.1. The forecasting activities**

Government policies have a significant impact on demand stability that causes the need for future demand forecasting either for a standard or customised product. Difficulties are experienced if the forecasting activity is related to a customised product rather than a standard product due to demand variability. The forecasting process is conducted on yearly bases for major supplies in the textile industry. The long-term estimation is based on three main factors. The first one is related to material availability in specific seasons. Cotton, for example, the main raw material in textile fabrics, is only available in the winter season. A second case is related to imported supplies such as chemicals which are critical and determined by product quality and has to be predicted in advance to guarantee continuous production activities. For the third factor, prices have a major impact on keeping large stock from suppliers that may raise their prices increments over time. For instance, in case the prices of chemical substances have been falling, the producers will be most encouraged to obtain a larger stock of these substances.

Forecasting activities are currently handled manually. The main sources companies rely on to handle these activities are CAPMAS data, previous orders, previous deals with clients, non-restricted contract in some cases and consumption rate of the developed countries if the firm had export records. CAPMAS provides figures regarding yearly production rates within different sectors. These figures illustrate ten year production rates. The main issue related to this source is that it does not indicate the last five year rates so consequently it cannot be considered as a reliable source. That is why each company attempts to avoid this limitation by keeping a buffer stock of its major raw material to handle unexpected demands.

**4.2.2. Procurement & Logistics activities**

The procurement activities differ based on the adopted strategy. For instance, numbers of textile firms act as original equipment manufacturers to provide a customised product to global marketplaces. These firms have to use pre-defined chemical substances, polyester type in addition to the special consideration of raw material quality to ensure the final product quality. Mostly, these supplies are imported and in rare cases, can be fulfilled

locally. Supplier selection criteria is based on price unless that the needed supplies are unique and can hardly be provided from other sources.

A manual based tendering process is used by the firm to procure its supplies. While the purchase cycle can be extended to months for imported supplies, many firms depend on fixed deals to fulfil their local supplies. Selection criteria of local or international suppliers are based on the lowest price. Time and quality issues are rarely considered as selection criteria. The communication between supply chain partners is based on ad-hoc transitions without a commitment to further collaboration. Organisations do not follow a predefined pattern for supply chain communication even if there is a contract with a number of frequent suppliers. Firms deal with any supplier without considering its location and its estimated delivery time. This does not match the selection criteria that have been proposed by the literature. These criteria encompass quality, reliability, time delivery, price and distance factors. Dealing with an unreliable vendor may cause a delivery delay and an increased lead time. Delays may occur especially in imported supplies due to a poor supporting infrastructure of the country. That is why decision makers emphasise the need for keeping yearly stock from major suppliers and at least three months buffer from minor suppliers. Additionally, the ordering process is initialised months before. Most firms keep a warehouse stock, even if there are no promising demands to sell this stock. Therefore, it is widespread to have a quantity order that exceeds a firms needs. This buffer can be used to handle unexpected demands, material shortage and the instability of supplier's prices.

Due to a large buffer, delay in delivery has little impact on production processes. An unexpected delay that may occur in a supplier's delivery is manageable with larger inventory buffers unless the shortage occurs occurring in machinery spare parts. It is familiar that major textile suppliers are being fulfilled for several months and may reach a yearly basis.

In case of an imported supply shortage, procurements are fulfilled locally; this may affect the final product quality. Most firms are used to track inventory and handle its ordering procedure manually with the support of basic ICT. Although a number of leading firms have invested in ERP modules such as the procurement module, limited features of these modules are being used. For instance, the procurement module is being used in supply calculations without using any more functions. A systematic manual-based system is used to initialise the order starting from a proforma invoice. Collaborative inventory

management with vendors is not applicable or permitted by the producers due to the trust issue. That is why delivery delays, inaccurate deliveries, damage and storage during transit are obvious issues. Despite the fact that lack of trust is a key driver that prevents collaborative activities, the country's poor supporting infrastructure is another key driver for unreliable logistics and transit system.

Most decision makers do not deal with held inventory as a buffer that should be optimised to reach the optimal point. Alternatively it is considered as an indicator for asset growth, which might affect financial status positively. This issue is more related to cultural factors and can hardly be resolved by the current study. Rapid fluctuation of material prices is considered as another reason leading to a larger buffer. Prices offered by a certain supplier can only be valid for a couple of days due to governmental policies and economic instability. Manufacturing units attempt benefit from the proposed price and order most of their needs. In case of a material shortage, suppliers may tend to increment the material prices which can consequently affect material availability and a firm procurement.

### 4.2.3. Manufacturing operations

Firms that adopt a customisation approach are facing more problematic issues than firms that produce a standard product. For example, customised textile fabrics are commonly provided to developed marketplaces where different preferences, design, sizes and colours have to be applied. The local marketplace is fed with standard products. Asian industries are providing the Egyptian market with high quality and lower priced textiles compared to Egyptian fabrics. The foreign products have captured a large portion of the Egyptian market share at the same time as local producers are competing to gain what remains. That is why many firms are looking to extend their export rate through duty free agreements and reach 60% - 90% as a rate of export.

Regarding production operations, a firm plays the role of original equipment manufacturer and cannot process the customised orders without defining materials needed to produce a high quality product. To estimate the production feasibility of a customised product, many constraints are involved. These constraints are represented by: production capacity, available machinery, reachable materials. Producing customised products is more difficult to manage than producing a standard product due to the need for continuous machinery re-configuration and limited labour skills. More controllable operations are being handled to

provide a standard product. High production costs, increased material wastage, labour skills needed for machinery re-configuration, lack of pre-defined quality standards and irregular machinery maintenance are more obvious in customisation production than in mass production. In addition, limited productivity of aged machinery is a major constraint for production capacity especially in the public sector. Customer interference during the manufacturing process can be handled in a limited manner in assembly or packing operations due to limited capabilities and IT-infrastructure that support production operations. Labour tasks that include switching from one machine to another, undertaking a preventive maintenance, and to set up the machinery requires more skilled and trained labour. Multifunctional skills should be ensured to increase labour productivity.

### 4.2.4. Distribution & Marketing Activities

Asian products swept away many industries in Egypt. Consequently, Egyptian textile producers have been affected and lost a large portion of their local market share. In addition, inconsistent governmental plans which are issued for providing licenses to a large number of manufacturers within the same sector have affected many industries. Studies of the reasons causing manufacturers trapping are still needed. Various distribution and marketing approaches are followed due to the competitive environment and product nature. For instance, many textile firms rely on their own points of sales to market the product locally. On the other hand, leading textile firms have extended their export rates to reach 60% - 90% of their production.

To facilitate marketing operations and survive in the face of Asian competition, industrial organisations in Egypt are looking for duty free access, tariff exemption and non-limited quotas on exports. These advantages can be obtained by joining trade agreements. For instance, the tariff exemption through QIZ is 32% on ready-made garments (Ministry of Trade and Industry, Egypt). These exemptions have encouraged more than 600 firms within different industrial zones to join the agreement and focus more on export rates.

Delivery time of finished products is an important factor to be considered. Despite the fact that the exported shipment of fabrics may take 14 days, reducing one or two delivery days will not have a significant effect. Sometimes, reducing one or two days may cost more because of shipment-line changes.

**4.2.5. IT role in supply chain activities**

As discussed before, supply chain operations are handled on a manual or semi automated basis with a support of rudimentary or legacy applications. Although leading manufacturers have implemented a number of ERP modules, their features and functions are not being fully utilised. For instance, purchasing & procurement modules are used to calculate the procurement needs without utilising its embedded electronic purchasing features. Whilst the resistance to IT adoption has less influence at the present time, the use of IT systems is basically handled for automation or calculations not for execution purpose. So far, there is an assumption that although IT capabilities can resolve the critical issue, human interaction and decision are more trusted.

Mainframes and terminals are deployed to run legacy systems such as COBOL-based or Visual Basic applications. Usually, these applications are used in the finance department as payroll systems and inventory systems. Limitation has been experienced due to limited features and isolated operations. For instance, a cost unit faces many problems to collect details from non-integrated departments and determine total revenues and expenses. Difficulties are experienced due to an un-integrated platform between departments especially for large firm size. The usage of a legacy system cannot guarantee any reduction in effort or in time. Data are collected manually from each department, which is why the financial status can only be computed once every three months. Although a number of leading firms have decided to utilise IT solutions in order to enable the company to act as one entity, inaccurate/non-cooperated implementation plan between hardware vendors and application providers, misestimating the network infrastructure, high processing time and low system performance have halted the implementation for years. Unresolved issues related to appropriate network infrastructure, bandwidth, and applicability of implementing a wireless connection and improved system performance are being managed by outsourced consultancy services in the later stage of implementation.

Although many of the proposed IT systems can provide many benefits to the firm, these benefits are mainly represented in activity automation. Currently, the automated system is simulating the manual procedures and decoupling barcode technology in some activities without utilising analytical or decision support features. Organisational culture and labour skills are considered as main obstacles for implementing these decision support tools. Despite process automation, limited capability is perceived. Automating processes to fill

essentials forms and develop small databases with relations remain a target for a number of SME. Lack of connectivity, limited resources, and labour skills are considered as barriers for these firms to accomplish such automation.

## 4.3. Discussion of Results

Textile fabrics producers in Egypt are working on an individual pattern and do not consider themselves as participant entities in a supply chain matrix. Many of these organisations attempt to reduce their dependency on vendors by keeping large inventory buffers, establishing their own sales points instead of dealing with distributors and depending on their own logistics systems to ensure the reliability of logistics. Organisations seek to get a share in the international marketplace through free trade agreements. The main obstacle for that is to extend their capability and produce a high quality product with minimum cost. Other obvious obstacles are associated with the poor supporting infrastructure of the country. Poor infrastructure leads to a numbers of unresolved issues that are illustrated by late delivery and therefore a material shortage. Magder investigated the Egyptian apparel industry in 2005. He emphasised the need to improve that infrastructure in order to support a wide range of export industries such as: apparel, fresh food and flowers. This can be considered as the main barrier facing Egyptian industries to proceed in their industrial upgrading. At the same time, as leading companies attempt to overcome this issue by employing more facilities to guarantee non-suspended production activities, SMEs cannot afford these facilities due to their limited budgets.

Companies are struggling to accelerate their performance within their boundaries. Emergence of right governmental plans and associated industries are still needed. This reflects negatively on the market stability and supplier-buyer relationship and therefore turns the business partners into competitors. Further collaboration with vendors is considered as an advanced stage to be an issue. There is a need to convince the management of the perceived benefits from collaborative activities to overcome the trust issue. From the decision maker's perspective, data related to production schedules, inventory level and demand forecasting are confidential and should not be accessed by any partners. The firm should be in control of its data. From their perspective, data can be misused and consequently it affects the organisation's competitive advantages. That is why a lack of trust between supply chain partners minimises the opportunity for collaborative activities across the individual chain boundaries. This match has been suggested by Han, et

al. (2002) in their study, where they emphasise *"the need for culture change from information holding to information sharing as a pre-condition for successful supply chain integration"*. Based on the trust issue, collaborative planning and forecasting approaches such as vendor-managed inventory or just-in-time replenishment cannot be adopted through this environment.

Cultural issues, un-planned governmental activities and poor supply chain design have a great impact on supply chain performance and integration in the Egyptian textile sector. Foreign investors in Egyptian industries have to consider these issues. While there is a need for an integrated platform with suppliers which enable the provision of customised products based on customer specifications and to ensure that the right type of items and batch sizes are available on-time, firms are holding large buffers of that to handle the demand variability. Textile fabrics producers that adopt customisation strategies handle unexpected demands with large inventory buffers instead of adopting collaborative inventory management. Lead time is another barrier to be considered. Lead time suffers from uncertainty in developing countries; poor infrastructure is the main driver for this long lead time.

Regarding the inventory activities, inventory replenishment is based on reorder levels which mean that firms follow a continual replenishment approach instead of a periodic one. A large volume of inventory buffers is considered as an important asset to indicate a good financial status. Companies keep a couple of month's buffer, considering it an order-driven unit. Although a number of companies attempt to utilise a small buffer inventory, a non-integrated platform between purchasing, sales and planning departments have precluded the value added and caused more problematic consequences. Internal activities are not the only obstacles firms face. The availability of raw materials decoupled with prices instability and supplier-oriented activities are significant obstacles too. Non-collaborated activities and inaccurate forecasting are considered as leading factors to these obstacles. Factors like price instability, limited infrastructure and non-integrated systems turn the small buffer kept or the just-in-time replenishment into inapplicable strategies.

International investors issue further constraints regarding the required quality level and used materials. Attaining these types of material is a major barrier to fulfil international orders. Firms are used to feeding the local marketplace needs with standard products where

there is no special constraint on produced quality. The quality issue is of vital concern for exporters rather than for local producers. Local producers are more concerned with price reduction than the offered quality.

From the technical perspectives, an integrated IT system is needed. There is a need for a well-developed system which enables real time information to trigger the movement of physical flow. The lack of highly developed information systems is obvious in many industries. For instance, planning activities which are mandatory for textile firms to precede customised production can easily be handled with the support of information systems to exemplify production feasibility, available materials, production operations, labour cost and other needed parameters to end up with unit cost and estimated return.

Several cultural and organisational challenges face IT implementation. High costs of recent technologies and machinery are due to the technological dependence on the developed world. High interest rates charged by the banks for loans are an obstacle to implementing information systems in Egypt, an example of a developing country. This matches a study conducted by Orala, Koglub and Erdisc (2003) in the Turkish industry. Most companies focus on short-term returns to survive and are reluctant to invest in areas such as R&D or technology. From the cultural perspectives, lack of managerial expertise was experienced in the development of an effective supply chain. Egypt, like other developing countries, suffers from the managerial level that would not be devoted to implementing systems that would enable participative management. Few managers in the private sectors would like to adopt these systems to achieve a promising target. The study by Orala, Koglub and Erdisc (2003) in Turkish industry and another conducted by Yisa et al., concerning Iranian managers, represent a similar outcome.

### 4.4. Summary and highlighted issues

Based on case studies analysis, issues related to supply chain deficiency have been defined. Issues related to supply chain planning and design have not been considered by respondents. This outcome is not aligned with previous studies which emphasise the significance of forecasting and planning activities on supply chain performances. These activities are the base for other supply chain processes. Later, this research proved that these issues are major factors that lead to supply chain deficiencies. Table 17 indicates supply chain deficiency issues and its leading factors. These issues have been categorised

into groups. Each category indicates supply chain activity in which problems occur and which are demonstrated in figure 20.

Respondents to case study organisations have been asked to define the importance of the highlighted outcome according to their business relevance. These ranks have been entered into an SPSS application to indicate its weight based on respondents perspectives.

|  | Issues | Causes |
|---|---|---|
| **Planning & Forecasting Activities** | No pre-defined Supply chain design | Poor planning activities, non-collaborative activities with partners, culture factors |
|  | Non- Integrated supply chain platform | Non-collaborative activities with partners, non-integrated organizational activities, trust and confidentiality, poor supply chain design, lack of highly developed information systems |
|  | Inaccurate and unreliable demand Forecasting | Manual records, non-restricted contract, Out-dated sources, demand instability, lack of IT support tool, non-integrated organizational activities, focus on Short-term return, lack of managerial expertise. |
| **Procurement & inventory activities** | Procurement Volume & Material Price Fluctuation | Lack of material availability, prices instability, long delivery term, delay in deliveries, damage during transit, inaccurate deliveries, supplier-oriented performance, non-automated ordering procedure. |
|  | Long delivery term | Delivery delay, poor supporting infrastructure, damage during transit. |
|  | Large inventory Volume & cost (finished and raw materials) | Large order Volume, lack of Marketing expertise, asset growth indictor, non- Integrated supply chain platform. |
| **Production Operations** | Increased production cost and time | Material wastage, need for machinery setting and reconfiguration, no pre-defined quality assurance, Irregular machinery maintenance, limited productivity of aged machinery, lack of IT support tools, limited labour skills. |
| **Distribution & Marketing activities** | Limited market share (Locally and internationally) | Marketing Expertise, competition, product quality, poor planning activities, need for industrial upgrade, non-integrated supply chain activities, increased lead time. |
| **Technological Aspects** | Poor IT infrastructure or limited capability | Basic tools/applications, undefined plan of technological development, lack of investment at R& D and technology, limited resources and connectivity, high costs of recent technologies and machinery, focus on Short term-return, culture issues. |
|  | Non-justified IT investment | Adopt inadequate technology, misestimate network infrastructure - Pre-defined processing time and system performance, lack of analytical and decision support tools, lack of managerial expertise, limited labour skills, and culture issues. |

**Table 17: Supply chain Deficiencies – Case Study Results**

The relevant descriptive statistics are shown in table 18 to indicate the score weight. According to these statistics, production issues, followed by procurements, are the most effective issues in supply chain deficiency, whereas large inventory cost is not considered an effective issue that affects supply chain performance.

| Issues | Std. Deviation | Mean | Rank |
|---|---|---|---|
| Inaccurate and unreliable demand Forecasting | 1.32 | 2.66 | 5 |
| Procurement & Material Price Fluctuation | 0.83 | 5.78 | 2 |
| Long delivery term | 1.66 | 4.3 | 4 |
| **Large inventory Volume & cost** | **0.73** | **1.55** | **7** |
| **Increased production cost and time** | **1.09** | **6.22** | **1** |
| Limited market share | 1.62 | 4.88 | 3 |
| Poor IT infrastructure or limited capability & Non-justified IT investment | 0.88 | 2.55 | 6 |

**Table 18: Descriptive Statistics**

Issues associated with supply chain designing and planning processes were disregarded by respondents. Due to its importance and effect on supply chain activities which were emphasised either by the literature or expert opinions (individuals who published intensively in the field), these issues were included to demonstrate their effects. The construction of relationships among these elements indicating their dependencies are needed. Driving power and dependence issues can be defined through an influence structure. Therefore, *Interpretive Structural Modelling* has been used to construct a structure and define the dependency of these elements. ISM methodology and model development help to impose order and direction on complex relationships among the elements of a system (Sage, 1977). The tangible products from ISM are logical structures, or maps of relationships, which define important interpretations concerning complex issues. Logical structures take many forms. A "*problematique*" can help us to understand how individual problems may contribute to other problems. That why it is more appropriate to be used as a research focus. problematique is "*a graphic representation of a*

*structure that shows how a set of problems are related to one another through aggravation or other forms of negative influence*" (Broome, 1997).

The issues of supply chain deficiencies, which is discussed in table 17, were grouped into a number of categorises according to their related supply chain activities and entered into ISM software. These categories are demonstrated in table 19.

| Num | Category | Label | Statement |
|---|---|---|---|
| 1 | 1 | SC DESIGN | Poor Supply chain design & Non- Integrated supply chain platform |
| 2 | 1 | FORCAST | Inaccurate and unreliable demand Forecasting |
| 3 | 2 | PROCURE | Large Procurement & Material Price Fluctuation |
| 4 | 2 | DELIVERY | Long delivery term |
| 5 | 5 | INVENTORY | Large inventory Volume & cost |
| 6 | 3 | PRODUCE | Increased production cost and time |
| 7 | 4 | DISTRIBUT | Limited market share |
| 8 | 1 | IT | Poor IT infrastructure or Non-justified IT investment |

**Figure 21: Problematique Elements using ISM**

Since the respondents of the empirical studies conducted for this research indicated the importance of each of these categories in the form of ordinal ranks, these ranks have been re-entered into ISM software, then the importance weight of each category was calculated. Table 19 represents this importance in the form of raw and weight scores. **Raw Score** represents the number of individuals who gave a rank to each category while **Weighted Score** is the total ranks assigned by individuals to each category.

| Element | Raw Score | Weighted Score |
|---|---|---|
| 6. (PRODUCE) Increased production cost | 6 | 27 |
| 3. (PROCURE) Procurement & Material | 6 | 23 |
| 7. (DISTRIBUT) Limited market share | 5 | 15 |
| 4. (DELIVERY) Long delivery term | 3 | 11 |
| 2. (FORCAST) Inaccurate Forecasting | 5 | 8 |
| 8. (IT) Poor IT infrastructure | 5 | 6 |

**Table 19: Voting Result Ordered by Weighted Scores**

Based on table 19, production and procurement issues got a high weight based on the respondent's perspectives. Since ISM software enables its users to enter the top five ranked elements, the issues which were totally disregarded by the respondents and were not ranked among the top five, will not appear in the score table. This is the case of supply chain design and large inventory issues, in which each of these categories got the least importance among the other categories.

A structural interaction of elements is developed to indicate the relationship of each pair of elements. Respondents of each case study were asked to indicate the relationship between these issues based on their causality and occurrence. The respondents were asked to rank these issues based on their occurrence level. According to this ordinal rank, each issue of supply chain deficiency leads to a successor one. So the relations between these elements are demonstrated in the form of cause and effect relationships. The outcome of respondents' ranks is demonstrated in table 20. These relations were used to input and develop the problematique structure.

| Elements | Median | Rank |
|---|---|---|
| Supply chain Integration | 3.5 | 3 |
| Supply Chain Design | 2.0 | 1 |
| Demand Forecasting | 5.0 | 4 |
| Delivery Terms | 5.5 | 5 |
| Procurement Volume & prices Fluctuation | 5.5 | 5 |
| Inventory Cost | 8.0 | 6 |
| Production cost & time | 5.5 | 5 |
| Market Share | 5.5 | 5 |
| IT Infrastructure | 3.0 | 2 |

**Table 20: Occurrence Ranks by participant**

Based on the developed structure, scores for each element are demonstrated and represented in table 21. According to these scores, supply chain designs are the most *potential* elements based on the highest position score while large inventory has the least influence. Supply chain planning and design is an essential activity in supply chains. On the other hand, large inventory is a natural consequence of unreliable forecasts, large procurements, and limited market shares. Succedent and antecedent scores are used to define the direction of influence starting from poor supply chain designs and ending with large inventory costs. "Succedent score" counts how many other elements in the structure it influences. "Antecedent score" counts how many other elements in the structure influence it.

```
Element      Position Antecedent   Succedent   Actvity   Net A/S    Net
               Score    Score        Score      Score     Score    Score
     1           5        0            7          7         7        12
     8           4        1            6          7         5         9
     2           3        2            5          7         3         6
     7           2        6            4         10        -2         0
     6           2        6            4         10        -2         0
     4           2        6            4         10        -2         0
     3           2        6            4         10        -2         0
     5           1        7            0          7        -7        -6
```

**Table 21: Elements Score Table**

While procurement and material price fluctuations, long delivery terms**,** increased production cost and time, and limited market shares have a low positional score, they are active elements in receiving and dispensing influence. The net influence score indicates that the absence of pre-defined supply chain design, inaccurate demand forecasting and poor IT infrastructure has a positive influence score, while large inventory has a negative score. Issues related to procurement, production, market share and delivery rely on the planning and forecasting stages. While these issues are active in receiving and dispensing influence, no contributed influence is added. These elements influence each other and form a cycle. Consequently, a large inventory buffer is a tangible result for non-collaborative activities.

| Driving Power | Poor Supply Chain Design | Inaccurate demand forecasts | Large Procurements and material price fluctuations | Long delivery Time | Large Inventory Volume | Increased Production | Limited Market Share | Poor IT infrastructure | Deficiency Issue |
|---|---|---|---|---|---|---|---|---|---|
| 8 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | Poor Supply Chain Design |
| 6 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | Inaccurate demand forecasts |
| 5 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | Large Procurements and material price fluctuations |
| 5 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | Long delivery Time |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | Large Inventory Volume |
| 5 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | Increased Production cost & time |
| 5 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | Limited Market Share |
| 7 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | Poor IT infrastructure |
|  | 1 | 3 | 7 | 7 | 8 | 7 | 7 | 2 | **Dependency** |

**Figure 22: Reachability Matrix**

Based on the structuring process which correlates each pair of issues in the form of a cause and effect or "problematique" structure, a reachability matrix was developed. A reachability matrix is an ISM- generated matrix using the numbers of the elements as rows and columns of the matrix. A "1" is entered into the corresponding cell of the matrix to

indicate that a relationship exists between two elements. A "0" is entered into the corresponding cell of the matrix for those elements that are not related to one another. The reachability matrix in figure 22 indicates the dependency between issues and driving power related to each issue. Based on that, major and minor issues leading to existing deficiencies could be classified.

The matrix indicates that the supply chain design followed by IT infrastructure had the highest driving power over other supply chain issues. The dependencies of these issues indicate their independency or the least dependency of one on the others. On the other hand, the large inventory got the least driving power among supply chain issues since it is the most dependant issue on the others. According to the driving power and dependencies outcome, it is obvious that issues related to supply chain designs and IT infrastructure occur in the earliest stages of supply chain deficiency cycles while the inventory buffer comes in the latest stage of supply chain deficiencies. Based on these results, stage-set is defined starting form driving issue to dependent one. The problematique structure goes from left to right based on the ISM methodology. Supply chain designs and the integrated platform have occupied the elementary stages at supply chain stages. Although the interviews with the participants have not proven that they pay attention to these essentials issues, the literature has proved its importance by different methodologies (Naim and Towill , 1994; Vos and Akkermans, 1996; Beamon, 1998). The structuring process of ISM has indicated similar results. These stages are demonstrated in figure 23.
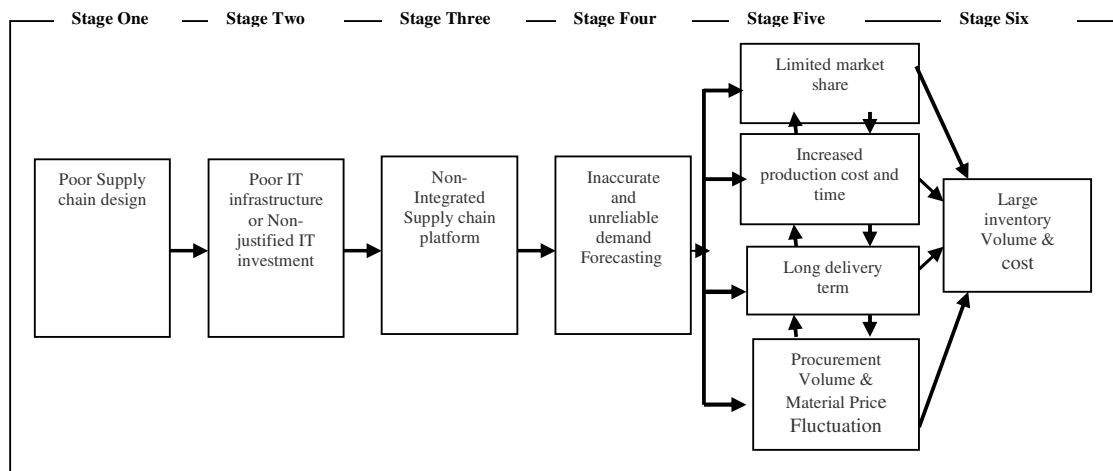


**Figure 23: Stage-based Model for Supply Chain Deficiencies across Egyptian industries**

### 4.5. Proposed Framework

Based on the discussed supply chain deficiency stages, a supply chain deficiencies framework is developed. The supporting factors for each element have been added to represent a unified model of supply chain deficiencies, the framework represents deficiency issues and their leading factors in a unified form as represented in figure 24. It merges the outcome from case studies and key issues emphasised by the literature. The framework demonstrates that most industrial supply chains in the Egyptian textile industry is suffering from poor supply chain designs. Smoothing information flow through the chain is not the only proposed solution; the emergence of designing information-related processes between partners and channels for these information flows is needed. This need has been supported with unstable market conditions, competition, and recently used production technologies by competitors. These factors have triggered the need for supply chain re-design. Defining a supply chain structure is a vital issue and its importance has been investigated by Persson and Olhager (2002) and Harrison (2001) to clarify the sequential links between different sourcing, production and distribution activities (Freiwald, 2005). Poor IT infrastructure participated as a major issue to aggravate the supply chain deficiency and lead to a fragmented supply chain platform. Unreliable forecasts lead the organisations to produce more to capture any possible sales opportunity. Due to the limited market share in the face of Chinese competition, the excess production was illustrated in the form of increased production cost and large inventory volumes. Issues related to diversity of procurements, delivery time and production issues are considered as minor issues that lead to existing deficiencies. Increased holding cost inventory is a consequence of internal deficiencies related to long delivery time, high production cost and limited market share. To address the existing deficiencies, major issues related to supply chain re-design should be addressed. Vertical Cooperation to define subsequent steps of the value chain is needed. To participate in the Global Supply Chain Forum, integration of business processes is essential. A collaborative-based strategy to link cross enterprise business operations is the only key to accelerate supply chain performance (Freiwald, 2005). Through this collaboration, firms can adopt different supply chain strategies that depend on the collaborative demand forecast. Modern supply chain systems opt for real-time demand visibility rather than being a forecast based system in order to provide greater responsiveness to customers. The possibility of implementing these expensive technologies, can provide real time visibility, and is hard to predict for Egyptian industry. Firms have to rely on further expectations of customer demands. This is stressing

more on the importance of sharing information and conduct collaborative planning. Information flow can hardly be integrated between partners for intra-organisational activities due to the current working environment.
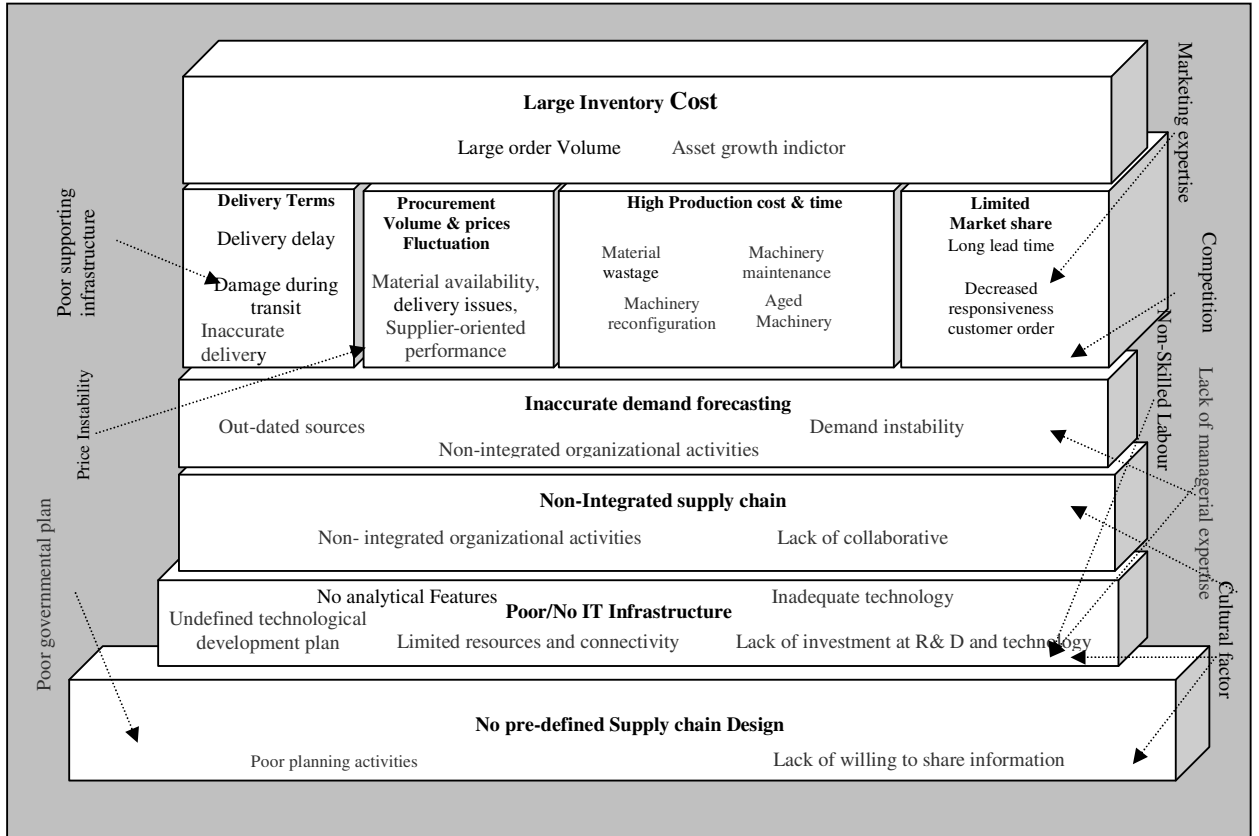


**Figure 24: Supply Chain Deficiency Framework at Egyptian Industries**

**Part Two: Survey**

In part one, interviews were conducted at six case study establishments. The main target behind these interviews was to explore and explain the deficiency occurring in the textile industry in Egypt. Based on the study questions, many issues were explored from interviews analysis to establish the causes of supply chain deficiency in Egypt. These issues can be represented in the following diagram.
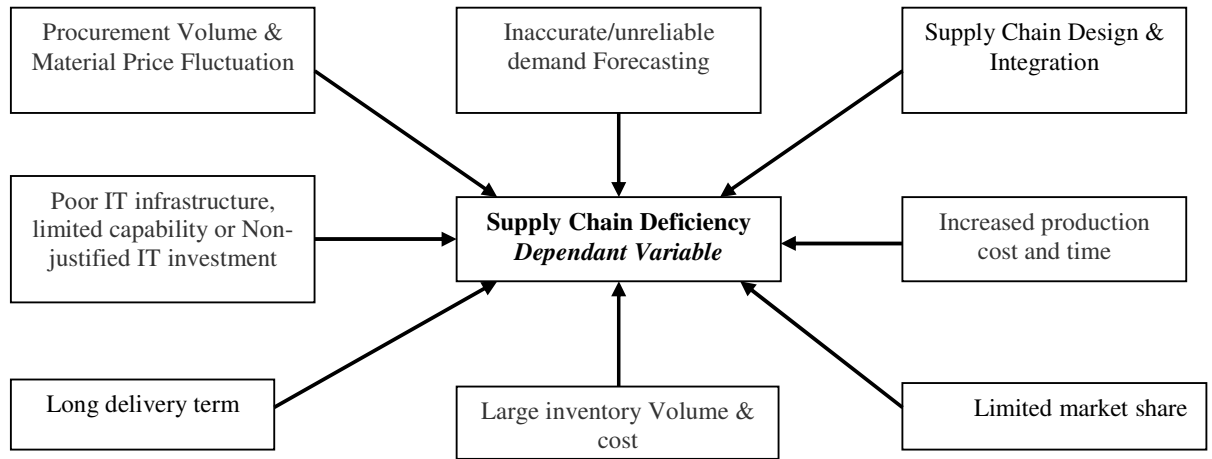


**Figure 25: Dependent and Independent Variables**

**4.6. Survey Overview**

Based on the research objectives, a qualitative approach was used to explore and explain issues related to supply chain activities. Using semi-structured interviews allows the researcher to achieve an in-depth investigation (Yin, 1993, 1994) and overcome cultural issues related to trust and revealing sensitive information. Quantitative approaches will be used to validate interview results and test the proposed hypotheses. To develop a study with high credibility, the study relied on a multiple method of data collection and multiple sources (Sekaran, 2003). Based on Creswell (2002) suggestions for data validation, a survey technique was adopted to validate the data obtained. A triangulation between quantitative and qualitative data was performed to investigate the extent to which they validate the same facts.

The questionnaire was used as a conformity instrument to validate the interview results. The main targets of this instrument are to:

1. Determine if the proposed issues are considered as interfering factors that lead to supply chain deficiency.

2. Define the most and least important issues that affect the supply chain performance and cause its deficiencies.

3. Rank stages of supply chain deficiency based on its occurrence stages

The questionnaire was designed to include close ended questions with defined alternatives and an open-ended one. The survey was conducted in two major industrial zones in Egypt. Data was collected through distributing questionnaires to thirty firms. The sample represents firms from the public and private sectors. Different firms applied mass production and/ or mass customisation strategy. The main audience of this questionnaire was decision makers at each organisation. The reason behind that is that their awareness of market demand, changes, competition and applied strategy and current faced problems and challenges. In addition, respondents to questionnaires should have a holistic overview of the critical issues that might impact supply chain activities in each departmental level. The questionnaire was administered by the researcher to ensure a high response rate. In-person interviews were conducted with each decision maker to explain issues that caused confusion. Rea and Parker (2005) suggest using in-person interviews to solicit the information directly from respondents. More flexibility is allowed in this way to probe greater detail than in an un-administered survey. Clarification about doubts in questions was given by the researcher prior to the questionnaire completion. The questionnaire was translated into Arabic to avoid any terminology misunderstanding. To design an effective questionnaire, suggestions by Rea and Parker (2005) were considered. These considerations are:

1. Questionnaire Comprehensiveness: responses to each question provide a complete range of alternatives.

2. Questionnaire Acceptability: the questionnaire should include straight forward questions and does not include questions that invade respondent privacy.

3. Logical Sequence: the questionnaire was designed to use logical order: e.g. ask the respondents to indicate if mentioned supply chain issues are considered actual factors that lead to supply chain deficiency or not, then ask the respondent to rank

issues that lead to supply chain deficiency. Finally, they are asked to define any other factors that were not mentioned in the questionnaire.

A pilot test was conducted to check clarity, style, and terminology used throughout the questionnaire and necessary changes were made accordingly. Questions related to causality between issues were deleted as most participants did not reply to these. A substitute test of relation detection was applied in a survey analysis. The following section explains the questionnaire structure.

## 4.7. Re-Structured Hypotheses Testing

Based on McCormack and Hill (1997), there are six steps to test the hypotheses:

1. State the hypotheses

2. Identify the dependent and independent variables

3. Select the appropriate statistical procedure for analysis.

4. Determine the acceptable level of statistical significance

5. Calculate the value of the test

6. State the conclusion about the hypotheses

Based on figure 25, the study hypothesis has been formulated to indicate different factors that affect the supply chain performance. The study proposed an initial hypothesis based on the literature survey. It indicates that "Lack of seamless Information flow" is the base factor, which leads to supply chain deficiency factors. The hypothesis has been modified to indicate the outcome of the current study. This outcome points to poor design for integrated channels that are needed to enable reliable and accurate information flow. Supply chain design and poor IT infrastructure factors are considered as base factors that lead to supply chain deficiencies. Many other factors are also inferred. These factors are formulated as research hypotheses. Null and alternative versions are considered in the newly re-structured hypotheses. These hypotheses can be classified into two groups of hypotheses. The first is associated to issues that cause supply chain deficiency and the second is concerned with defining major issues that lead to this deficiency. The hypotheses are summarised in the following tables 22, 23, 24:

| |
|---|
| **H1.** Poor supply chain design causes supply chain deficiency in textile industry in Egypt. |
| *$H_0$1. Poor supply chain design does not cause supply chain deficiency in textile industry in Egypt.* |
| **H2**. Poor IT infrastructure causes supply chain deficiency in textile industry in Egypt. |
| *$H_0$2. Poor IT infrastructure does not cause supply chain deficiency in textile industry in Egypt.* |
| **H3**. Un-integrated supply chain causes supply chain deficiency in textile industry in Egypt. |
| *$H_0$3. Un-integrated supply chain does not cause supply chain deficiency in textile industry in Egypt.* |
| **H4.** Inaccurate and unreliable demand Forecasting cause supply chain deficiency in textile industry in Egypt. |
| *$H_0$4. Inaccurate and unreliable demand Forecasting does not cause supply chain deficiency in textile industry in Egypt.* |
| **H5**. Limited market share cause supply chain deficiency in textile industry in Egypt. |
| *$H_0$5. Limited market share does not cause supply chain deficiency in textile industry in Egypt.* |
| **H6**. Increased production cost and time cause supply chain deficiency in textile industry in Egypt. |
| *$H_0$6. Increased production cost and time does not cause supply chain deficiency in textile industry in Egypt.* |
| **H7**. Long delivery time causes supply chain deficiency in textile industry in Egypt. |
| *$H_0$7. Long delivery time does not cause supply chain deficiency in textile industry in Egypt.* |
| **H8**. Procurement volume & material price fluctuation cause supply chain deficiency in textile industry in Egypt. |
| *$H_0$8. Procurement volume & material price fluctuation does not cause supply chain deficiency in textile industry in Egypt.* |
| **H9**. Large inventory volume & cost cause supply chain deficiency in textile industry in Egypt. |
| *$H_0$9. Large inventory volume & cost does not cause supply chain deficiency in textile industry in Egypt.* |
| **H10** Non-justified IT investment cause supply chain deficiency in textile industry in Egypt. |
| *$H_0$10. Non-justified IT investment does not cause supply chain deficiency in textile industry in Egypt.* |

**Table 22: Issues cause supply chain deficiency**

| |
|---|
| **H11**. Poor supply chain design is an earlier stage of supply chain deficiency in textile industry in Egypt. |
| *$H_0$11. Poor supply chain design is not an earlier stage of supply chain deficiency in textile industry in Egypt.* |
| **H12**. Poor IT infrastructure or Non-justified IT investment is an earlier stage of supply chain deficiency in textile industry in Egypt. |
| *$H_0$12. Poor IT infrastructure or Non-justified IT investment is not an earlier stage of supply chain deficiency in textile industry in Egypt.* |
| **H13**. Un-integrated supply chain is an earlier stage of supply chain deficiency in textile industry in Egypt. |
| *$H_0$13. Un-integrated supply chain is not an earlier stage of supply chain deficiency in textile industry in Egypt.* |

**Table 23: Supply chain deficiency Cycle**

| |
|---|
| **H14**. there is a difference in experienced supply chain deficiency issues between public and private firm |
| *$H_0$14. there is no difference in experienced supply chain deficiency issues between public and private firm* |
| **H15**.there is a difference in experienced supply chain deficiency issues between mass production and mass customisation firm. |
| *$H_0$15.there is no difference in experienced supply chain deficiency issues between mass production and mass customisation firm.* |

**Table 24: Difficulties faced by different sector, strategy**

Based on these hypotheses, the supply chain deficiency is considered as a dependent variable that all supply chain issues affect. The survey conducted was used to test these issues and relationships between the leading parameters. A 95% level of confidence was adopted. The confidence interval determines *"To what extent is the response from the sample likely to reflect the population?"* It is used to estimate the average frequency of

attendance of all attendees at these venues (McCormack and Hill, 1997). In order to define the use of parametric or non- parametric test, data normality for each scale is measured using one sample K-S test. If the significance of the scale is greater than 0.05, this indicates that data is normally distributed otherwise another data distribution will be tested. When the data is normally distributed, a parametric test is used. In order to test the first and second set of hypotheses, analysis is conducted to compare the mean of each variable with a certain test value. In case the scale mean exceeds the test value by a significant level of 95%, the alternate hypothesis is accepted, otherwise the null hypothesis is accepted. Most researchers use the 95% confidence level. A t-test was conducted to validate these results. Based on this test, leading issues of supply chain deficiency and their importance level are defined. In order to test a third set of hypotheses, two or more independent sample tests were conducted to indicate the differences. A t-test for two independent samples was conducted for scaled data while the Mann Whitney U test and Kruskal-Wallis H test were used to test two or more independent samples of ordinal data (Bryman and Cramer, 2005). Mann-Whiteny is a non-parametric test used to test data from different samples to conclude the differences between the groups. The test compares scores of two samples which is ranked ordinally. The test finds out the number of times a score from one of the samples is ranked higher than a score from the other sample. Kruskal-Wallis H does the same but for more than two groups for unrelated samples. The outcome of these tests can indicate whether there is a difference or not in experienced issues and occurrence stages of supply chain deficiency between: 1. Public and private firms; 2. Mass production, mass customisation and mixed strategies (Cramer, 1994).

Before detailing and discussing these outcomes, the applied survey structure is explored to indicate its relevance to the main research question.

**4.8. Questionnaire Structure**

The questionnaire (Appendix A) consists of six sections with 31 statements:

1. The first section is the major one. It measures whether issues resulting from the interview analyses are considered as leading factors for supply chain deficiency to occur in Egypt. An interval scale is used in the form of a 5-point Likert's scale, with 1 as strongly disagree, and  5 as strongly agree. Likert's scale is *"multi-dimensional approach which can give an overview of an issue rather than measure individual elements of it"* (McCormack and Hill, 1997).

2. The second uses an interval scale in the form of 5-point bipolar scale, the respondents have been asked to indicate the importance level of each issue on a (1-5) scale for the second question. The bipolar scale describes the positive and negative end of the scale. The central point on the scale is neutral. It is used to measure the intensity of an attitude (McCormack and Hill, 1997).

3. The third section uses an ordinal or ranking scale. A choice is forced to rank this question. The respondents were asked to indicate the occurrence of each issue, ranked by respondents on a (1-9) scale. The reason behind using a forced choice technique is to indicate each issue with relative importance to other issues.

3. The fourth section has a nominal scale to define the applied strategy by each organisation (mass production, mass customisation or mixed strategy of mass production and mass customisation) and whether the firm is related to the public or private sectors. Production capacity and monthly sales rate are included in this section as well.

4. The fifth and sixth sections are open-ended questions. Regarding the fourth question, respondent are asked to define the cause of each issue based on their business relevance. The fifth question is used by respondents to express their views and define other issues that are not addressed, and might be considered supply chain deficiency issues. Proposed solutions which can address supply chain issues might be expressed by the respondents.

## 4.9. Sampling

Stratified sampling was conducted as it is more efficient than simple random sampling (Sekaran, 2003). Subgroups of firms adopt mass production, mass customisation strategy or mixtures of both. Disproportionate sampling was used to represent reality. The research relied on a real dataset from CAPMAS to indicate the actual representation of each subgroup. Industrial directories were used to get different samples of each category. The survey was conducted in two major industrial zones in Egypt. Public and private sector firms are included. SME organisations in addition to larger firms were also included in this sample. Over 150 questionnaires were distributed in-person and by email to firms in different industrial zones; 32 firm agreed to participate in the study. The confidential nature of collected data and cultural issues related to revelation of sensitive information is inferred from a limited number of participant organisations.

## 4.10. Reliability and Validity

The reliability of a measure is an indication of the stability and consistency to assess the quality of a measure (Sekaran, 2003). To assess the reliability of the model, Cronbach's Alpha coefficient was used since it is the most common method of estimating the reliability of an instrument (Zmud and Boynton, 1991). Cronbach's α is a coefficient of consistency and measures how well a set of variables or items measure a single, unidimensional latent construct. Cronbach's Alpha coefficient is used as a measure for interitem consistency, which answers to what degree the questioned items are independent measures of the same concept (Sekaran, 2003). Results obtained show that alpha coefficients for interval and ranking scale exceeded 0.5 which indicates a satisfactory level of internal consistency (Howitt and Cramer, 2003). For the first interval scale question, the alpha coefficient is 0.61 while it is 0.57 for the second question. Ranking questions have alpha coefficients equal to 0.52 while the nominal scale' coefficient is 0.64 for internal reliability. The overall reliability is 0.63 which represents a satisfactory level. Content validity was used to ensure that measures include representative sets of items that tap the concept (Sekaran, 2003). Previously conducted surveys in the field and references to field experts were consulted to ensure that items are adequate and address the investigated problem.

## 4.11. Study Results

### 4.11.1. Demographics

Results of different industrial sectors indicate that a small number of organisation belong to the public sector (12.5%), while the majority of organisations are private sector companies (87.5%). This is due to the privatisation policy, which was recently implemented by the Egyptian government, and resulted in reduced number of public sector firms (CAPMAS, 2005). The majority of organisations apply a mixed strategy of mass production and mass customisation strategies (56.2%), while (25.0%) of organisations adopt a pure mass customisation approach and (18.8%) have a pure mass production strategy.

### 4.11.2. Supply chain issues

A Likert scale questionnaire is used to define issues that affect and lead to supply chain deficiency. The data is shown to be normally distributed with a significance of each issue

exceeding 0.05 (See Appendix B). A t-test is used to determine the significance of the differences between the mean of the sample and a specified value (Colman and Pulford, 2006). Therefore it was used to measure at what level the respondents considered each issue as one leading to existing deficiencies. The t-test demonstrates whether all the local samples belong to the same population. One sample t-test has been conducted three times to compare the mean of each issue and produced test value of 3.5, 3.0 and 2.0. The outcome of each test is indicated in Appendix B. The first test value was issued to indicate a level above the (Neutral) and up to the (Agree) level on Likert's scale. Elements in this range can be considered as leading issues for supply chain deficiency while other elements that had values entirely below 0 and a significance value less than 0.05 are considered as non-leading issues. The second test value was used to indicate the (Neutral) level on Likert's scale. Elements that match this level can hardly be classified by respondents as leading or non-leading to supply chain deficiency. A third t-test was conducted using 2.0 as a test value. The test value represents the (Disagree) level in the Likert scale.

A t-test was conducted with a value 3.5 which represents the respondents' agreement on the questioned issue. The analysis indicates that diversity of procurement and high production costs had significance levels that did not exceed 0.05. Based on that, the respondents agree to consider these issues as interfering issues that cause supply chain deficiency in the textile industry. The outcome shows other issues that did not interfere to cause supply chain deficiency. These issues are represented in supply chain design and integration, IT infrastructure and non-justified IT investment.

Another t-test was conducted with a test value of 3.0 which indicates the neutral level indicated by the respondents. The outcome of this test represents issues that have not been classified by respondents as leading or non-leading issues. The t-test outcome indicates a number of issues, with significance levels that do not exceed 0.05 and have not been classified by respondents as leading or non-leading issues to supply chain deficiency. These issues are represented in issues such as limited market share, inaccurate demand forecasting and long delivery time.

The third t-test with a value of 2.0, representing the disagreement of respondents, was conducted. It is proved, with a significance level less than 0.001, that inventory cost has not been considered by respondents as a leading issue to supply chain deficiency.

**4.11.2.1 Mass production versus mass customisation strategy**

My survey was conducted to examine different strategies of supply chains. Mass production, mass customisation or mixed approaches were included. In order to estimate the difference in difficulties faced due to mass customisation or mass production adoption, an independent sample t-test was conducted. The outcome of the test is indicated in Appendix B.  The group statistics indicate that on average many of the deficiencies faced such as diversity of procurement, long delivery, and inaccurate demand forecasting are higher in mass customisation firms than mass production firms. A limited IT infrastructure has a higher average in a mass production firm than in mass customisation firms. The outcome of the test indicated that equal variances are assumed since the result of a Levene's test for equality of variances is non-significant (significance results exceed 0.05 levels). The significance of a t-test for means equality indicates that there is no difference between mass production and mass customisation firms in faced deficiencies except for diversity of procurement and instability of material prices which had a significance of 0.015 value. While the average means of the procurement issue is 2.83 for mass production firms, it reaches more than 4.25 for mass customisation firms. This illustrates that means are significantly different in mass customisation firms than in mass production firms. Due to demand uncertainty in mass customised products, procurement problems are more common and important in producing tailored products rather than standard ones.

**4.11.2.2 Public firms versus private firms**

As mentioned before, public and private firms are included in the selected sample. In order to define problems that face each sector, a t-test is used to conduct a mean comparison of each issue from both sectors. The outcome of the independent sample t-test is included in Appendix B. Levene's Test for Equality of Variances indicated non-significance results, which means that the assumption of equal variance between public and private firms is valid. The analysis of the outcome does not indicate significant mean differences between the public and private sectors for any of the issues. Although the average mean of issues, such as poor supply chain design, un-integrated supply chain platform, inventory cost, production cost and un-justified IT investments, are much higher in public firms than in private firms, theses differences cannot be considered a significant level of mean differences which exceeds 0.05.

**4.11.2.3 Confidence Interval**

T-tests conducted for this research have adopted a 95% level of confidence. Confidence interval generates a lower and upper limit for the mean. The interval estimate gives an indication of how much uncertainty there is in the outcome. (Snedecor and Cochran, 1989) Concerning the significance level, an acceptable level in the study is 0.05 which means that the researcher is willing to accept that 5 times out of 100 in the sample have occurred by chance. The 95% level of confidence is commonly used in academic research.

**4.11.2.4 Hypotheses testing**

The outcome of t-tests can be concluded to accept or reject the set of hypotheses outlined in Tables 22 and 24. Table 25 demonstrates the results of hypotheses testing.

**4.11.3. Degree of Importance for supply chain issues**

Respondents have been asked to indicate the importance of each issue using a (1-5) bipolar scale. Descriptive statistics in Appendix B indicate the mean and standard deviation of each issue.  Based on the mean as a tendency measure for an interval scale, the most important issues illustrated are production cost and production delay time, diversity of procurement, material prices and a limited market share. Data distribution was tested using the One-Sample K-S Test. Normal distribution was proven by a 2-tailed significance that exceeds 0.05 for each issue (See Appendix B). The t-test was used to determine the significance of differences between the mean of each issue and 3.5 as a test value. This test value represents the Agree level. The outcome of this test is represented in Appendix B. It is proven by a significance level that did not exceed 0.05 that procurement, production and market share are the most important issues that lead to supply chain deficiency. Additionally, the test result indicates that poor supply design, un-integrated supply chain, poor IT infrastructure and unjustified IT investment are not considered as important issues. Another t-test with the value of 3 was conducted to determine which issues are not classified by respondents as important or non-important issues. The test indicates that all issues have been classified by respondent as important and non-important issues. These issues as well as supply chain design, integration, poor IT infrastructure and unjustified IT investments were not considered by respondents as importance issues. These issues have been ranked based on a mean as a measure of central tendency (Mccormack and Hill,1997). The ranks are indicated in the table 26.

| Accepted Hypotheses | Decision | Conducted test & tested value | Evidence |
|---|---|---|---|
| $H_0 1$ Poor supply chain design does not cause supply chain deficiency in textile industry in Egypt. | Accept Null hypothesis | t- test with 3.5 as test value | Confidence interval is entirely below 0 Significant is .001 < 0.05 |
| $H_0 2$. Poor IT infrastructure or Non-justified IT investment does not cause supply chain deficiency in textile industry in Egypt. | Accept Null hypothesis | t- test with 3.5 as test value | Confidence interval is entirely below 0 Significant is .000 < 0.05 |
| $H_0 10$. Non-justified IT investment does not cause supply chain deficiency in textile industry in Egypt. | Accept Null hypothesis | t- test with 3.5 as test value | Confidence interval is entirely below 0 Significant is .018 < 0.05 |
| $H_0 3$. Un-integrated supply chain does not cause supply chain deficiency in textile industry in Egypt. | Accept Null hypothesis | t- test with 3.5 as test value | Confidence interval is entirely below 0 Significant is .019 < 0.05 |
| H4. Inaccurate and unreliable demand Forecasting cannot be classified leading or non-leading issue cause supply chain deficiency in textile industry in Egypt. | Reject alternate and Null hypothesis and re-structure the hypothesis to represent Neutral level | t- test with 3.0 as test value | Confidence interval is entirely above 0 Significant is .037 < 0.05 |
| H5. Limited market share cannot be classified leading or non-leading issue cause supply chain deficiency in textile industry in Egypt. | Reject alternate and Null hypothesis and re-structure the hypothesis to represent Neutral level | t- test with 3.0 as test value | Confidence interval is entirely above 0 Significant is .033 < 0.05 |
| H6. Increased production cost and time cause supply chain deficiency in textile industry in Egypt. | Accept alternate hypothesis | t- test with 3.5 as test value | Confidence interval is entirely above 0 Significant is .004 < 0.05 |
| H7. Long delivery term cannot be classified leading or non-leading issue cause supply chain deficiency in textile industry in Egypt. | Reject alternate and Null hypothesis and re-structure the hypothesis to represent Neutral level | t- test with 3.0 as test value | Confidence interval is entirely above 0 Significant is .037 < 0.05 |
| H8. Procurement Volume & Material Price Fluctuation cause supply chain deficiency in textile industry in Egypt. | Accept alternate hypothesis | t- test with 3.5 as test value | Confidence interval is entirely above 0 Significant is .05 < 0.05 |
| H9. Large inventory Volume & cost does not cause supply chain deficiency in textile industry in Egypt. | Accept Null hypothesis | t- test with 2 as test value | Confidence interval is entirely above 0 Significant is .000 < 0.05 |
| $H_0 14$. there is no difference in experienced supply chain deficiency issues between public and private firm | Accept Null hypothesis | Two independent sample t-test | Significance level of all issues > 0.05. |
| H15.there is a difference in experienced supply chain deficiency issues between mass production and mass customisation firm. | Accept alternate hypothesis | Two independent sample t-test | Mass customisation had higher average mean in procurement issue coupled with 0.015 of Significance level. |

**Table 25: Hypotheses Testing**

### 4.11.4. Supply chain deficiency stages

A stage-based model for supply chain deficiency was developed based on the interview analysis. In order to validate this model, the ordinal scale was used. Respondents have been asked to rank supply chain issues based on their occurrence. Each issue is related to a

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supply chain activity. The median was used as a measure of central tendency due to the nature of the ordinal data (Rea and Parker, 2005).

| Descriptive Statistics | | |
|---|---|---|
| | Mean | Rank |
| Production cost and production delay time | **3.97** | **1** |
| Diversity of procurement & material prices | **3.97** | **1** |
| Market share of local and international marketplace | **3.94** | **2** |
| Reliability of Demand Forecasting | **3.34** | **3** |
| Supplies Delivery | **3.03** | **4** |
| Inventory volume and holding cost either for raw materials or finished products | **2.97** | **5** |
| IT infrastructure and IT capability | **2.94** | **6** |
| Information system investment | **2.78** | **7** |
| Integration between departmental information systems or with their supplier's information system. | **2.75** | **8** |
| Pre-defined channels for dealing with Suppliers | **2.44** | **9** |

**Table 26: Descriptive Statistics**

The outcome is represented in table 27. A deficiency cycle starts with a poor supply chain design and integration and ends with a huge inventory and a limited market share. The poor supply chain design and integration are followed by poor IT infrastructure or un-justified IT implementation. A poor IT infrastructure consequently leads to unreliable demand forecasting which in turn leads to delivery, procurement and production problems. Limited market shares and inventory costs are consequences of previously mentioned supply chain issues.

**4.11.4.1 Difference of supply chain deficiency stage in public and private sector**

In order to investigate the difference of supply chain deficiency between public and private sector, Mann-Whitney U to test two-independent samples was conducted as tested data is

ordinary scaled instead of interval or ratio (Colman and Pulfod, 2006). "I*t is used to test the significance of difference between sample of scores that represent ordinal measurement*" (Colman and Pulfod, 2006) .

| Supply chain Issues | Rank | Median |
|---|---|---|
| Supply chain Integration | 1 | **2.00** |
| Supply Chain Design | 1 | **2.00** |
| IT Infrastructure | 2 | **2.50** |
| Demand Forecasting | 3 | **3.00** |
| Delivery Terms | 4 | **5.00** |
| Procurement Volume & prices Fluctuation | 4 | **5.00** |
| Production cost & time | 4 | **5.00** |
| Market Share | 5 | **6.00** |
| Inventory Cost | 5 | **6.00** |

**Table 27: Ranks of Supply Chain Issues**

The outcome of the test in Appendix B indicates that there is no significant difference between the public and private sector in the supply chain deficiency stages. Although Mann-Whitney U values range from 30-50, Exact Significance exceeds 0.5 for each issue.

**4.11.4.2 Difference of supply chain deficiency stage in different strategies**

Kruskal-Wallis H test is a non-parametric test used to differentiate between more than two groups using an ordinal scale. It was used to test the difference that might be in the occurrence stages of supply chain deficiency between mass production, mass customisation and a mixed strategy of both. This test is similar to the Mann-Whiney U test as it is used for ordinal measurement but in addition it can compare scores in more than two groups (Bryman and Cramer, 2005). Based on output analysis, Chi-square values range from 0.3 to 3.0 while the significance level exceeds 0.05 for each issue. This means that there is no significant difference between mass production, mass customisation and mixed strategies in the occurrence of supply chain deficiency stages.

**4.11.4.3 Hypothesis testing**

The outcome of the above conducted tests indicates that public and private sector firms adopting mass production, and mass customisation or mixed strategies have not

experienced these differences. Occurrence levels of each issue in supply chain deficiency are based on an ordinal scale rank. At this stage, the second set of hypotheses can be tested. The outcomes of hypothesis testing are indicated in table 28.

| Accepted Hypotheses | Decision | Conducted test for difference detection | Evidence |
| --- | --- | --- | --- |
| **H11.** Poor supply chain design is an earlier stage of supply chain deficiency in textile industry in Egypt. | Accept alternate hypothesis and reject Null hypothesis | Mann-Whiney U , Kruskal-Wallis H | - Ordinal rank, Median value =2.00<br>- no difference in ordinal rank between different sector or different strategies was detected |
| **H12.** Poor IT infrastructure or Non-justified IT investment is an earlier stage of supply chain deficiency in textile industry in Egypt. | Accept alternate hypothesis and reject Null hypothesis | Mann-Whiney U , Kruskal-Wallis H | - Ordinal rank, Median value =2.50<br>- no difference in ordinal rank between different sector or different strategies was detected |
| **H13.** Un-integrated supply chain is an earlier stage of supply chain deficiency in textile industry in Egypt. | Accept alternate hypothesis and reject Null hypothesis | Mann-Whiney U , Kruskal-Wallis H | - Ordinal rank, Median value =2.00<br>- no difference in ordinal rank between different sector or different strategies was detected |

**Table 28: Hypotheses Testing**

### 4.11.5. Relationship between Supply Chain issues

Measuring relations between issues is conducted in the survey analysis; Pearson Correlation is used as it is recommended to explore the relationship between interval data (Colman and Pulford, 2006). *"The correlation coefficient is a numerical index which describes how closely related two variables are and whether it is a positive or negative relationship"* (Howitt and Cramer, 2003). The strength of relation is indicated by the numerical values of coefficient, while direction is indicated by the sign.

Pearson's Correlations are represented in Appendix B. Based on these results, there are significant relations in the following, where (r) refers to the significance of relation and its direction, (p) is the significance level where this correlation could be achieved by chance, and finally (df) is the degree of freedom (df=Number of cases-1):

- Positive modest correlation between supply chain design and integrated platform of supply chain. (r= 0.50 ,df=32, p<0.005)

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- Positive modest correlation between supply chain design and IT infrastructure. (r= 0.40 ,df=32, p<0.005)

- Positive modest correlation between integrated platform of supply chain and IT infrastructure. (r= 0.50 ,df=32, p<0.005)

- Positive modest correlation between reliability of demand forecasting and supplies deliveries. (r= 0.50 ,df=32, p<0.005)

- Negative modest correlation between supplies deliveries and inventory cost. (r= 0.40 ,df=32, p<0.005)

- Positive modest correlation between IT infrastructure and information system investment. (r= 0.50 ,df=32, p<0.005)

To explain the equation, the modest relation is defined by Cohen and Holliday (1982) to be the range between 0.40 and 0.69 (Bryman and Cramer, 2005). The significance level of these relations ranges between 0.004 and 0.014 which is <0.05. There are several other positive and negative relations which cannot be considered as significant relations (p>0.005).

## 4.12. Discussion of Results

Based on the above results, there is a greater concern about internal organisation activities than supply chain activities by textile producers in Egypt. Production and procurement issues are the only obvious activities that lead to supply chain deficiency. Long delivery, unreliable demand forecasting and limited market share were not categorised by respondents into leading or non-leading issues of current deficiencies. Competitive Asian products have affected the textile industry and redirected the Egyptian producers to focus on optimising production and procurement activities apart from collaborative activities that may negatively influence these internal activities. Difficulties experienced by textile producers to compete with low-price Chinese fabrics result in limited market shares both locally and internationally. While internal issues optimisation can guarantee short term benefits, planning and collaboration activities can provide long term benefits. Production issues, diversity of procurement and limited marketplace shares are considered as the most important problems they suffer. This supports the fact that collaborative activities are still beyond consideration for these organisations, which in turn provide less flexibility for

adopting a collaborative inventory or production strategy. Large and small size organisations that adopt a certain production strategy are trapped in it and can hardly change it. Mostly, public sector firms are wedded to mass production while private sector organisations adopt mass production, mass customisation or mixed strategies. Organisations, that have export records adopt mass customisation in order to reach a global customer' preferences, while others firms that supply the local market have been trapped in the production of a standard product without paying attention to customer preferences. Machinery life time, non-skilled labour and out-dated production technologies have imposed more constraints on production capability. All these factors are inferred to cause a limited market share and a large finished product inventory.

Each firm applies a periodic plan for inventory replenishment. The procurements volume is pre-defined a year or several months before. Diversity of procurement is a critical issue facing customised production due to material availability. Most organisations consider huge inventory amounts as an indicator of large assets, as well as an order-driven strategy for raw materials is applied by a small number of organisations. That is why organisations do not consider high inventory costs as an issue that leads to supply chain deficiency. Delivery delay is managed with larger inventory buffers to avoid possible suspension or delay in production. Consequently, long delivery time hardly affects the production process.

In addition, participants did not correlate the unreliable demand forecasts to explain the limited share of Egyptian products locally and internationally. The technological infrastructure, supply chain design and integration have not been flagged as issues affecting supply chain performance although they ranked at early stages of supply chain deficiency. The reason for this relies on the perception of new technology adoption and its importance. Resistance to change is the main barrier that faces large organisations when adopting new technology. To avoid employee resistance, organisations are developing their own system that simulates its traditional and manual systems. The benefit gained from these systems is limited to process automation. Process execution and decision making features are excluded.

Supply chain design and integration are directly affected by a non-integrated infrastructure inside the organisation. Many organisations refer to the sensitivity of information which is hardly shared between different departments. Fragmentation between each organisational

unit, despite objective similarities, can hardly formulate an integrated platform for a supply chain between the retailer and supplier. Lack of trust is the main reason behind that.

The respondents have indicated many external factors that cause the above supply chain issues. Government plans play an important role in procurement availability. The governmental policy of exporting Egyptian cotton and importing cotton of lower quality has imposed a huge barrier on these organisations to procure raw material with high quality. There is a need for supportive governmental plans that can assist the textile sector and enable it to face the Asian competition. The workspace has affected labour productivity negatively. Health protection and more tangible benefits are needed by labour. In addition, there is a need for training programmes to improve labour skills.

External and internal factors are inferred to cause current supply chain issues. After representing the survey outcome, the next part of this chapter will demonstrate the matches and differences between both conducted quantitative and qualitative methods. The conducted match has provided a validated framework of supply chain deficiencies.

**Part Three: Quantitative and Qualitative Outcome**

Based on interview discussions and the survey outcome, the following part focuses on matching the outcome of both qualitative and quantitative methods. Validated study results are used to re-structure the proposed framework. Table 29 indicates the outcome of surveys, interviews, observations and document analysis.

| Supply Chain Issue | Survey | Interviews | Observation | Documents Analysis |
|---|---|---|---|---|
| **Collaborative supply chain activities** | - Do not lead to supply chain deficiency.<br>- occupy earlier stage at supply chain deficiency.<br>- had significant positive relationship with IT infrastructure. | - Managerial level does not pay attention to these activities.<br>- Inventory replenishment follows periodic replenishment approach.<br>- Firms hold large buffer that may reach yearly basis | - There no collaborative strategy between business partners.<br>- There is no access is permitted to supplier for inventory tracking or other collaborative activities.<br>- Information holding rather than sharing is applied due to cultural issues.<br>- Selection of supplier is based on price criteria regardless its location and delivery terms. | |
| **Demand Forecasting** | - Classified as leading or non-leading issue to supply chain deficiency.<br>- had significant positive relationship with supplier deliveries. | - based on:<br>1. CAPMAS reports are main sources of data.<br>2. Previous contracts.<br>3. Informal agreement with retailers.<br>4. International report for global markets demands. | - Manual based activity.<br>- Firms suffer to get reliable source for future demands. | - CAPMAS does not provide rates of recent years. |
| **Delivery Terms** | - Classified as leading or non-leading issue to supply chain deficiency.<br>- had significant negative relationship with inventory cost. | - is not considered as a critical issue affect production process due to large held buffer.<br>- is not considered as criteria in selecting suppliers.<br>-Large firms rely on its own logistic while SMEs use third party logics.<br>- Delivery terms are critical for machinery spare parts. | - Despite that delay is limited and controllable for local supplies; delay is uncontrollable for imported supplies due to poor supporting infrastructure of country.<br>- to guarantee reliable delivery, firms operate its own logistics system instead of third party logistics | |
| **Procurement Volume & prices Fluctuation** | - is a major issue leads to supply chain deficiency.<br>- Procurement issue is more obvious in mass customisation rather than mass production. | - Main problem face managerial level to procure diversity of supplies.<br>- filling requirement of customised product is challengeable. | - Deal with frequent supplier for local procurements.<br>- Price is main criteria for supplier selection and in few cases quality factor is considered. | - Long systematic cycle is used for procurement if supplies exceed certain limit |
| **Inventory Cost** | - Do not lead to supply chain deficiency. | - Large inventory is essential to prevent production suspension.<br>- rely on small buffer was experienced by few firms and it is unfeasible to implement. | | - hold yearly buffer of main supplies.<br>- hold Few months' buffer for chemical and production supporting substance.<br>- Large inventory buffer is indicator for assets growth which is preferred by managerial levels. |

| Supply Chain Issue | Survey | Interviews | Observation | Documents Analysis |
|---|---|---|---|---|
| **Production cost & time** | - is major issue leads to supply chain preference is challenging. | - Producing customised products with different preference is challenging.<br>- Labour skills are limited especially skills needed for machinery re- configuration to produce tailored products. There is a need for more training programs.<br>- There is a need to adopting recent production technologies.<br>- public firms use out-dated machinery<br>- number of firms works as original equipment manufacturers globally.<br>- High production cost.<br>- High material wastage.<br>- No predefined standards for quality assurance.<br>- Lack of periodic machinery maintenance. | - Labour suffers from un-protected workspace.<br>-need for labours health insurance.<br>- need for full utilisation of machinery and human power.<br>- No pre-defined standards for quality and production monitoring.<br>- low labour wages<br>- High production cost of spins leads textile producers to buy imported spins instead of local one. | - high material wastage |
| **Market Share** | - Do not be classified as leading or non-leading issue to supply chain deficiency | - Asian competition had affected the market share of local producers badly.<br>- Poor governmental plans could not save Egyptian fabrics competitive advantage and its share in local and international markets.<br>- Firms attempt to maintain relations with existing customers to market its products.<br>- rely on their own distribution point for marketing in addition to local distributors | - Firms struggle to get market share in global markets. | - there is an obvious decline of Egyptian textile fabrics at global markets |
| **IT Infrastructure** | - Does not lead to supply chain deficiency.<br>- occupy earlier stage at supply chain deficiency. | - Legacy system or basic IT application are used at many firms.<br>- Number of large organisations adopts ERP modules. | - Limited or no connectivity between departments.<br>- No connectivity between business partners.<br>- Large firms implemented ERP modules in finance, payroll and procurement department and are not fully utilised.<br>- Unplanned system implementation, no pre-defined system requirement.<br>- Adoption of IT system is based on recent technology adoption or least price offered by IT rather than system requirements. | - Systems are implemented as tool for process automation rather than process execution or decision making. |

**Table 29: Match between Quantitative and Qualitative Findings**

## 4.13. Validating Empirical Findings

While managerial levels admit the existence of issues such as unreliable demand forecasting, long delivery times and limited market shares, they believe that these issues do not affect their supply chain performance positively or negatively. Participants inferred that

these issues are out of their control and un-manageable. Absence of a governmental role led to an obvious decline of the Egyptian fabrics share on both the local and the international markets in spite of the support of Asian governments of textile producers and provision of financial facilities. CAPMAS, which is considered as the official source for providing all organisations with the information that can help them to make informed decisions (CAPMAS), is providing out-dated sources of information about industrial rates. This leads each firm to find a way out to forecast its demand even if is based on informal agreements. The poor supporting infrastructure of the country affects supplies delivery especially the imported supplies. These external factors may explain why issues such as demand forecasting, delivery and limited market share are excluded by respondents. Alternatively, high production cost and diversity of procurements issues are major concerns for textile producers. Lack of standards needed for production monitoring and quality assurance, labour skills, need for recent production technologies and high material wastage are the main factors that affect the production process. Firms adopting customisation strategies experience more difficulties in procuring the diversity of supplies needed to produce the tailored products. Predefined quality of fabrics and uniqueness of some substances interfere to cause a difficulty in fulfilling these supplies locally. The poor supporting infrastructure of the country is a common barrier causing late deliveries. The supplier-customer relationship is limited to inventory replenishment without commitment to any further collaboration. The selection of business suppliers is based on the offered price. Based on this, there is no pre-defined business supplier although locally supplied material is handled by a number of local suppliers. The organisation tends to keep a large buffer to overcome delivery issues and instability of supplies prices. The inventory buffer is mandatory for each firm to guarantee non-suspended production. That is why an increased inventory buffer is considered as beneficial rather than a burden by respondents. Cultural issues negatively affect the supplier-producers relationships so that inventory replenishment is the only means of communication that might occur without any sort of information sharing. Consequently, collaborative activities are not applicable due to supply chain defragmentation. Firms refer to the confidentiality of data and organisational policies preventing them from sharing sensitive data. So collaboration activities and establishing channels for information sharing is still beyond consideration. From the respondents' perspective, an IT system is a tool used to facilitate or automate some business processes. There is still a prevalent perception that IT has limited capability and cannot be deployed

as decision making tools. Human expertise is more trusted in handling the managerial issues.

## 4.14. Framework of Supply chain deficiency

Accordingly, the addressed research question of the empirical study indicates that poor supply chain design, fragmented platforms and a poor IT infrastructure are considered as basic issues leading to the current deficiencies, while large inventories and limited market shares are consequences of other deficiencies. Although procurements and production issues were indicated as the most important issues from respondents' perspectives, these issues occurred in the late stages of supply chain deficiency stages as a consequence of unreliable forecasts and fragmented supply chain design. At the same time, unreliable demand forecast and delivery time were not considered as issues experienced by their supply chain despite their level of occurrence in supply chain deficiency cycle. Based on the survey outcome, a framework of supply chain deficiency has been re-structured to indicate agreed levels of supply chain occurrence stages. The framework which was illustrated before in figure 26, has been re-structured according to the validated outcome of the empirical study. Supply chain fragmentation has been indicated as a major issue for supply chain deficiencies. Limited market shares have been re-located as a consequence of existing internal deficiencies such as long delivery time, diversity of procurements and high production cost.

The framework indicates sequences of occurrences rather than relations between issues. Relations between stages exist but most of these are not considered conformity relations due to the possibility that may occur by chance. Confirmed relations with high significance were indicated in the correlation section above.
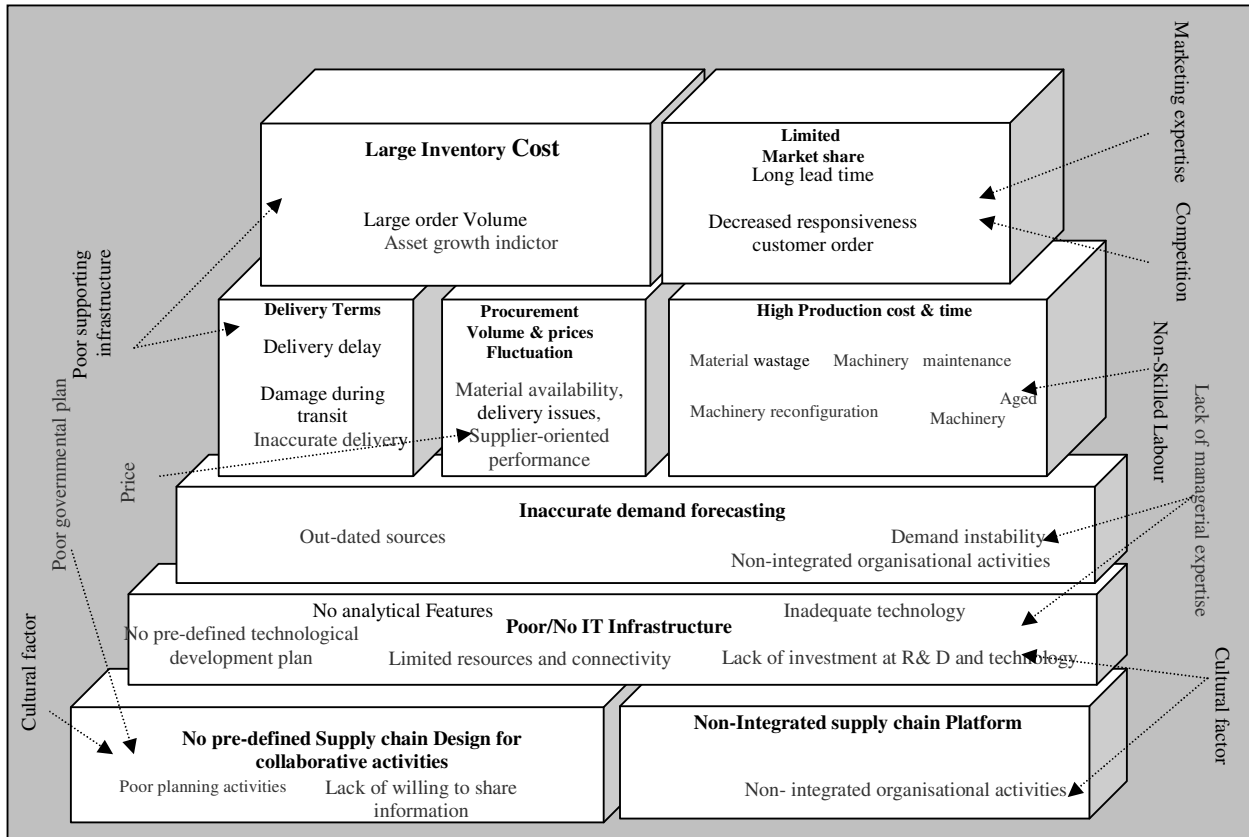
**Figure 26: Framework of supply Chain Deficiencies in developing countries**

### 4.15 Summary

Based on these results, organisations focus on issues related to internal activities rather than issues caused by external factors. The empirical study reached the following outcome:

- The respondents emphasise the significant role of production and procurement issues in supply chain deficiency.

- Supply chain design and integrated platforms are not considered by respondents as critical issues despite their high driving power and effect.

- A well established IT infrastructure and investments in information systems are still far behind to be adopted by textile fabricators.

- An inventory buffer is a representative of firm assets and its large size is a consequence of internal deficiencies related to production, delivery, procurement and delivery issues.

- Inaccurate demand forecasting is an issue dependent upon a poor IT infrastructure and un-integrated supply chain platforms.
- External issues related to the governmental role and cultural barriers aggravate existing deficiencies.

Issues related to the internal deficiency are controllable and can provide solutions for supply chain deficiencies. Possible alternatives that might improve supply chain performance will be proposed in the next chapter. The effect of the proposed solutions will be examined in terms of supply chain performance, these solutions are represented in:

- Extended production capacity
- Reduced delivery time
- Reduced inventory buffer
- Collaborative supply chain activities and smooth flow of information.

# Chapter Five

## Beer Game Simulation

### 5.1. Introduction

In chapter four, data collection methods have been used to explore and validate the difficulties faced by the industry. While the main objective of this research is to find out what issues cause supply chain deficiency in the Egyptian textile industry and propose solutions, the next step is to present and explore, by performing simulation experiments, possible solutions that might diminish current deficiencies. A System Dynamics approach was applied to demonstrate the production-distribution cycle in the textile industry. Sterman's Beer game was adopted in this study to represent the production-distribution cycle, and adjustments have been made to its traditional form to indicate current supply chain deficiencies and limitations. The following section explains the reasons for adopting the System Dynamic approach to explore possible solutions.

### 5.2. System Dynamic Overview

System Dynamics (initially called Industrial Dynamics) is a methodology for studying and managing complex feedback systems, such as one finds in business and other social systems (System Dynamic Society). It was established by Forrester around 1961, Forrester defines Industrial Dynamics as "*the study of the information feedback characteristics of industrial activity to show how organizational structure, amplification (in policies), and time delays (in decision and actions) interact to influence the success of the enterprise. It treats the interactions between the flows of information, money, orders, materials, personnel, and capital equipment in a company, an industry, or a national economy*".

The underlying concept in Systems Dynamics is to define the system as set of interacting parts. It focuses on how a set of elements interrelate to result in a pattern of behaviour. System Dynamics implies a combination of the theory, methods, and philosophy to analyse the behaviour of systems. System Dynamics defines problems or the situation which needs to be explored. Then simulation is used to confirm the causal dynamic hypothesis. The model is used to test the effect of proposed solutions by interpreting the pattern of behaviour (System Dynamic Society) (Forrester, 1991). Feedback and delays are considered as important causes that lead to system behaviour from a System Dynamics perspective (Angerhofer and Angelides, 2000). In principles System Dynamic defines all

systems in terms of levels and rates of changes. The relationships between levels and rates are made by the feedback, flows forwards and delays between quantities.

System Dynamics modelling has been adopted by many researchers to solve problems in supply chain management (Angerhofer and Angelides, 2000). Towill et al (1996) have pointed out that "*the use of industrial dynamics modelling of real-life supply chains has only recently re-emerged from the shadows after a lengthy gestation period.*"

Angerhofer and Angelides (2000) have also classified research adopting the System Dynamic approach into three groups: (1) research concerned with contribution to theory-building; (2) research using System Dynamics Modelling for problem-solving; and (3) research work on improving the modelling approach. This research is related to the second classification where the System Dynamics approach is being used to solve the addressed problem statement.

### 5.2. Beer Game

The beer game is used to represent a production–distribution system. It includes four parties: factory, distributor, wholesaler and retailer. Beer game was developed at MIT in the 1960's by the System Dynamic Group. The game was used to introduce the key concepts of System Dynamics: (1) structural causal behaviour, (2) the importance of delays, and (3) the concepts of stocks and flows. The stock is defined as an accumulation while the flow is the movement or flows from one stock to another.

Kirkwood has built a Vensim model for the beer distribution network based on Sterman's description of the beer game as designed at MIT (Kirkwood, 1998). The beer distribution game consists of a series of stocks which are interconnected with flows into and out of these stocks. The cycle starts with order placement and ends with their fulfilment and delivery by downstream positions (Goodman et al., 1993; Kirkwood,1998).

It could be inferred that many factors affect supply chain performance. Feedback, interaction, and time delays impose variability or instability to supply chain behaviour, revealing the dynamic attribute of supply chain performance. In a multi-tier supply chain, information visibility is considered a vital issue. Lack of visibility has been demonstrated

in demand and inventory amplification. These amplifications increase while moving toward upstream level. (Hwarng and Xie, 2008)

In the beser game, orders are placed by customers and transmitted along the chain to the factory. A retailer estimates customers' demands and places their orders with a regional wholesaler; in turn, the wholesaler places an order to the distributor; the distributor places orders with the factory and the factory will be responsible for producing and shipping the orders to distributor's site. In turn the wholesaler transports the goods to the retailer who is dealing with the end customer. The production process and the shipment of goods are coupled with time delays. Order processing time is also indicated in the beer game (Joshi, 2000).

Based on Sterman's beer game, two rules were considered in the model: (1) orders must be filled if there is sufficient inventory; and (2) unfilled orders are kept in backlog and shall be filled when the inventory amount is sufficient (Hwarng and Xie, 2008). To figure out supply chain performance, a cost indicator was used in Sterman's beer game. Each unit in the supply chain attempts to minimize inventory holding cost while overcoming stock-out situations. The inventory holding cost is considered to be half of the stock-out cost (Joshi, 2000).

Sterman's original beer game had some interesting assumptions (Joshi,2000):

1. Each level in the supply chain holds one inventory stock. The original beer game did not include raw inventory stock in producers tier and considered only the finished product warehouse. This assumption is not realistic when it comes to simulate the producer's role and production activities.

2. Production capacity is assumed to be unlimited so timing constraints are not considered. Since the production time is dependent on machinery capacity and labour skills which in turn define the error rate, these factors should be considered to simulate the reality of production activities.

3. It includes four independent units. The original beer game excluded supplier's tier and focused on the distribution cycle. Since the main target of the beer game is to simulate production-distribution cycle, procurements delivery time and pattern of raw buffer replenishment should be included to simulate more realistic production activities.

4. Random events such as machine break down or transportation issues are excluded. These issues may suspend the production activities and therefore its effect is obvious on product lead time.

Each unit in the supply chain acts independently. There is no information sharing for inventory levels or forecasting information. The communication between these units in the original beer game is limited to receiving and shipping orders to the customer. (Joshi, 2000). Figure 27 represents Sterman's beer game.

While the classical supply chain simulated above is far simpler than a real life supply chain, the model was adapted to be more realistic. The modified model demonstrates current deficiencies that face textile industry.

## 5.3. Modified Beer Game

The simulation experiment has been applied to a real case study in Egypt. This organisation adopted a mass customisation strategy to provide the international and local marketplace with tailored products. The experiments simulate the case of producing towel as sample product. The reason of using towels is due to the popularity of this home-textile which is made of Egyptian cotton in the global market (EgyTex, 2009).

Regarding the model's calibration, data used in the model's equations was derived from a real dataset. This data includes: the pattern of customer's demand, the time needed for an order's perception, the safety level included in order procurement, the safety buffer of raw material inventories, the initial amount of supply lines, the rate of production loss, the time to adjust the production, the production's capacity for each producer, the delivery time of domestic and international procurements, and the time needed to deliver the final product overseas. This information was collected from textile and spinning producers, and Vensim software was used in supply chain modelling and simulation. For the model validation, the data for collaborative case studies, mainly complete input and output data was not available due to the commercial sensitivity.
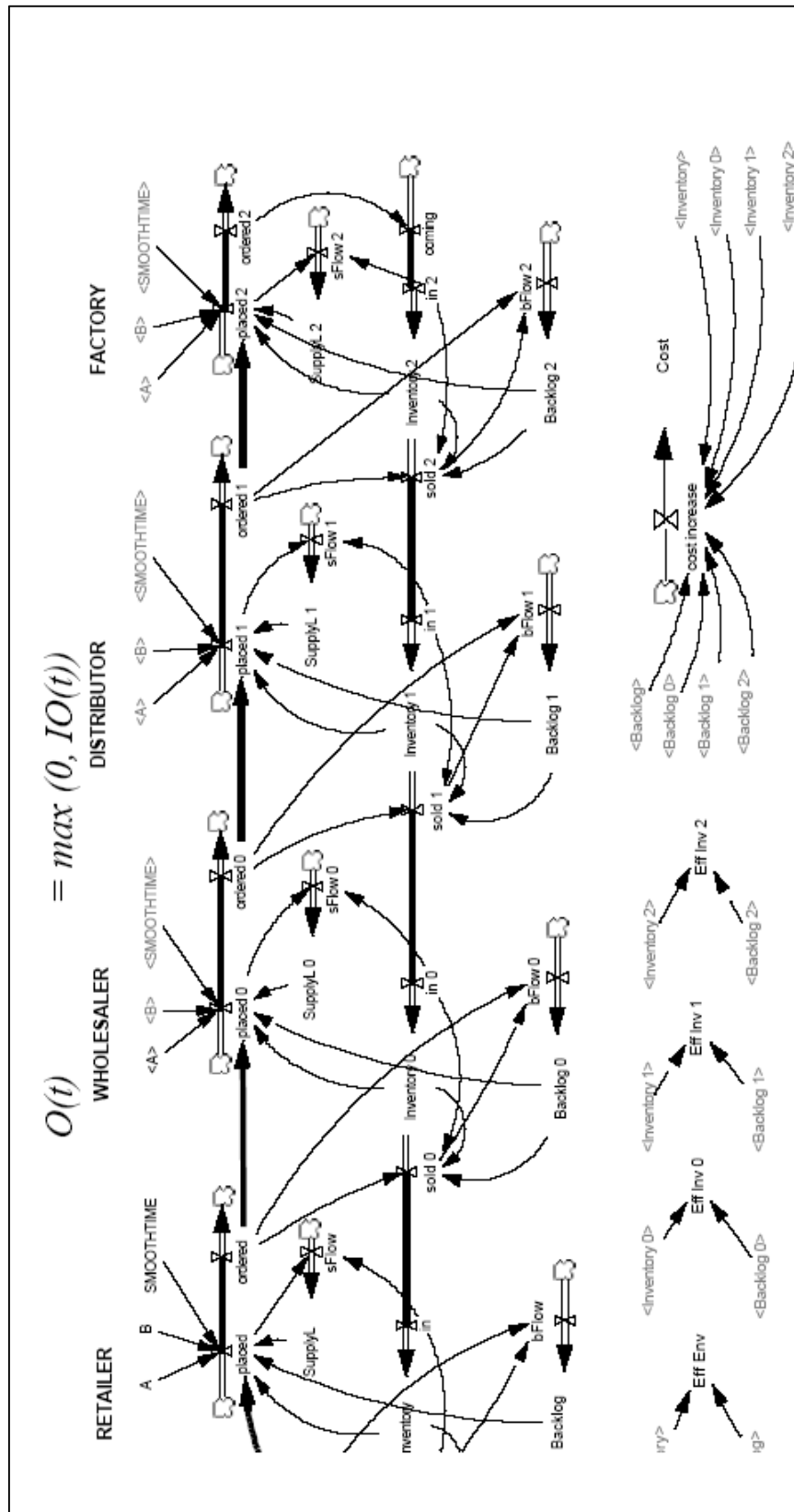
**Figure 27: Traditional Beer Game**

In order to represent empirical findings in my experiments, the selected case study includes most of the issues that are imposed in supply chain behaviour and discussed in this research. Real datasets will be used in the simulation experiments. Beer game modification will consider the design indicated in table 30 to include previously discussed issues:

| | Issues | Beer Game Design |
|---|---|---|
| **Planning & Forecasting Activities** | No pre-defined Supply chain design | While the vision of supply chain concept is not clear to respondents in my case, individual patterns of decision are used by each partner and Ad-hoc pattern are deployed. Decision and strategies followed for replenishment and inventory size represent conflicting goals. |
| | Non- Integrated supply chain platform | Represented in the sequential pattern of passing order manually. Order processing delays, lack of visibility along the chain indicate the existence of fragmented platform. |
| | Inaccurate and unreliable demand forecasting | Each partner relies on amplified data of demand due to the sequential supply chain. In addition, the safety level is included in each order placed to the next partner. No real time feeding of real set regarding customer demand is provided. Each partner relies on such amplified data for forecasting. |
| **Procurement & inventory Activities** | Procurement volume & material price fluctuation | Supplies are being ordered to fulfil each incoming customer's need despite the large amounts held in inventory. The safety level is included by each producer in procurements order. Price issues are excluded as they more related to economical factor rather than the internal deficiencies modelled in simulation experiments. |
| | Long-term delivery | 1-2 week for domestic supplies and 1-8 week for overseas supplies. Unstable delivery or logistics conditions are represented by random function adoption. |
| | Large inventory volume & cost (raw materials and finished products) | Inventory kept in large size to overcome delivery delay and dependency on suppliers. Order fulfilment is coupled with inventory replenishment with same size even if buffer is large enough to fulfil such order. Replacement strategy is consciously adopted. |
| **Production Operations** | Increased production cost and time | While cost and time are co-related, a long time of operation affects the cost negatively. Production timing is indicated by production capacity constraints. |
| **Distribution & Marketing Activities** | Limited market share (Locally and internationally) | Real data set regarding actual demand feeds into the simulation. |
| **Technological Aspects** | Poor IT infrastructure or limited capability | Sequential supply chain uses manual techniques which are represented in order passing delay. |
| | Non-justified IT investment | Results in limited automation benefits inside the organisation. |

**Table 30: Mdx Beer Game Design**

This study includes two different beer games, the first beer game represents supplying local marketplaces with tailored products **(Mdx Beer Game 1)**. Figure 28 do represents the

case of fulfilling local market demands. The game started with a customer order. The traditional beer game assumes that customer demand is fixed for a while and then increases by a certain amount. As I rely on a real dataset in this beer game, information about demand has been tested to define its distribution. The data was normally distributed so that the customer demand's equation is indicated by function **RANDOM NORMAL** of weekly demand rates (equation 45, Mdx beer game 1).

The order is placed at retailer site by a unit *O*, at time *t*, are given by:

*O(t) = max (0, IO(t))*

*IO(t)* = indicated order rate, is computed based on three factors:

- The expected losses from the stock *(L)*
- The discrepancy between the desired and actual stock *(AS)*
- The discrepancy between the desired and actual supply line *(ASL)*

*So the order rate equation is:*

*IO(t)* = Demand Forecast + actual stock gap + actual supply line gap

*IO(t)* = Demand Forecast + A•(Safetylevel –(Inv-Backlog(t)) – B•Supplylinegap(t)

Inventory buffer of finished products is 10000 towels stored by the textile producer. The spinning factory does not keep a large stock of finished inventory. Its spin buffer is about 10 tonne (Equation 3-4, Mdx Beer Game 1). The order is being passed from a retailer at supply chain downstream to reach the distributor, the wholesaler and the producer at upstream. The time delay for passing orders and shipments from one stage to the next is fixed to one week and represented by a **FIXED DELAY** function (Equation 46-50, Mdx Beer Game 1). Decision makers in the current case study include a safety margin in each order placed by the producer in order to overcome material misuse during production process. Thus, a safety margin is included in the material's order by each producer. Unit conversion is applied when supplies are being order. Order amount of towels is converted into spins supplies when an order is placed by the textile producer to the spinning and weaving factory. In turn, the quantities of spin amounts are translated into cotton supplies by the spinning factory to be ordered from its suppliers.

In order to imitate reality in the textile industry, the traditional beer game was adapted to represent two levels of production. The first production level indicates the transformation

of cotton into spin. The second level indicates the transformation of the yarn spin into towels. A safety margin is included in each producer's order to overcome production loss. Units used in the order equations have been converted into supplies when order is placed by a producer to its suppliers. Hence, the order amount demonstrates units of material requested and placed to the next partner's site.

Supplies are ordered to replenish the inventory buffer. Whereas the delivery issue is not considered important according to case study respondents, the case study under investigation does not pay attention to material delay that may occur in delivery. From their perspective, a delay can be overcome by a large safety buffer. Material delivery can vary from one to two weeks. It depends on the available stock in the spinning and weaving warehouse. Supply movement is demonstrated in the form of flow connecting two stocks, semi-finished stock at each supplier site with the stock of raw material at the client site. Supply rate is represented using **DELAY MATERIAL**, which conserves the material in the delay when the delay time changes (Equation 31-32, Mdx Beer Game 1). It is discrete delay functions, which have the property of preserving quantities (Vensim documentation). The rate of supply is affected by the duration of the delivery. Delivery durations have been tested and they are randomly uniformed distributed (Equation 10, Mdx Beer Game 1).

The raw material stock has been included for both producers due its importance. Moreover, the production process is a transformation of raw materials; thus the raw material stock should exist there to formulate the production process. Because the production process represents transformation from the raw material stock to the finished product stock, the production process is illustrated with a flow that connects the two stocks (raw material inventory and finished products inventory) at each production level. Production entry is defined as a difference between demand (total of backlog and customers orders including safety margin) and the available amount (delivered and available inventory amount). An **IF THEN ELSE** statement is used to do this comparison (Equation 58-59, Mdx Beer Game 1). Production equations indicate unit transformation from material (cotton or spins) to semi-finished or finished products (spins or towels). The production time is not fixed as assumed in the traditional model. It depends on the production capacity of each producer as illustrated in the following equations.

**Production Time**=Production size / Production Capacity

The production size is reduced by the material loss rate during the production stage at both levels (equation 56-57, Mdx Beer Game 1). Regarding the production, a **FIXED DELAY** is used to indicate the production duration at each level (equation 73-74, Mdx Beer Game 1). The time needed for production and machinery adjustment is considered. A **SMOOTH** function is used to state that the factory production is delayed from the desired one with adjustment time, which limited labour skills interfere to cause.

Based on case study respondents, the safety margin is produced in addition to the amount ordered to avoid material misuse during the production. Units are converted from raw material unit into semi-product or finished product units to represent the transformation process. The delivery of the finished product from producer site downstream is represented by a **DELAY FIXED function** of one week delay. (Equation 70-72, Mdx Beer Game 1).

The supply line accumulation and its incoming flow imitate the traditional beer game (Equation 33-44, Mdx Beer Game 1). The same applies to the partner's backlog stock (accumulation of unfulfilled order) and its incoming flow (Equation 60-69, Mdx Beer Game 1).

The second beer game represents the case of providing international marketplaces with tailored products **(Mdx Beer Game 2)**, which is represented in Figure 29. This model shows the role of Egyptian firms as original equipment manufacturers (OEM). Based on this case study, the second beer game is similar to the first except for a few details. There are no intermediaries between international retailers and the textile producers; direct marketing is applied to reach the international markets in this case. Distributors and wholesalers are therefore eliminated from the beer game. The beer game simulates the role of producers toward fulfilling demands of an international retailer regardless of the retailer's role. This is due to unavailability of data access to the retailer's information.
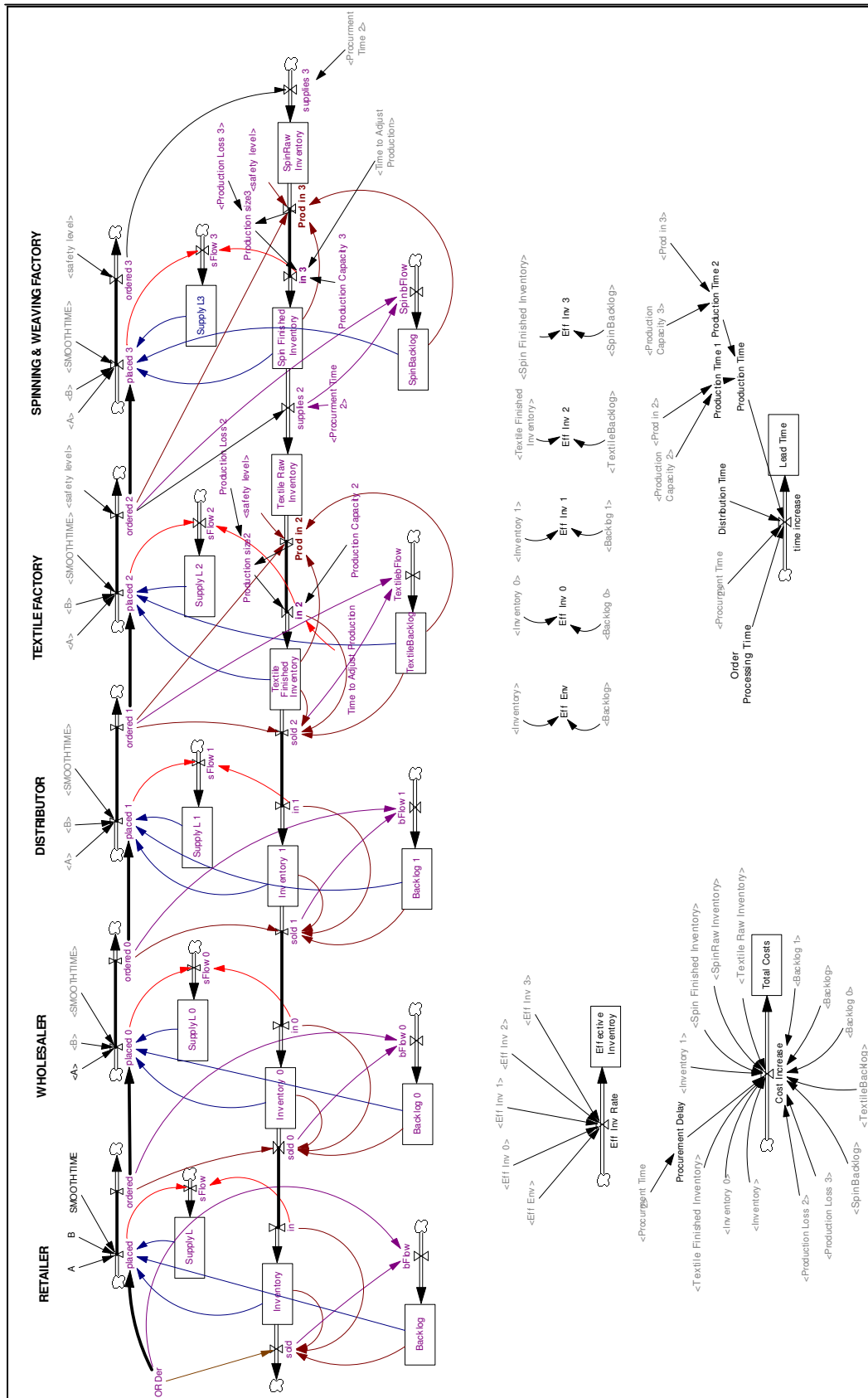
**Figure 28: Mdx Beer Game 1-Fulfilling Customization Orders of Local Markets**

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A retailer's order is normally distributed so a **RANDOM NORMAL** function is used in equation 7, Mdx Beer Game 2. **RANDOM NORMAL(m,x,h,r,s)** provides a normal distribution of mean 0 and variance 1 before it is stretched, shifted and truncated. This is equivalent to a normal distribution with mean **h** and standard deviation **r**. The units of **r** should match **m**, **x** and **h** (Vensim Documentation). The simulation starts by placing the retailer's orders to the OEM unit and place this order to manufacturing units as illustrated in equations 7 and 8, Mdx Beer Game 2. The textile producer spends more time to estimate the feasibility of producing such order based on available resources. The delay in receiving the retailer's order and placing this order by the producer to its units is estimated at about five weeks. A planning department in the investigated case study estimates the feasibility of producing the customised product, available machinery, required supplies, available material with defined quality and estimated cost associated to these production processes.

The textile producer places an order to the spinning and weaving producers with certain constraints to place its production process in equation 10-11, Mdx Beer Game 2. Due to a pre-defined quality constraints that have been set by international retailers and adopted by producers, and the fact that many supplies are being imported, they face long delivery time as represented in equation 12-13, Mdx Beer Game 2.  The spinning factory provides textile producers with semi- finished materials. Procurement delivery ranges between 1- 2 weeks based on stock availability and the production delay (Equation 18, Mdx Beer Game 2). The textile producer produces the requested order and stores it until shipment is available. Delivery relies on the selected method for overseas shipment which is estimated between 1- 8 weeks based on the destination. (Equations 24-25, Mdx Beer Game 2). The production of each producer is represented in equations 14-17 and 20-23, Mdx Beer Game 2. Supply line and backlog equations are illustrated in equations 40-47, Mdx Beer Game 2.

The modified beer game considers:
1. Production capacity constraints at production levels.
2. Material loss during production processes.
3. Two inventory stocks (raw material and finished products stocks) at each production levels.
4. Delivery delay of procurement at production levels.
5. Adjustment time needed to produce tailored products.
6. Safety margin in production input to avoid material loss.

7. Lost sales opportunities caused by material delay and as consequence production delay.

8. Unit' conversion from finished products to its encompassed raw materials.
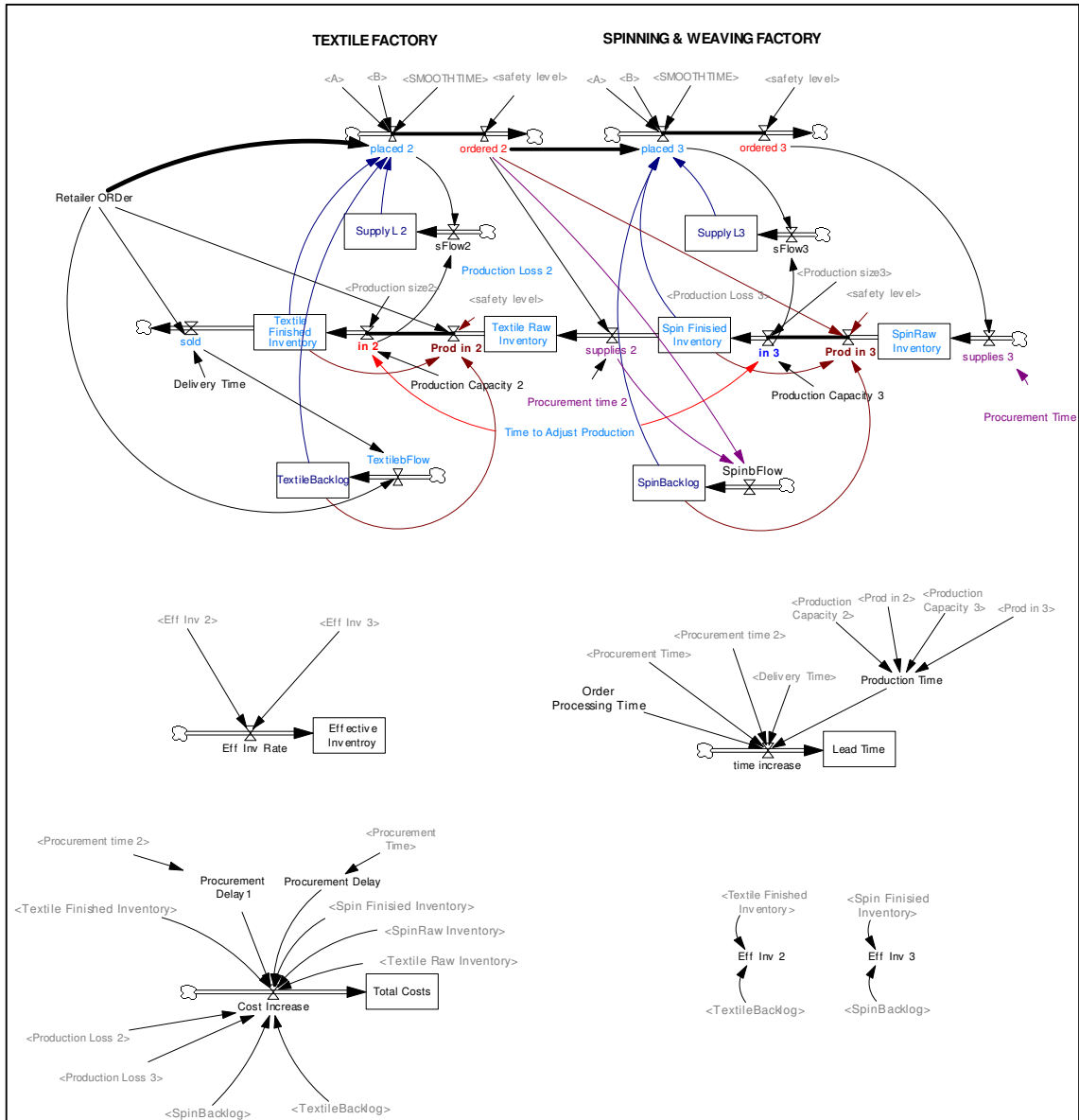


**Figure 29: Mdx Beer Game 2-Fulfilling Customised Orders of International Markets**

The adapted beer game incorporates additional supply chain factors to reflect a customisation approach setting. The modified beer game has considered performance measurements as follows:

1. **Total Supply Chain Cost:** A cost measure was utilised by Sterman's beer game to indicate supply chain performance. The objective of the classical beer game is to

minimise supply chain costs while maintaining inventory within safety stock levels and having the ability to fulfill the incoming orders. The adapted beer game as well includes a cost measure. The total cost includes inventory holding cost (raw material and finished product inventories), stock-out cost; material loss cost and lost sales opportunities. Lost sales opportunities are measured in the Mdx Beer Game based on procurement delay. While delivery time of procurements is supposed to be one week locally and four weeks internationally based on the company's perspective, it is uniformly distributed between 1-2 weeks value for local orders and 1-8 weeks for international orders. So any material delay after one week for local supplies and four weeks for an outsourced one is included in cost estimation as lost opportunity for sales. The delivery time will be tested to see if it exceeds estimated values. In case it does, a difference between an estimated value and the actual one will be included in the cost calculation as demonstrated in equation 22. The holding cost is considered to be half the cost of stock-out as assumed in Sterman's model (Sterman, 1989).

2. **Effective Inventory:** This represents the available inventory for each partner. It is measured by differences between the inventory amount and backlog (the accumulation of unfulfilled orders) at each supply chain level. Effective inventory controls the level of responsiveness to customers' orders. Effective inventory is measured at each stage of the supply chain and the total effective inventory is indicated as a measure for performance.

3. **Lead Time**: **Order-to-Delivery lead time** is the time elapsed between the placement of an order by a customer and the delivery of this order. It includes supplier lead time, manufacturing lead time, distribution lead time, and order management time. The lead time is utilized as a performance measure at conducted beer games due to its effect on the performance of the supply chain. The lead time is a critical factor in build-to-order supply chains. Lead time is correlated to inventory levels, costs, and customer service levels. Lead time reduction will encourage a decision maker to keep a small buffer while the firm is able to fulfil a diversity of customer demands (Hwarng and Xie, 2006). This will lead to improved order responsiveness, which is mandatory in the mass customisation adoption. Lead time is used to estimate the time needed to receive an order placed by retailer.

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## 5.4. Beer Game Results

The simulation ran for 36 weeks, the typical time period that is taken for a traditional beer game to be played. Figure 30 shows the output of the experiments. The output proves that a customer or retailer order is amplified while moving forward in the chain. This pattern of demand amplification along the supply chain is obvious in the first Mdx beer game experiments (Joshi, 2000). The bullwhip effect distorts demand information when it passes up along the chain and causes these amplifications. Many studies have indicated that the bullwhip effect is a result of long lead times and lack of information visibility across the levels of a supply chain (Hwarng and Xie, 2008). Orders placed by producers to their supplier have not followed the same pattern of amplification. The reason behind that is that order units have been converted into units of material supplies requested from that supplier, so a customer's order is transformed into units of material required to produce this order.



Customer Order

# Retailer Order

Graph for placed



placed : Graphs\Local Model ———————————————————————————————— Towel Unit

# Wholesaler Order

Graph for placed 0



placed 0 : Graphs\Local Model ———————————————————————————————— Towel Unit

# Distributor Order

Graph for placed 1



placed 1 : Graphs\Local Model ———————————————————————————————— Towel Unit
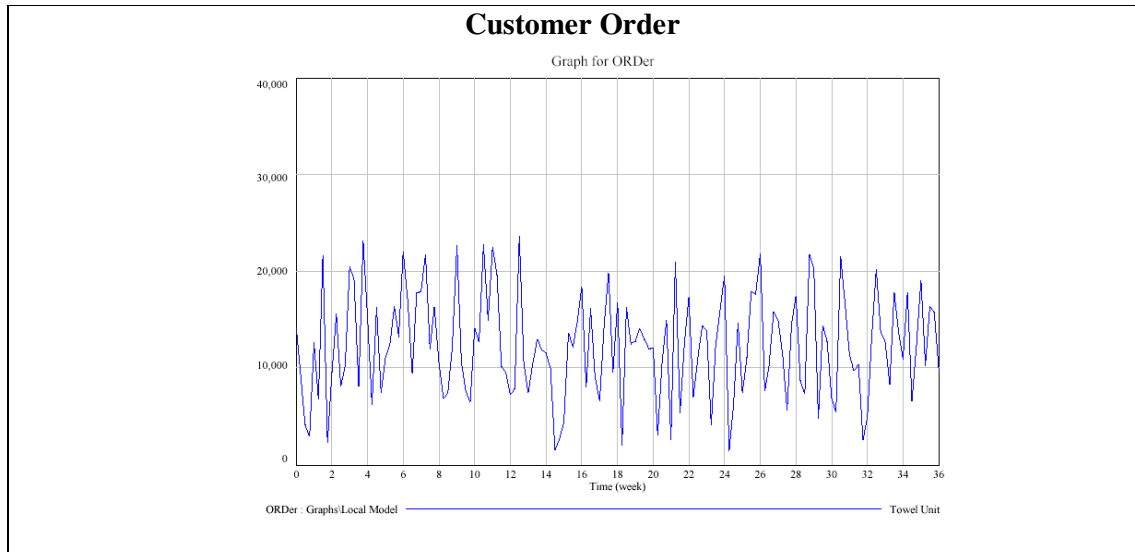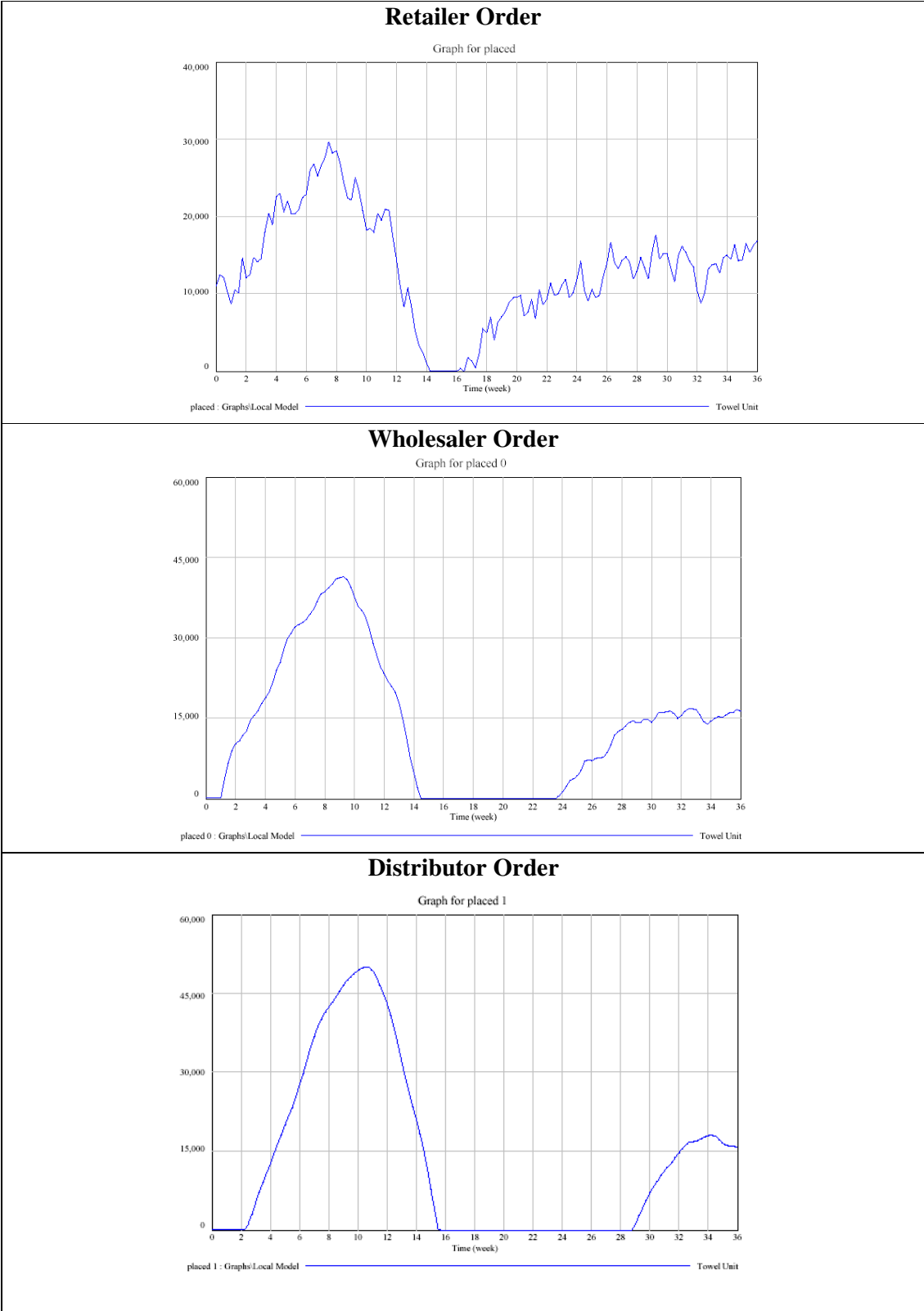
**Figure 30: Order Pattern- Mdx Beer Game 1**

Based on cost measures, the total cost of the chain grows exponentially during 36 weeks in both experiments. In the first experiment (Mdx Beer Game 1), this demonstrates a case of fulfilling customised orders locally in figure 31, the cost rate increases rapidly till week 9 to reach a value of $276,000. The increased rate is due to the obvious drop in effective inventory over the chain which reaches - 0.2813 M unit by week 9. Effective inventory drop is referred to the large backlog of textile and raw material inventories during the same period which is coupled with high production loss. Following that, the cost rate shows a fast drop till week 14 followed by small increase by end of the same week. This is synchronized with a rapid rate increase of effective inventory increment. By week 17, the cost rate declines gradually with only little increase by week 32. This pattern is simultaneously coupled with effective inventory reduction. The reason behind it is that textile backlog and production loss rates are at their minimum levels and show a rise in the last few weeks of the simulation. Raw material buffer at each production level, in addition to textile inventory are quite enough to fulfill the partner's need till week 32 where they show another drop. The effective inventory measure is represented in figure 32.

The total supply chain cost encompasses many factors such as holding cost, stock-out cost, and procurement and material wastage. Consequently, a high cost rate increase between week 2 and week 9 is compared to an effective inventory shortage, which is in turn caused by procurement delivery fluctuation, textile inventory shortage, high backlog cost and increased material loss. Rapid cost reduction is due to the availability of textile fabrics. While the textile inventory illustrates a rapidly increasing rate with a minimum production loss, this rate enables the fulfillment of incoming orders and reduces the textile backlog to the minimum. By the end of the simulation, the decrementing rate becomes slower and stabilises when it reaches the last week of the experiment. The decreasing rate of effective inventory is synchronized with the cost rate increment. The reason behind this is a shortage of textile inventory and high production losses which could not fulfill the market demands coupled with increased cost rate. Supply chain patterns of behaviour for Mdx Beer Game 1 are demonstrated in figure 33.

**Figure 31: Mdx Beer Game 1- Cost Measure**

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**Figure 32: Mdx Beer Game 1- Effective Inventory Measure**

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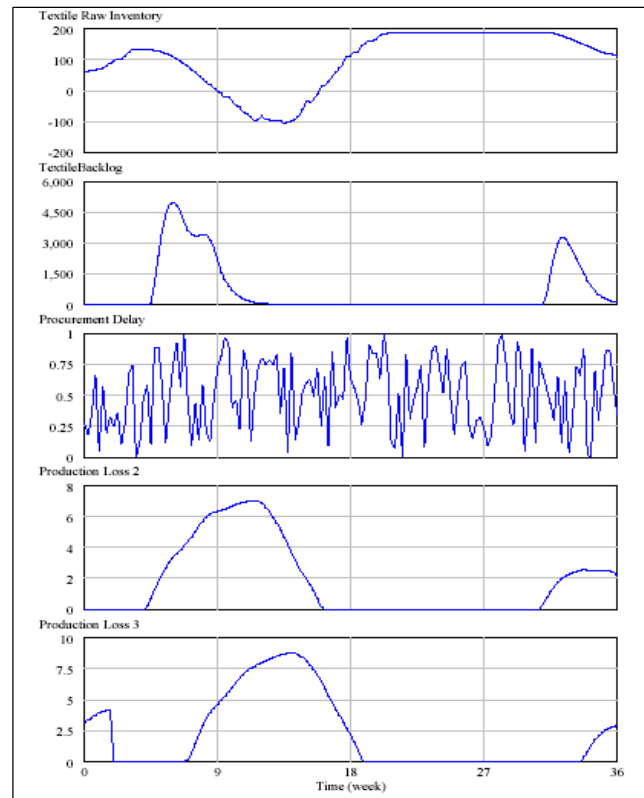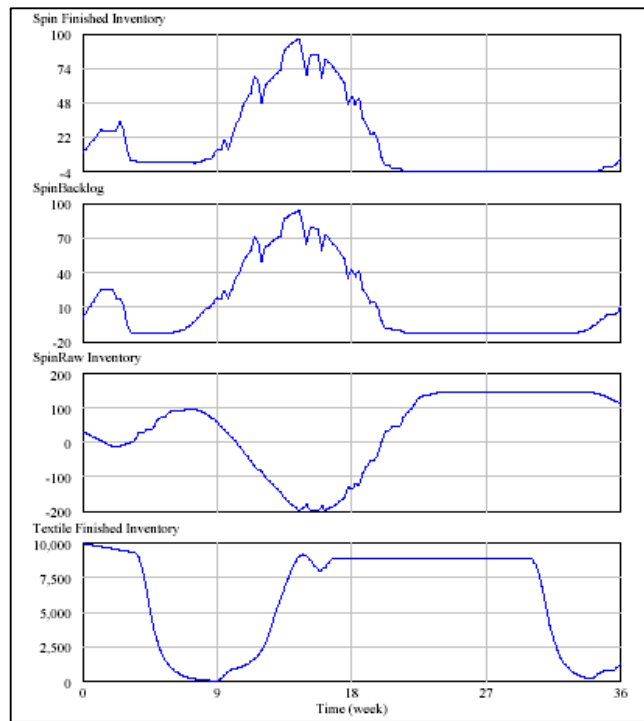
**Figure 33: Supply Chain Behaviour in Mdx Beer Game 1**

Regarding the second experiments (Mdx Beer Game 2), figures 34 & 35 indicate the performance measure and system behaviour. Cost oscillates over the experiment time. Oscillation ranges between $200,000 as a minimum value and $607,000 as a maximum

value. This pattern is combined with a fluctuating rate of effective inventory over the experiment. Variations of textile inventory and backlog of textile fabrics are the main cause of oscillating flow of production loss and fluctuating delivery delay for overseas and local supplies. Delay of outsourced supplies may reach 4 week while it is limited for local supplies. Supply chain pattern of behaviour of Mdx Beer Game 2 is demonstrated in figure 36.

**Figure 34: Mdx Beer Game 2- Cost Measure**



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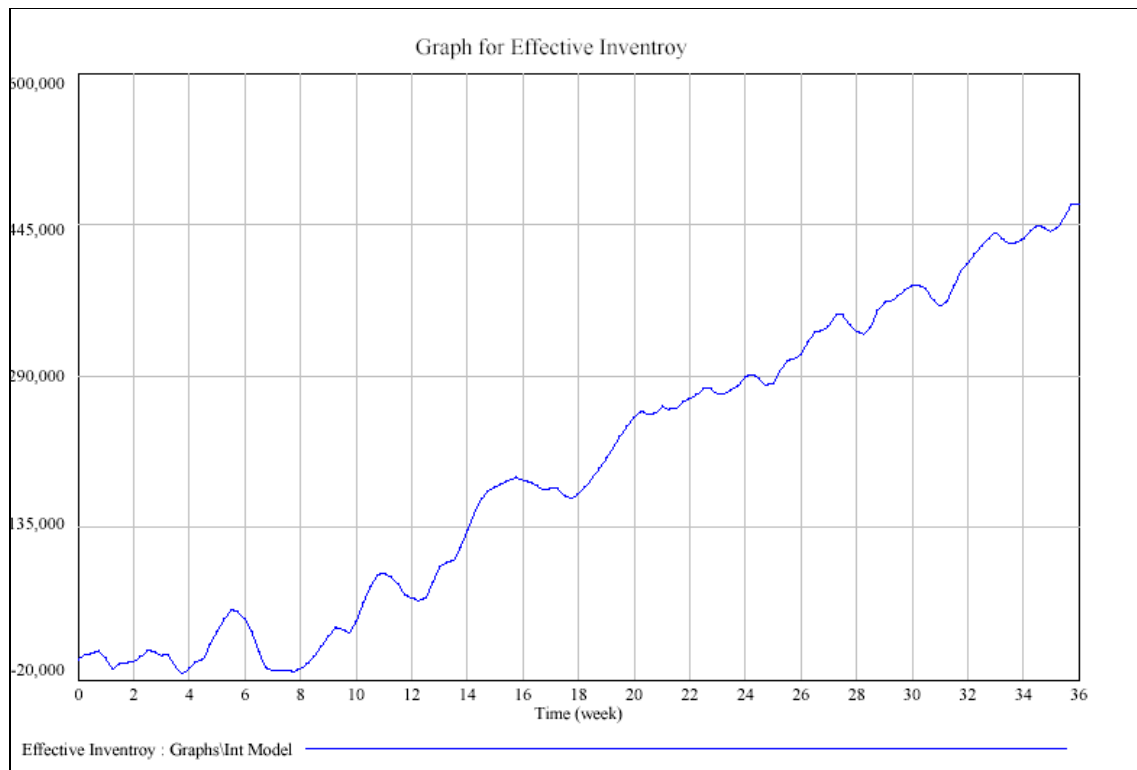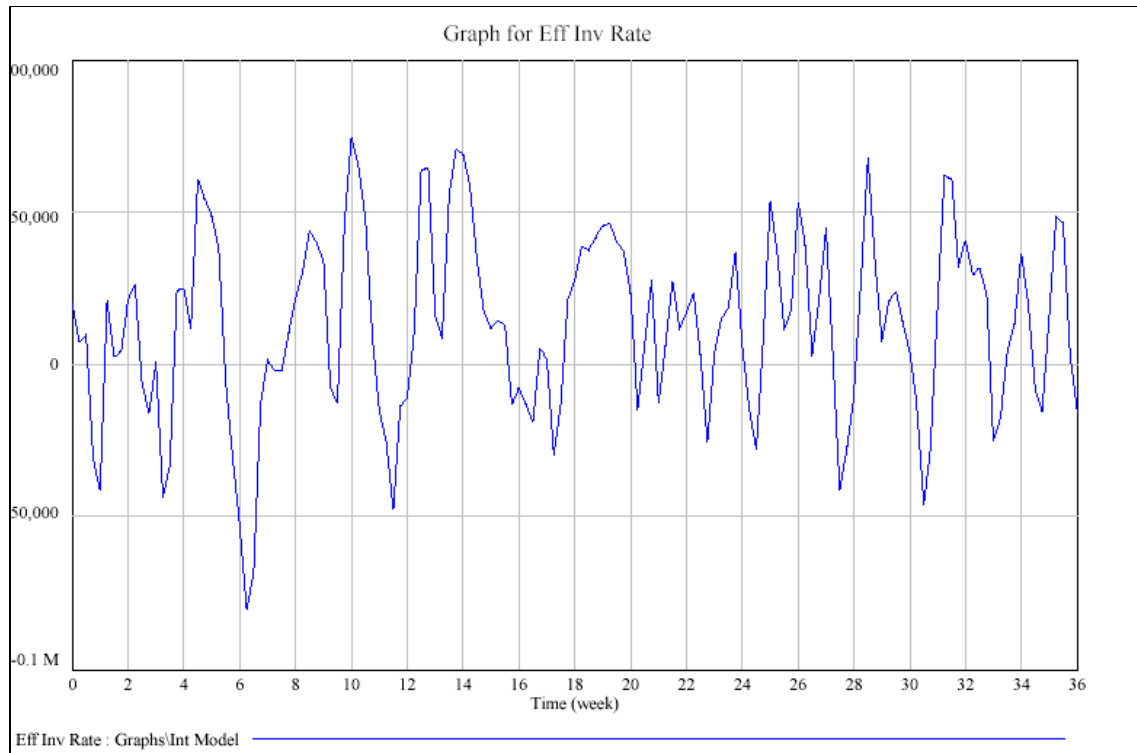
**Figure 35: Mdx Beer Game 2- Effective Inventory Measure**
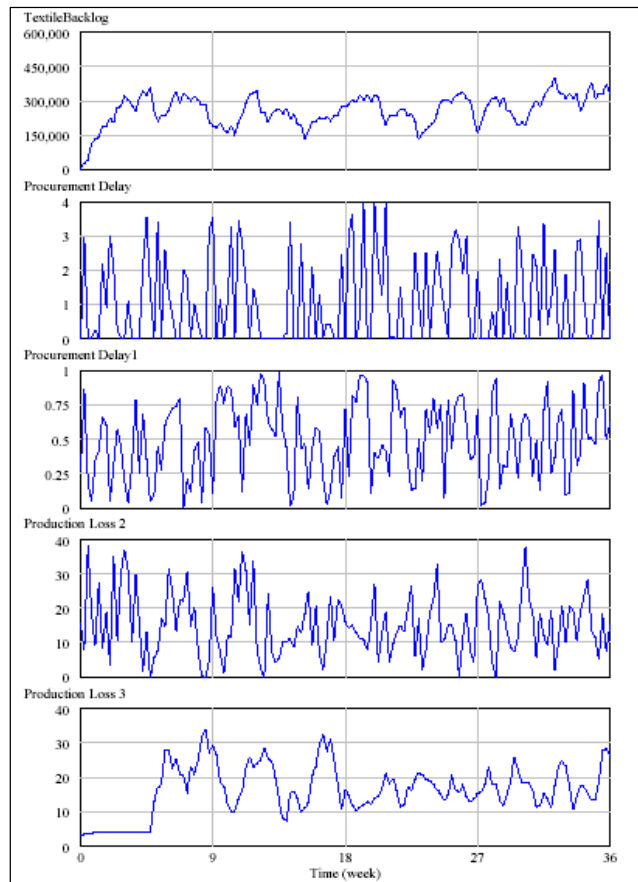

**Figure 36: Supply Chain Behavior in Mdx Beer Game 2**

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Lead time measures indicate a rapidly growth over lead time over both simulation experiments. Rate of lead time change fluctuates over weeks in both experiments due to a procurement delivery oscillation. While distribution time for local product is considered to be fixed to a certain extent, delivery duration for overseas shipments contributes more to the oscillation in the pattern. Order processing consumes more time when the order fulfills international demand rather than for the local market. Production time shows a fluctuating rate for international order processing while it is more stable in local order processing. Therefore, to fulfill international demand requires more outsourced supplies in addition to local supplies. These outsourced supplies can hardly be stored in advance due to the high demand variation. The production time for the first experiment (Mdx Beer Game 1) indicates an obvious increased production rate that between week 6 and 18 and between week 33 and 36. The rate declines to reach zero value in the rest of the experiment is due the suspension of production.

Based on this discussion, procurement delay for overseas supplies contributes to production time oscillation. The delay of local supplies in second Mdx Beer Game also makes a contribution to the pattern while such delay is the only factor affecting production time for locally supplied products in the first Mdx Beer Game. Fluctuating delivery time for overseas and local procurement in addition to oscillating final product delivery time, affects lead time positively in the second experiment (Mdx Beer Game 2) with an amount exceeding the first one. Order processing is considered to be fixed in both experiments. As discussed before, transmission of orders from one partner to the other take place using FIXED DELAY functions.  Figures 37 & 38 illustrate lead time patterns in both experiments (Mdx Beer Game 1and 2) and the causes of each.
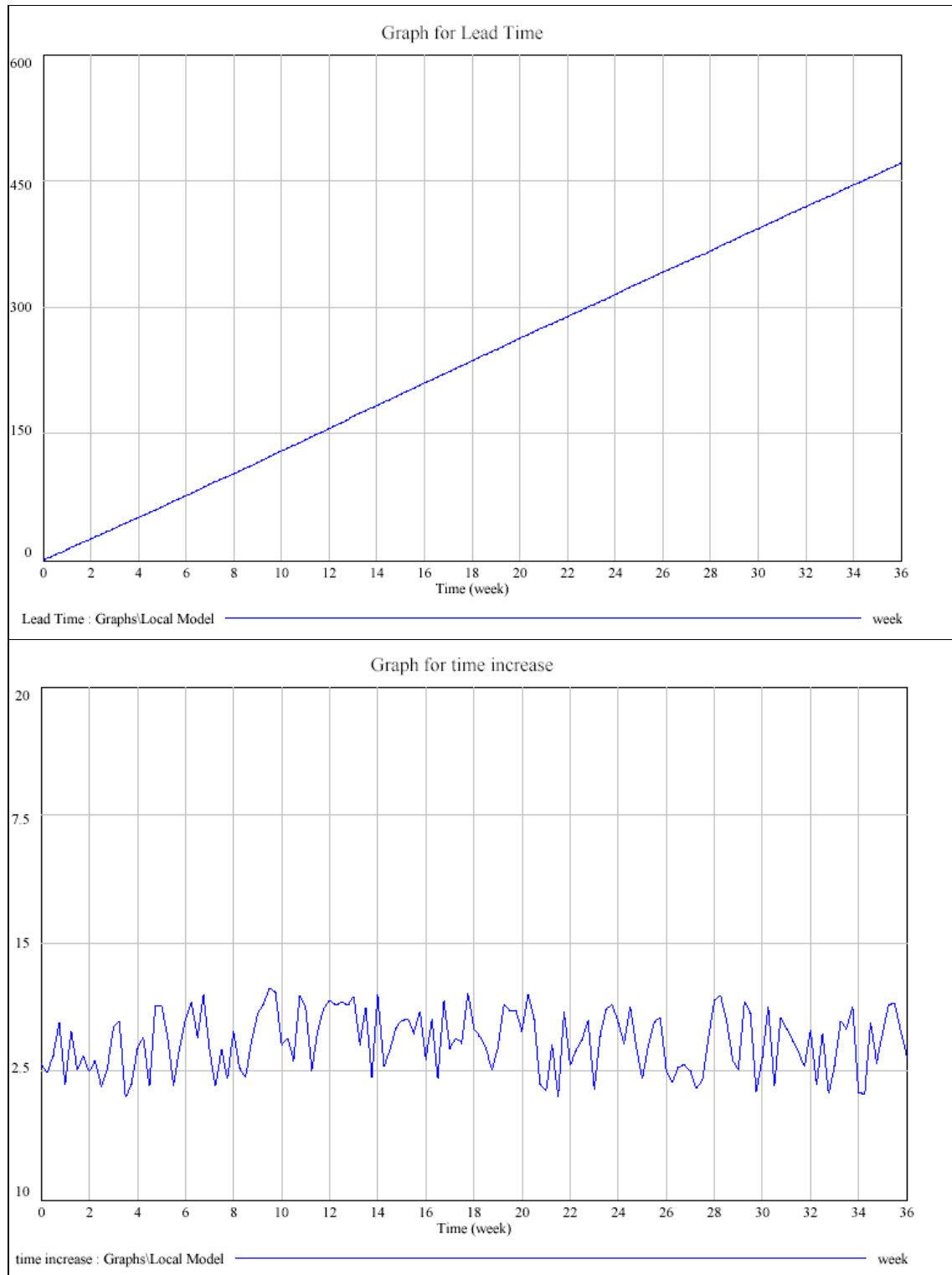
**Figure 37: Mdx Beer Game 1- Lead Time Measure**
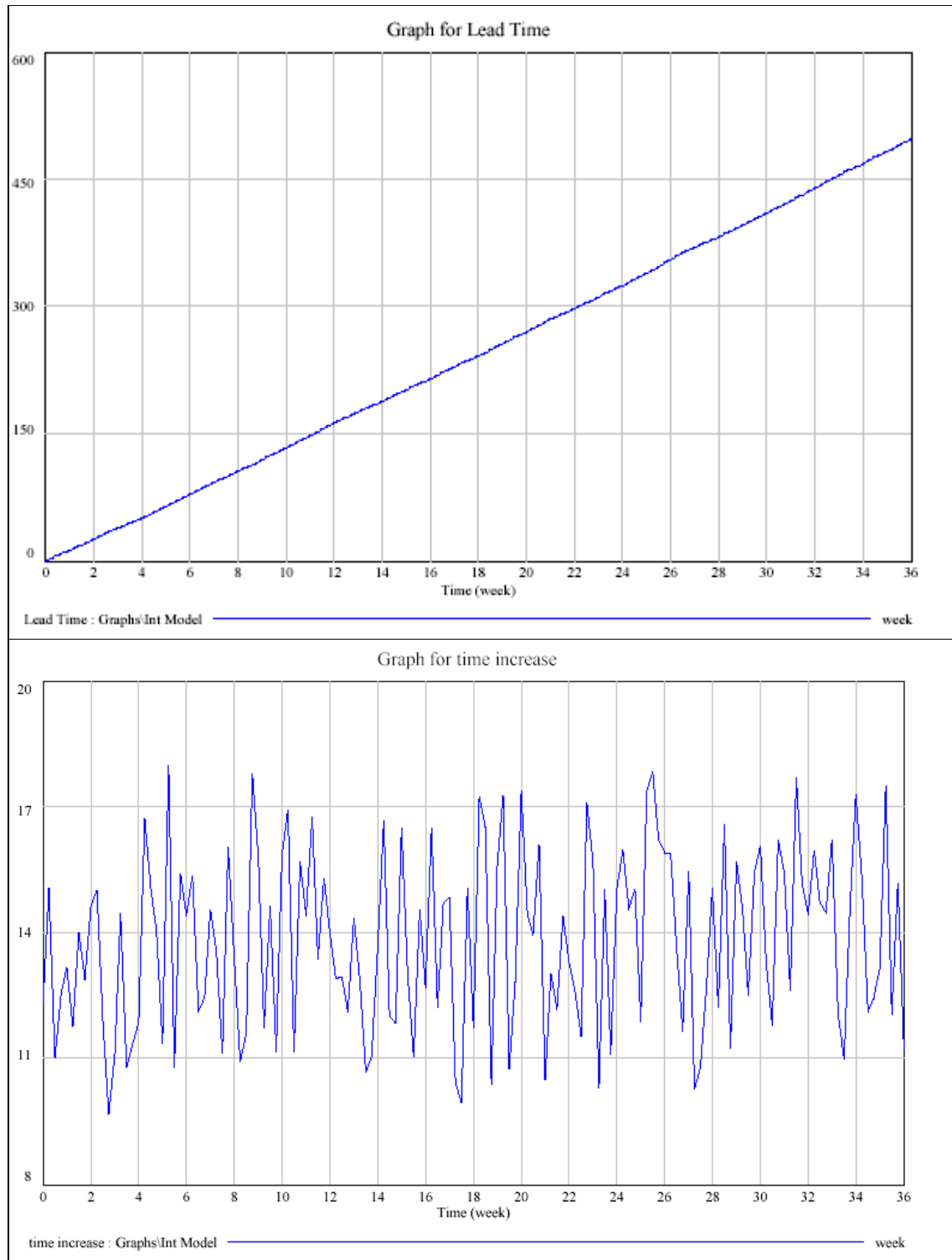
**Figure 38: Mdx Beer Game 2- Lead Time Measure**

**5.5. Proposed Solutions**

Based on the Mdx Beer Games (1-2) conducted, outcomes indicate increased cost and long lead time coupled with discrete backlog to fulfil local and international demands. The total cost of fulfilling a local order is over $3.4 Million while it is about $14 M for an international order.

In order to improve supply chain performance and reduce deficiencies experienced, possible alternatives for supply chain improvement were investigated. These solutions were adopted based on my case studies and a survey of the Egyptian textile industry. Respondents of these studies indicate that the high production costs and the long duration are the major issues facing successful supply chains although they point out that supply chain design is the main issue initialising a deficiency cycle. Several simulation experiments to define the impact of each of the possible alternatives on supply chain performance have been conducted. The research investigates the effect of expanding production capacity as a way of reducing production time and decreasing backlog over the chain. Reduced material loss is also investigated to see its impact on total cost. Procurement issues are of high importance to textile firms. While diversity of procurement and prices are considered uncontrollable and affected by external market factors rather than organisational performance, reduction of procurement delivery delay is tested to indicate whether it affects existing chain performance or not. Inventory reduction is examined to explore its influence on order fulfilment and cost reduction within current delivery circumstances. Improvement of supply chain performance is measured based on lead time diminution, effective inventory availability and cost reduction. The following section includes a description of each situation.

**5.5.1. Production capacity expansion**

The estimated production capacity of a textile factory is 6000 towel unit/week. To examine its effect on supply chain performance, production capacity is incremented with 1000 unit for production extension. Hence, a textile factory can produce 7000 towel units per week to fulfil local and international orders, and the material loss rate during textile fabrication is reduced to half. This scenario was simulated in **Mdx Beer Games 3 and 4**. These expansions require more investment in machinery and labour in addition to labour training. The estimated cost of the proposed expansion is about $250,000, which is included in the total cost measure. This cost represents the investment in new production machinery and

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additional labour force. The figure was estimated and derived from the investigated case study. Figures 39-41 represents the outcome of Mdx Beer Game 3 and figures 42-44 represents the outcome of Mdx Beer Game 4. A reduction in lead time by 0.08 week for local orders and 0.22 week for international orders is achieved by end of experiment. This reduction is referred to the shortening of the production time with limits not exceeding 44 minute for local orders and reaching 0.005 of week for international orders. The production capacity expansion does not indicate reduced cost rate due to the investment needed in Mdx Beer Games 3 and 4. Cost figures reach $12.45 M for local orders and over $23 M for international order due to such expansion. In case of excluding the cost of machinery expansion from cost equation, the cost will indicate little increase with $130,000. Consequently, by including machinery cost which is $250,000, the total cost will be $380,000. Effective inventory indicator indicates a little increase with 0.007 M towel unit after production expansion for local orders and shows an increased rate of 302,348 towel units for international orders. While this increase does not cover the incoming order, it is not considered as value added rather than holding cost.

Based on such discussion of the outcomes of Mdx Beer Games 3 and 4, the extended capacity and reduced material loss could hardly justify its investment amount. In case decision makers consider extending their production capacity, limited order-to delivery time reduction is the main benefit they can get. Whilst introducing more machinery and labour necessary for that extension, investment cost of machinery and labour overtime has to be considered. It is a matter of cost/benefit analysis to compare the expected profit from increased sales opportunities with the investment in more machinery and labour. This expansion is feasible for decision makers in the case of higher international market demand. The proposed expansion can avoid further backlog and enable the firm to capture more profit when demand increases even higher. The problem, however, is that local management waits for high backlogs before considering capacity extension. While a firms capacity controls sales, actual customer demands can hardly be a good indicator used by a firm to extend its capacity. Capturing the opportunities for expected sales should be the aim of managers in order to consider the scenario of expanding the production capacity.
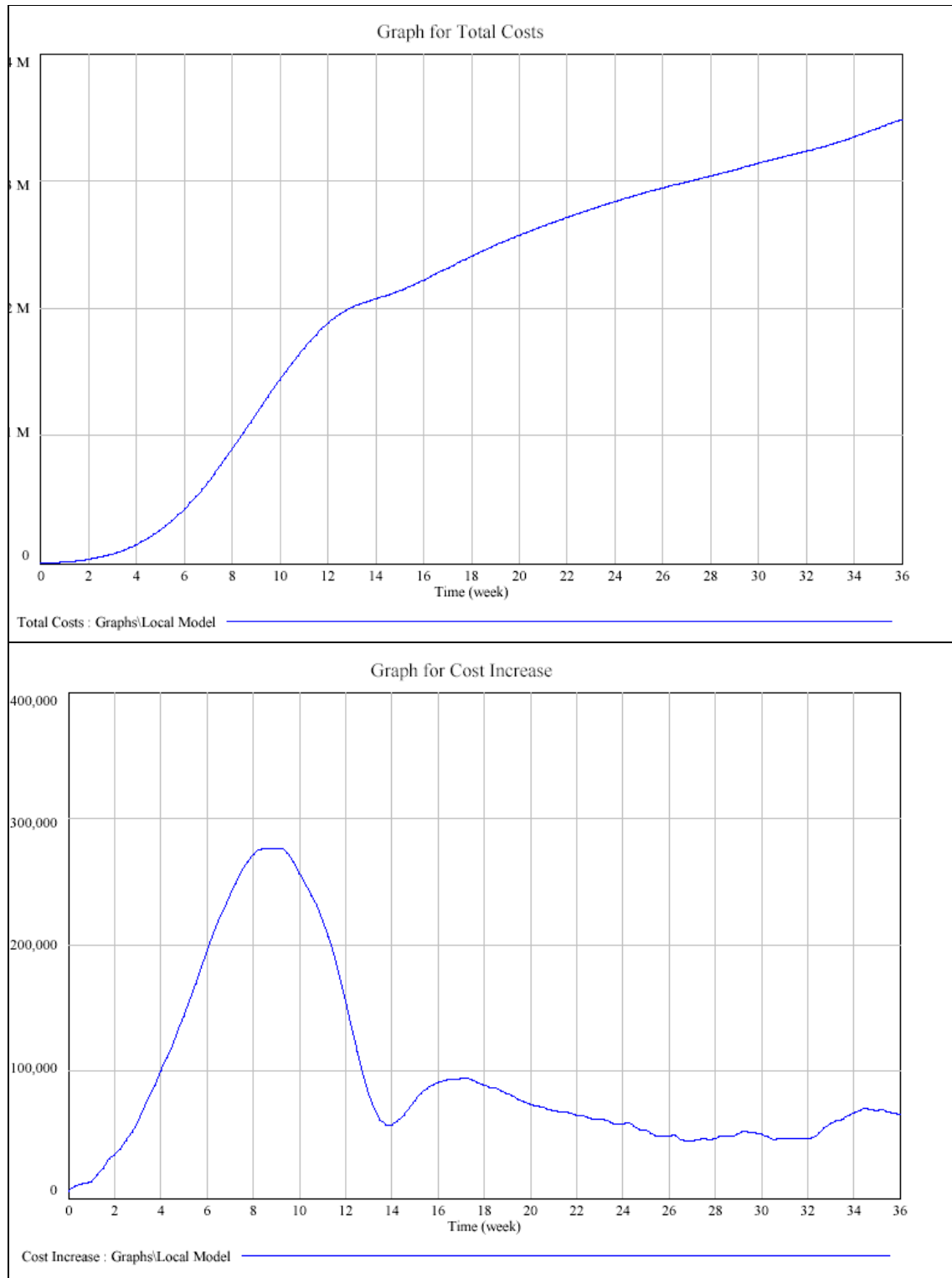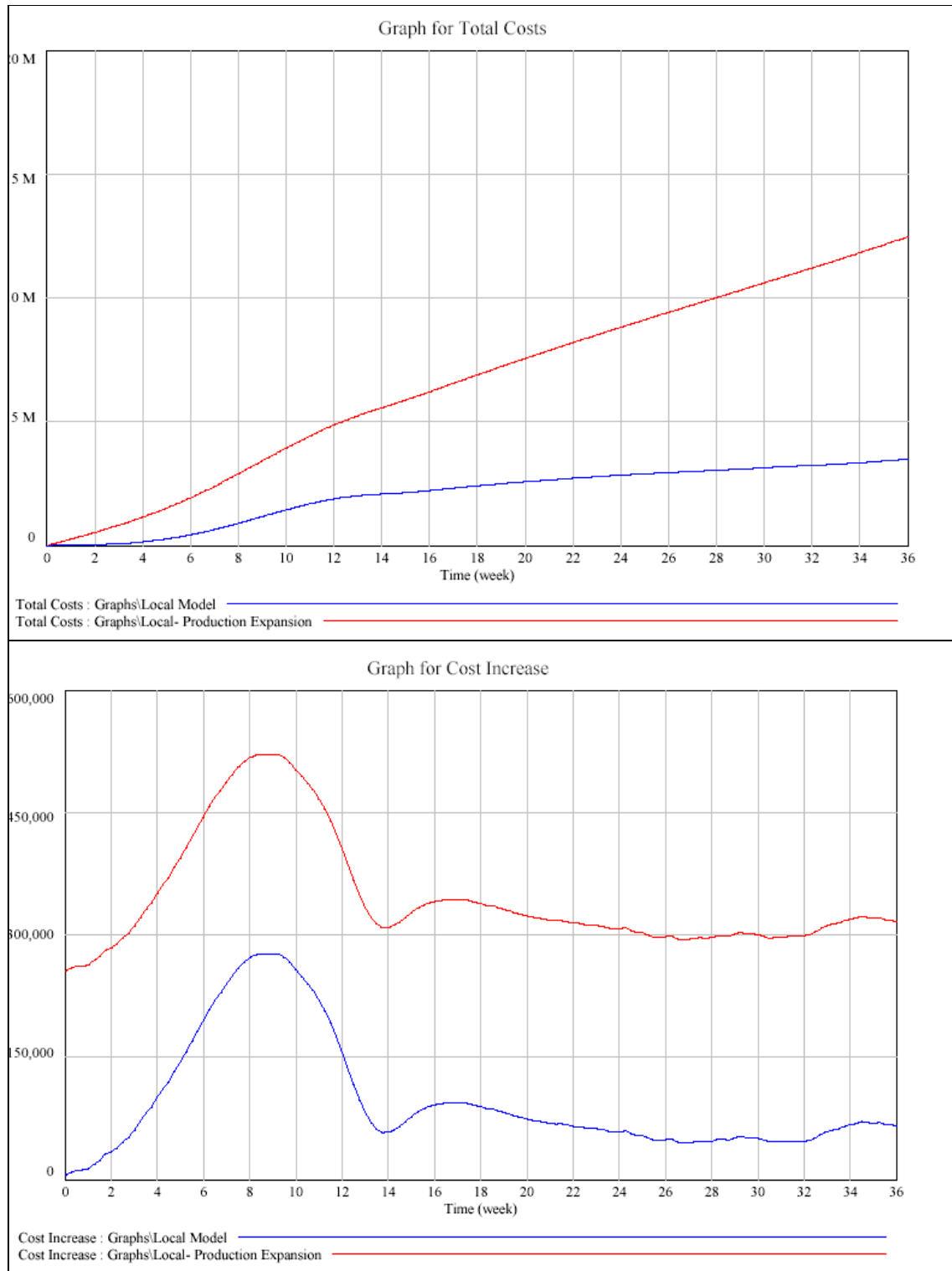
**Figure 39: Mdx Beer Game 3- Cost Measure**
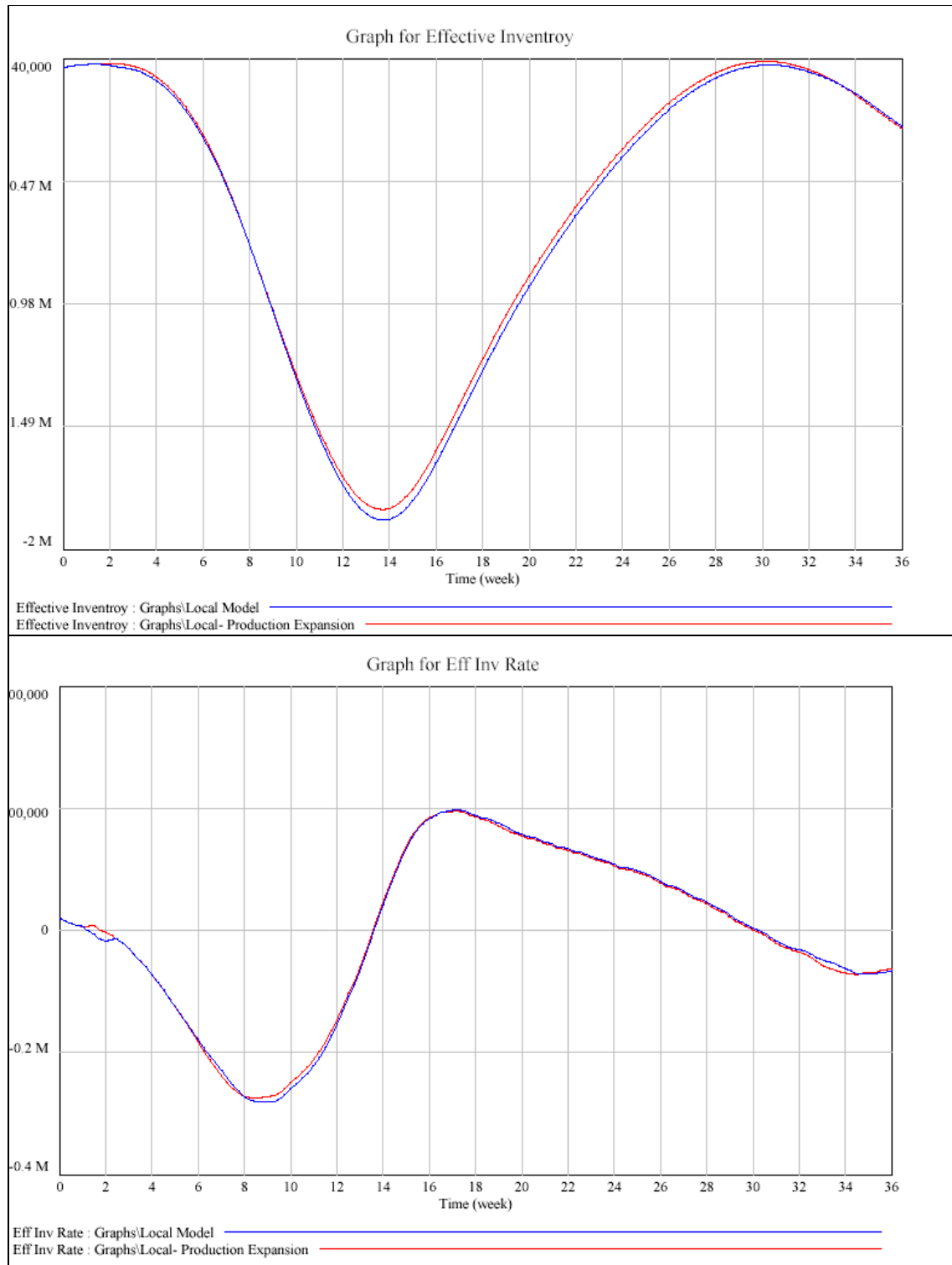
**Figure 40: Mdx Beer Game 3- Effective Inventory Measure**
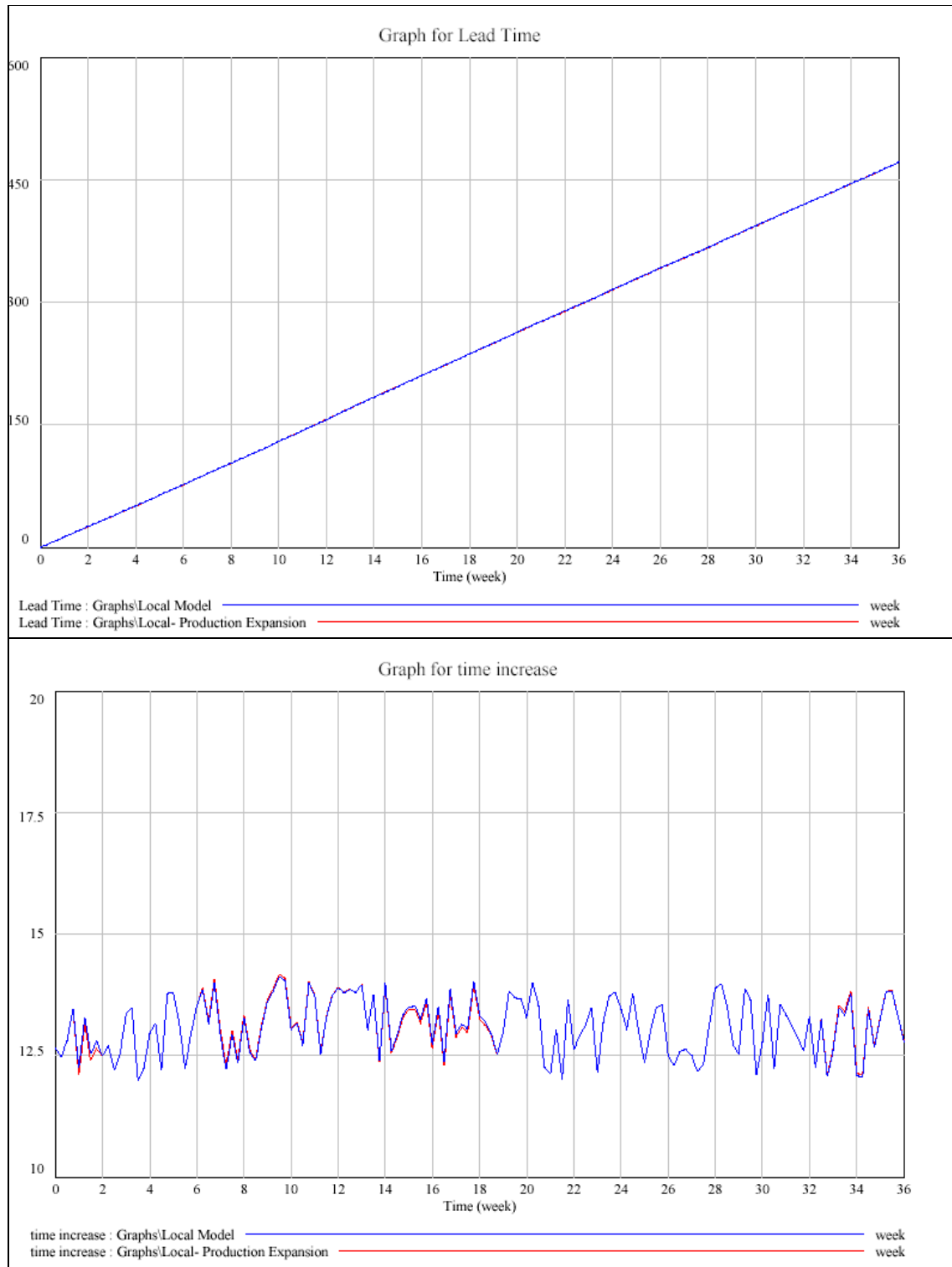
**Figure 41: Mdx Beer Game 3- Lead Time Measure**
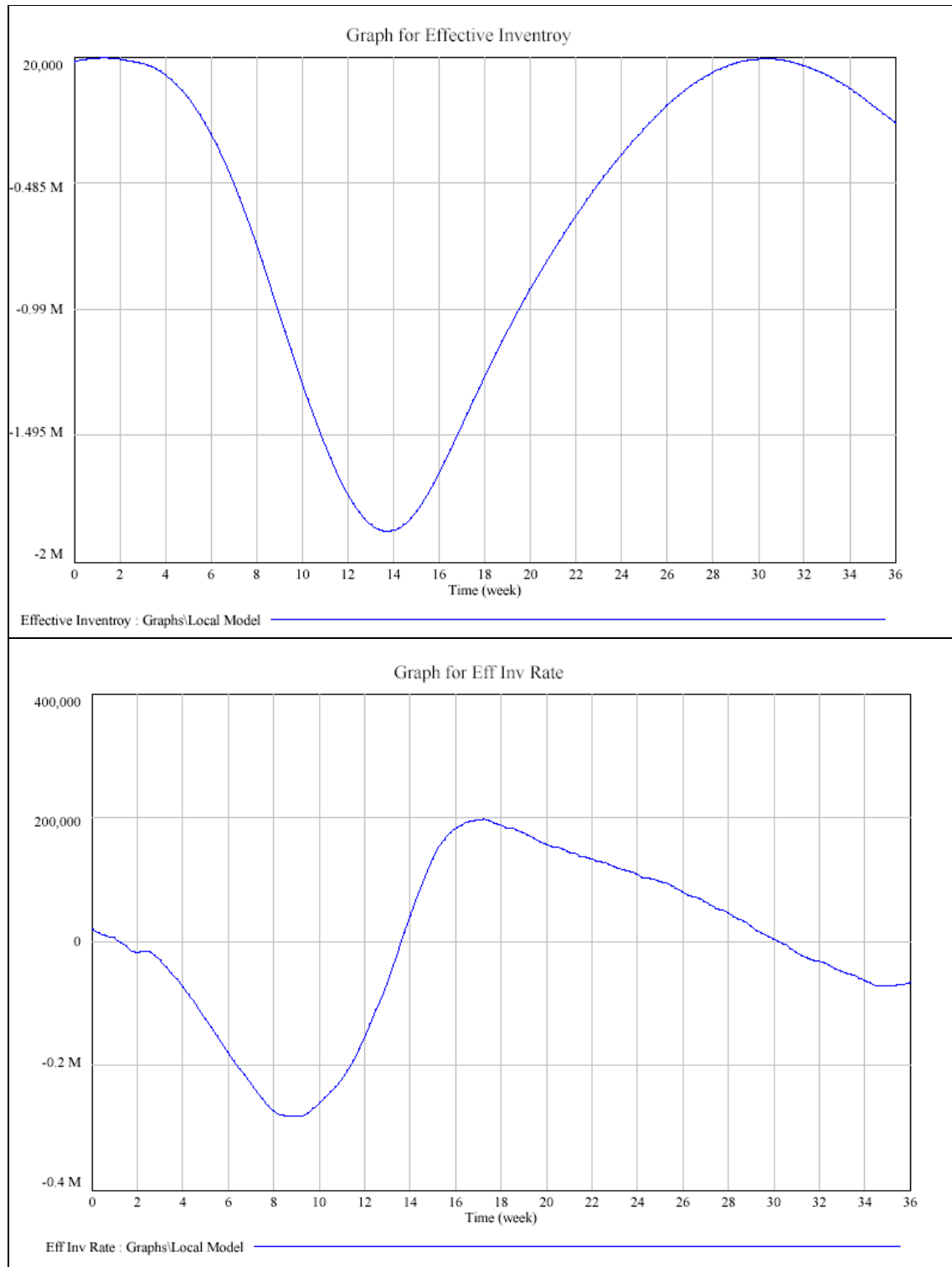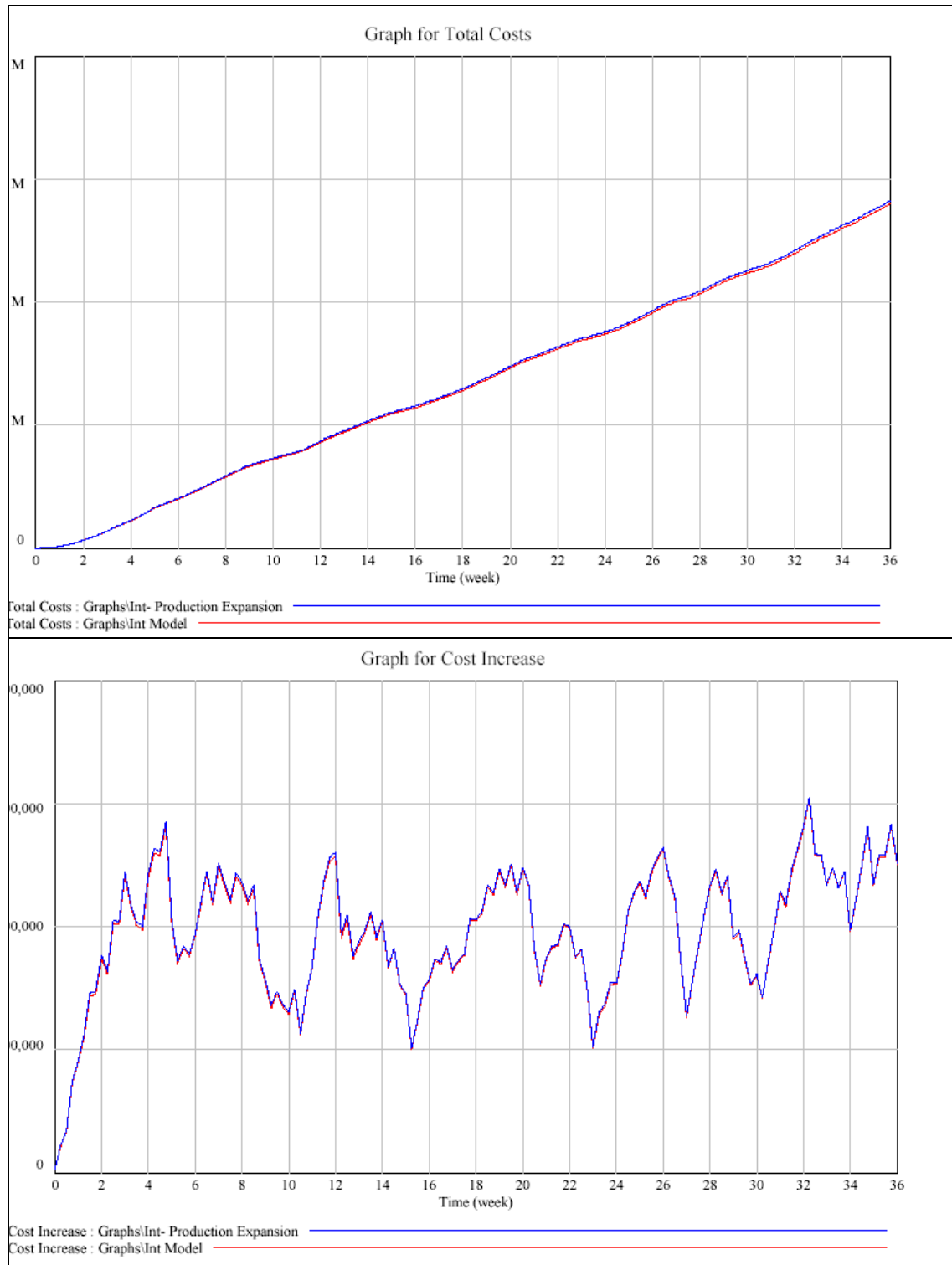
**Figure 42: Mdx Beer Game 4- Cost Measure**
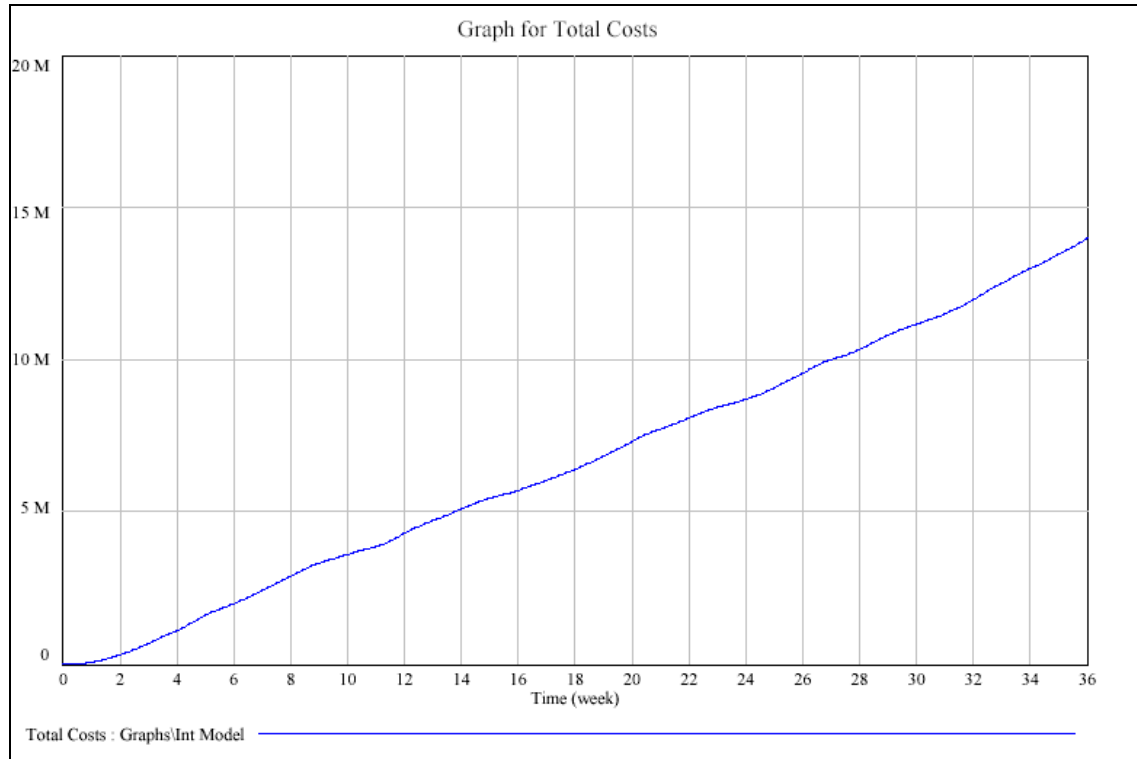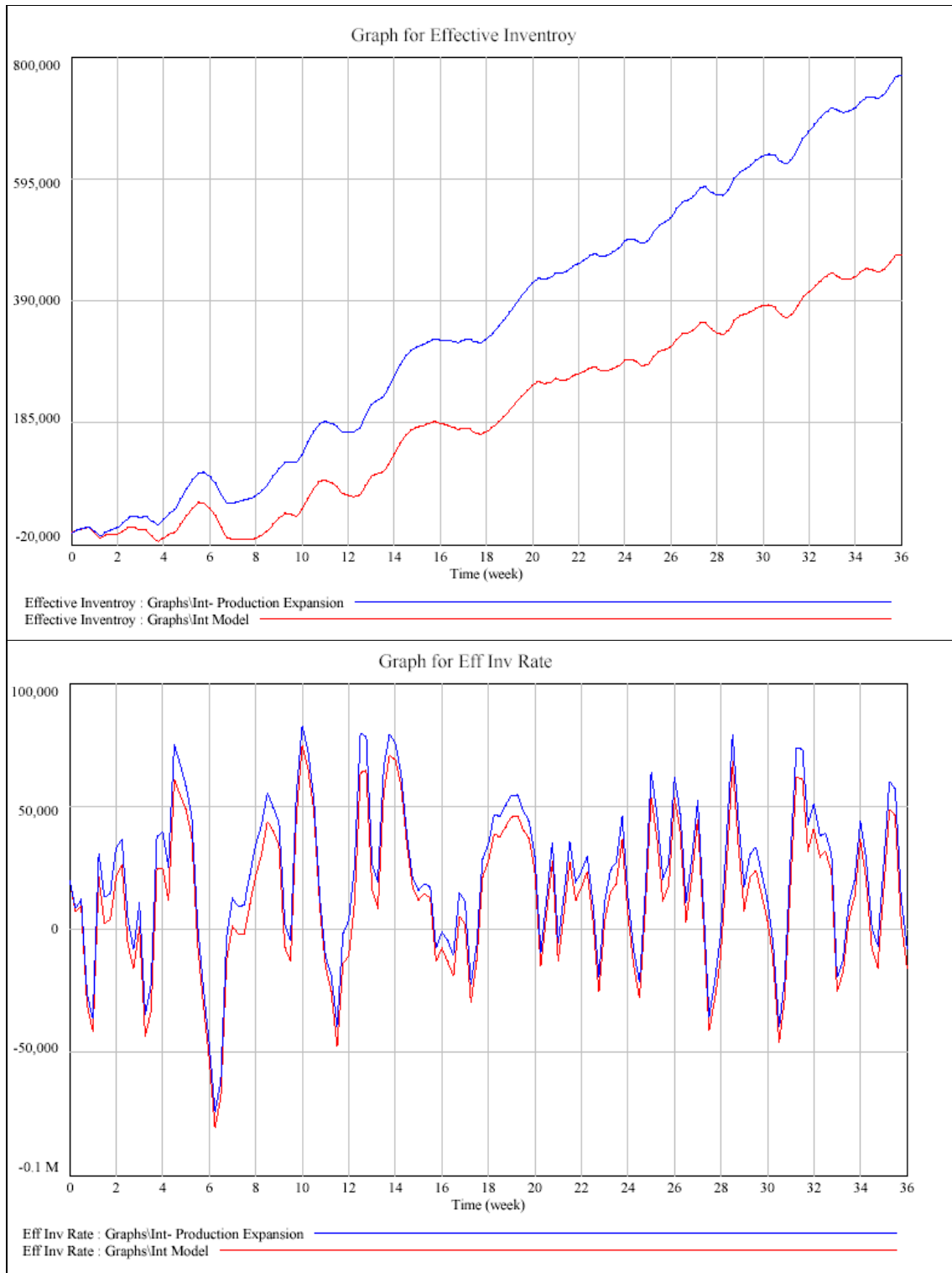
**Figure 43: Mdx Beer Game 4- Effective Inventory Measure**
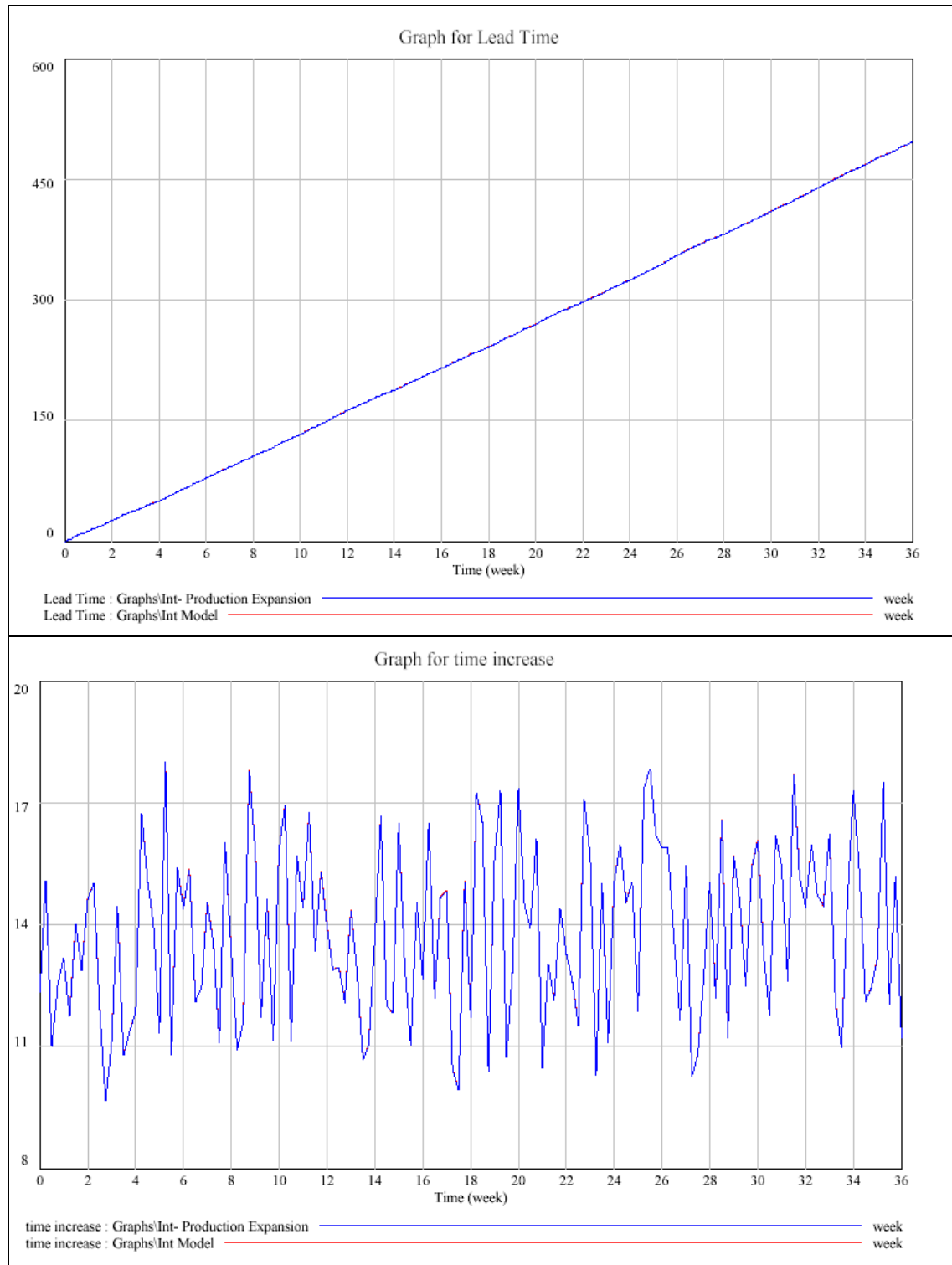
**Figure 44: Mdx Beer Game 4- Lead Time Measure**

Expanding production capabilities cannot provide improvement for existing supply chain deficiencies. Despite the fact that decision makers used to keep a large inventory buffer, which affects cost negatively, they can hardly decide to reduce the entire buffer and rely on

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automatic inventory replenishment. Inventory buffer represents an essential element of a firm's assets where its huge amount is used as an indicator for the financial status. The next experiment will test the situation where inventory buffer is reduced.

## 5.5.2. Inventory Reduction

Inventory buffers in the simulation experiment have been reduced to half the amount for both raw material and finished products inventories at the textile producer. Initial values used in the **DELAY FIXED** function have been modified to indicate the size of new inventories **Mdx Beer Games 5 and 6**. As a result for both experiments, figures 45 and 46 represent the supply chain performance according to the conducted Mdx Beer Game 5 and figures 47 and 48 represent the supply chain performance according to the conducted Mdx Beer Game 6. Inventory reduction has little positive effect on cost measure with $0.12 M in the situation of fulfilling local orders due to an inventory reduction with 0.0535 M towel unit, Therefore; an increased rate of backlog had shown a rise in stock-out costs. For international orders, it shows a small cost saving reaching $0.03 M. This cost saving is referred to effective inventory reduction with more than 3,000 towel units. On the other hand, effective inventory indicators show that inventory reduction contributes to more backlog to fulfill the demands of local customers.



Graph for Total Costs

Total Costs : Graphs\Local Model
Total Costs : Graphs\Local- Production Expansion
Total Costs : Graphs\Local- Inventory Reduction

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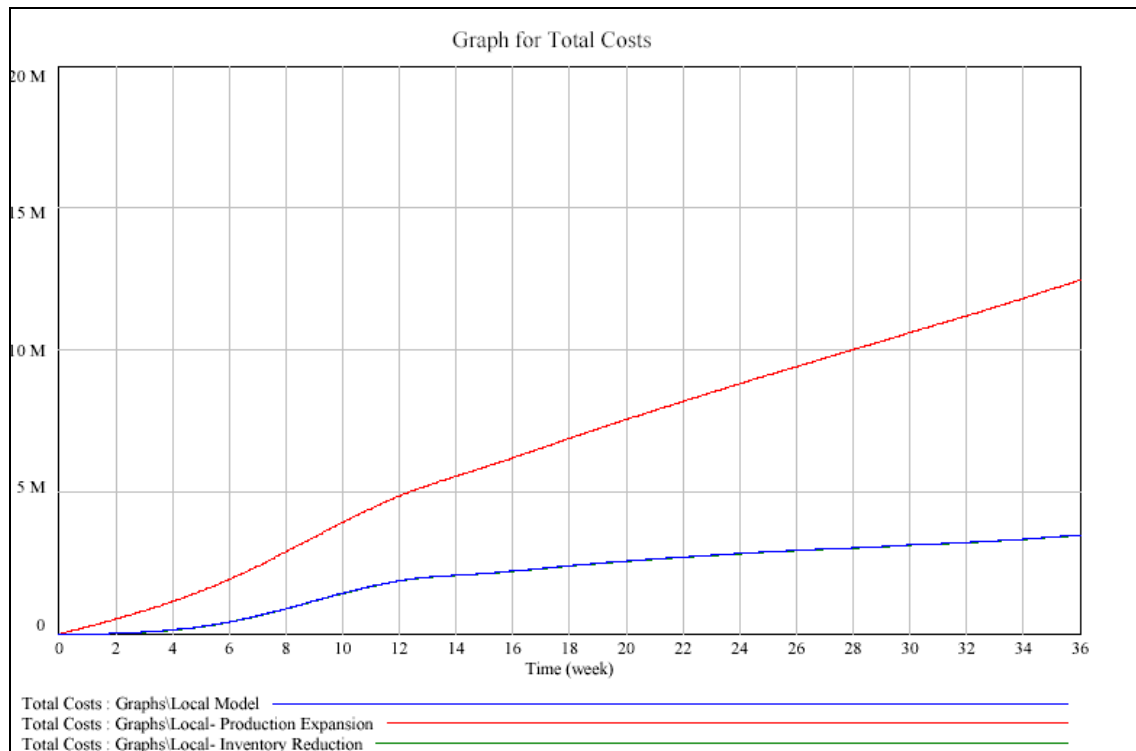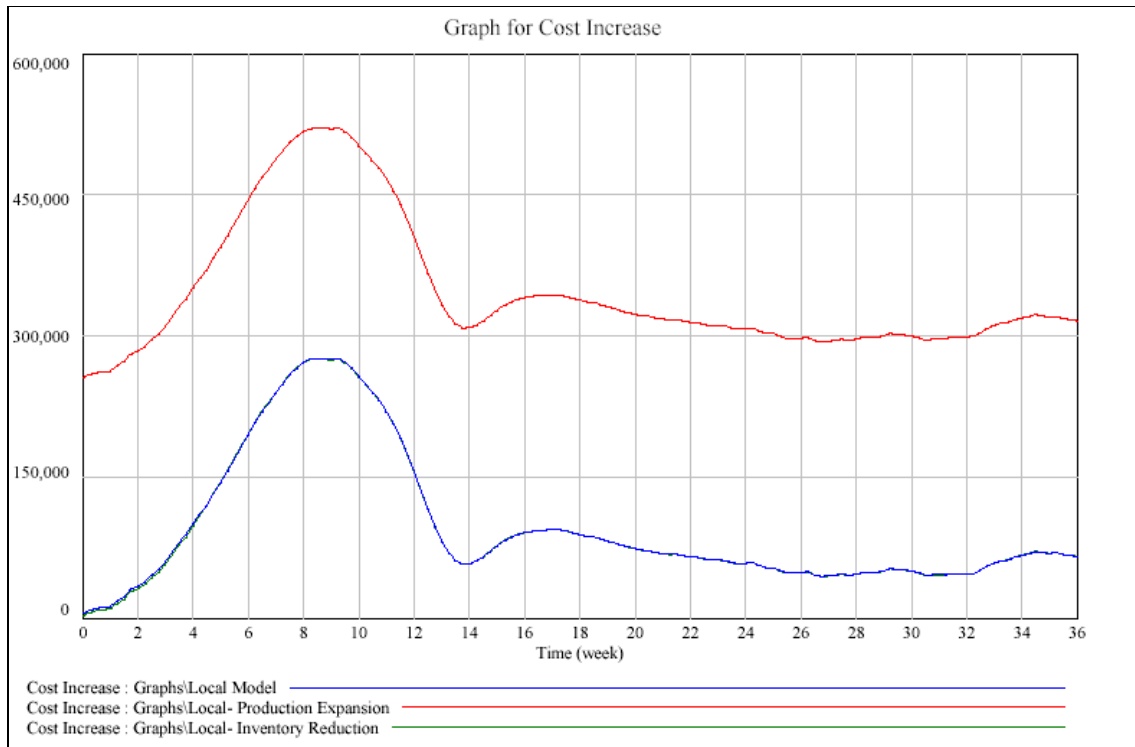
**Figure 45: Mdx Beer Game 5- Cost Measure**



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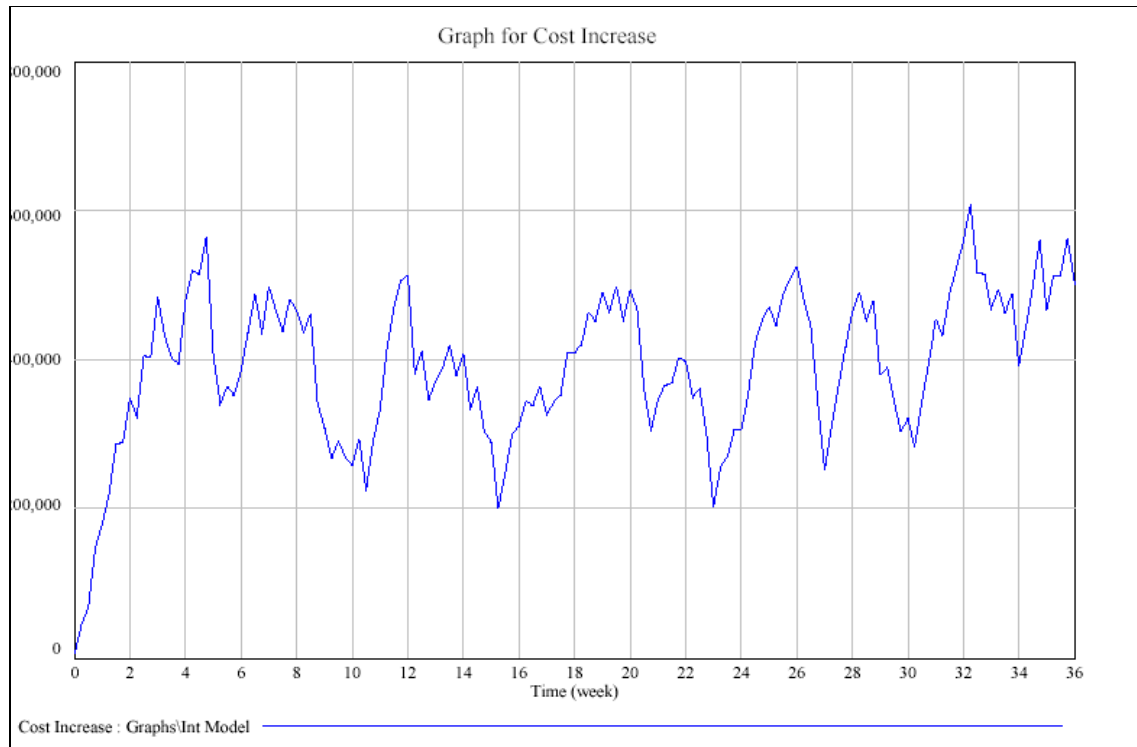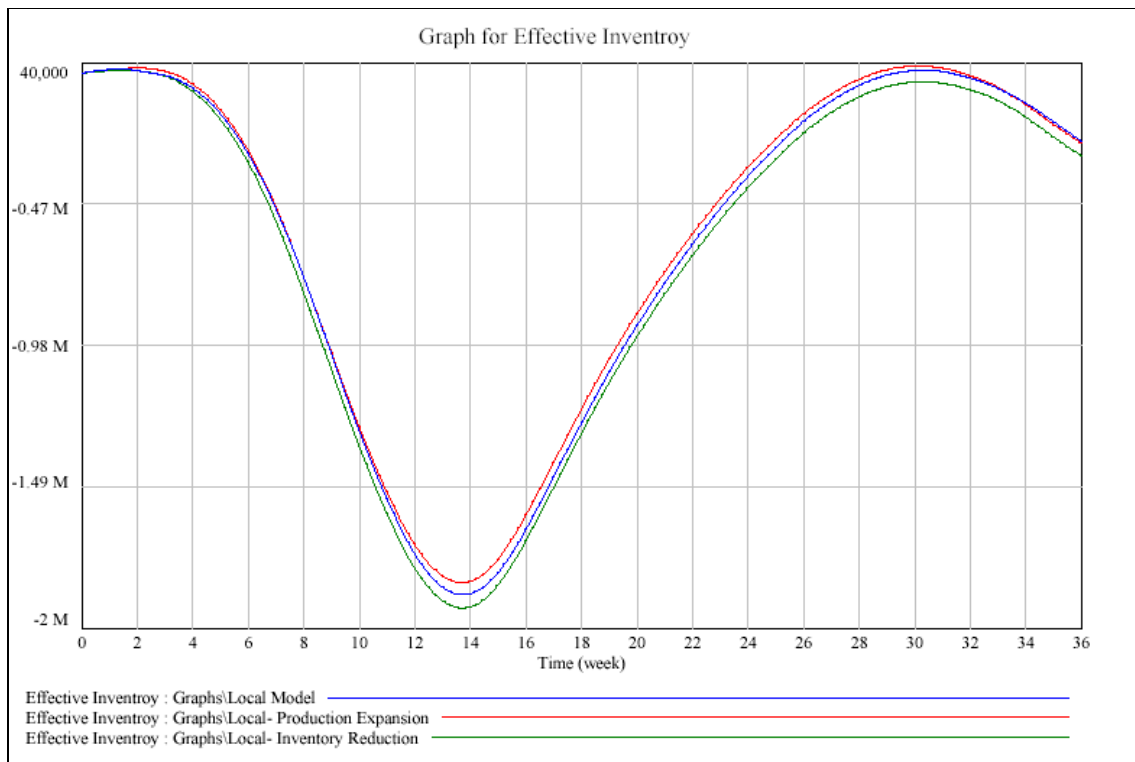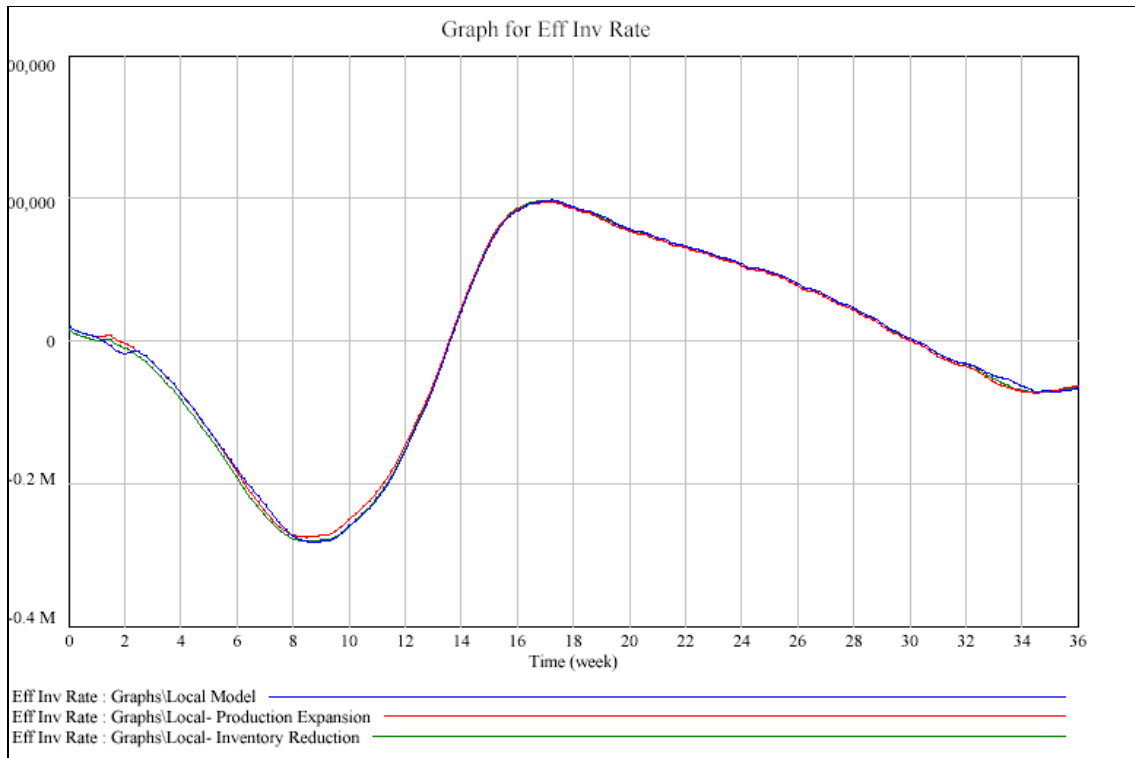**Figure 46: Mdx Beer Game 5- Effective Inventory Measure**



174
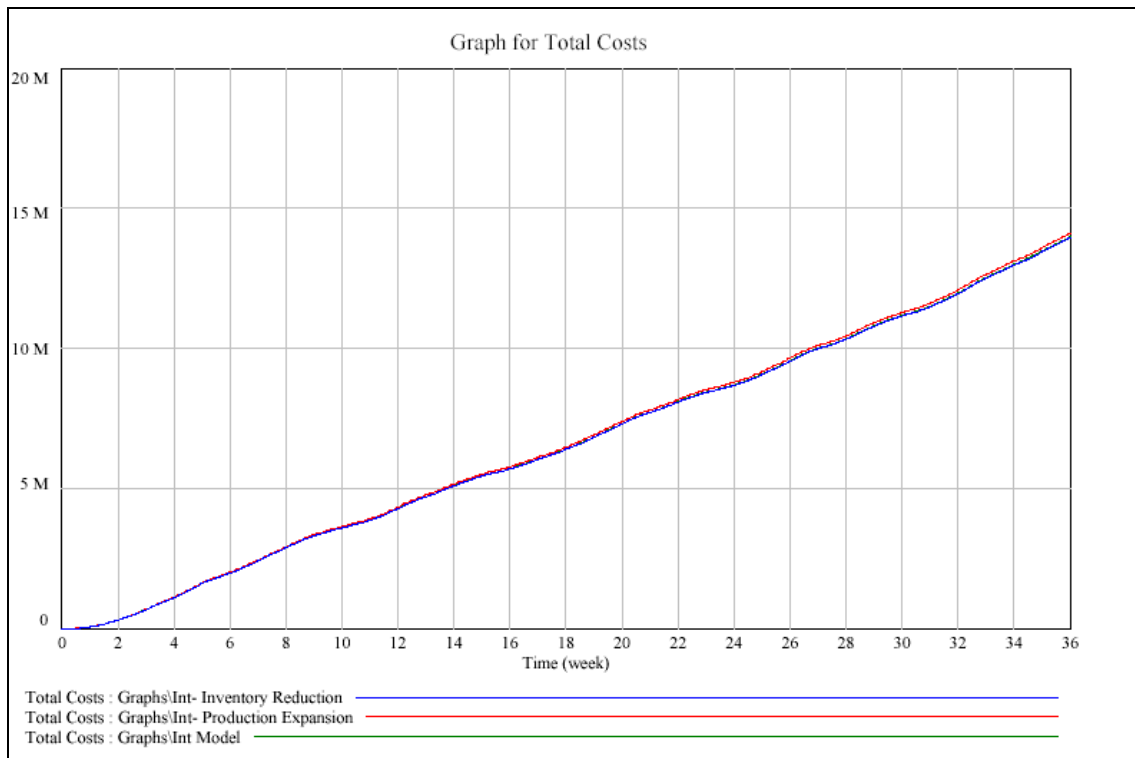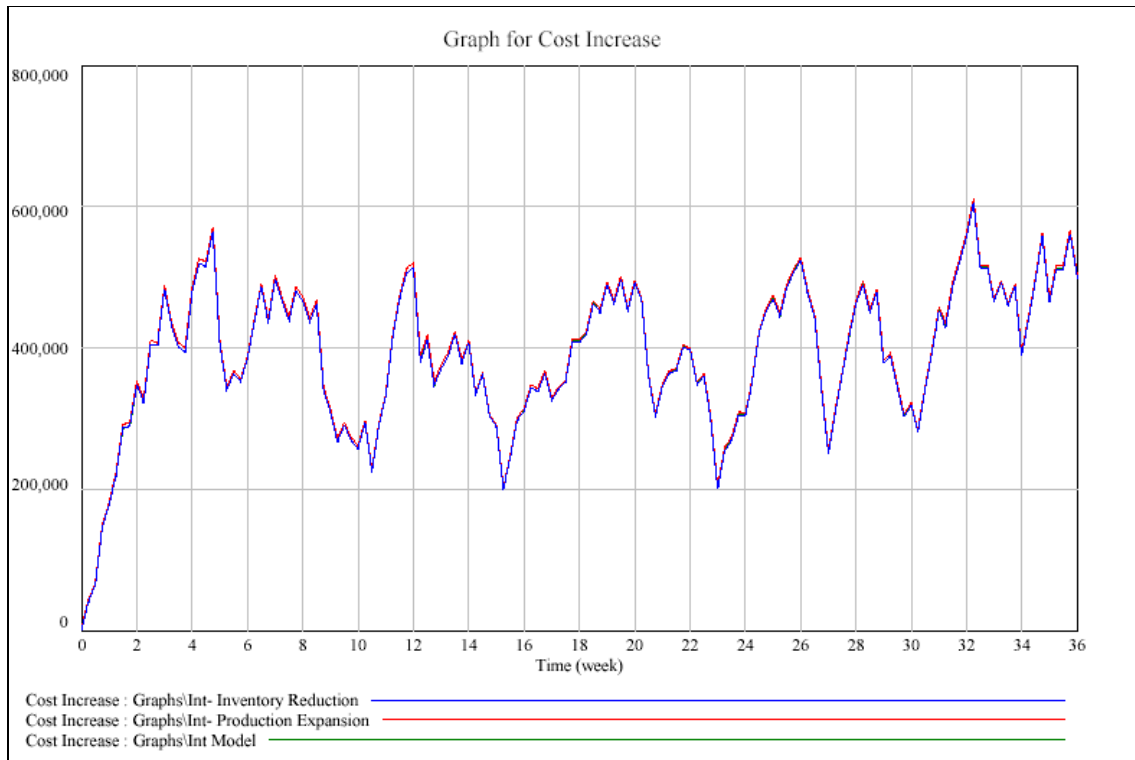
**Figure 47: Mdx Beer Game 6- Cost Measure**
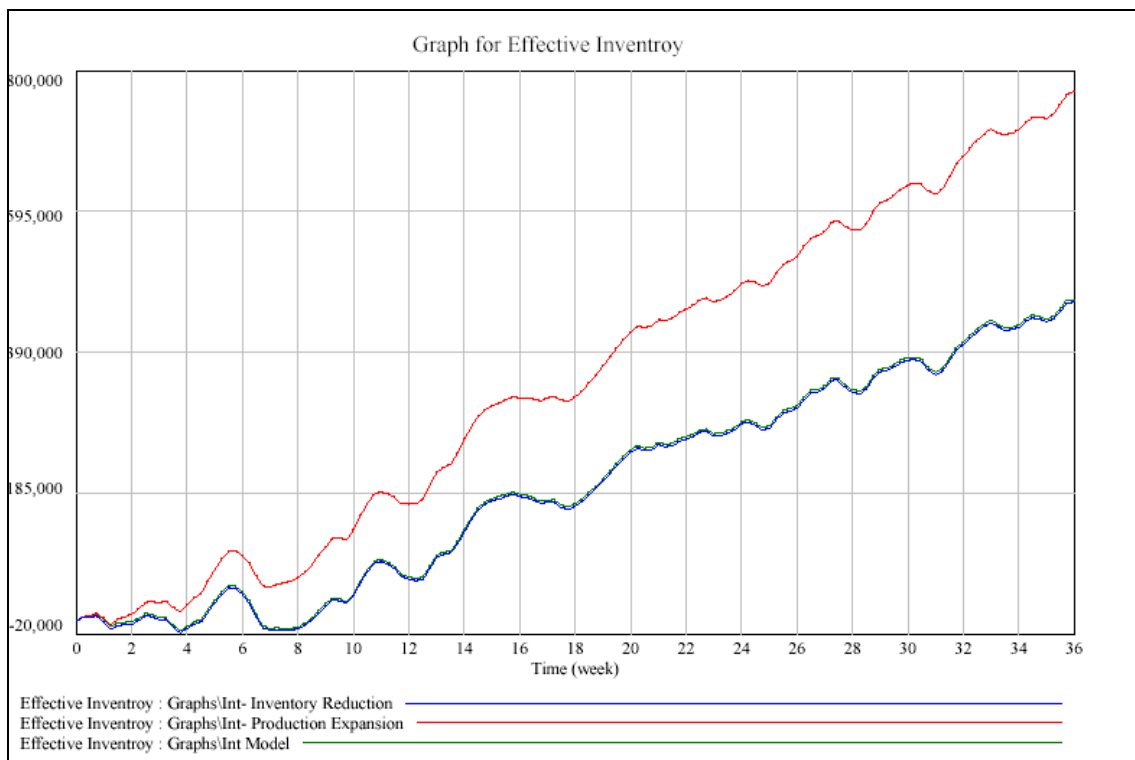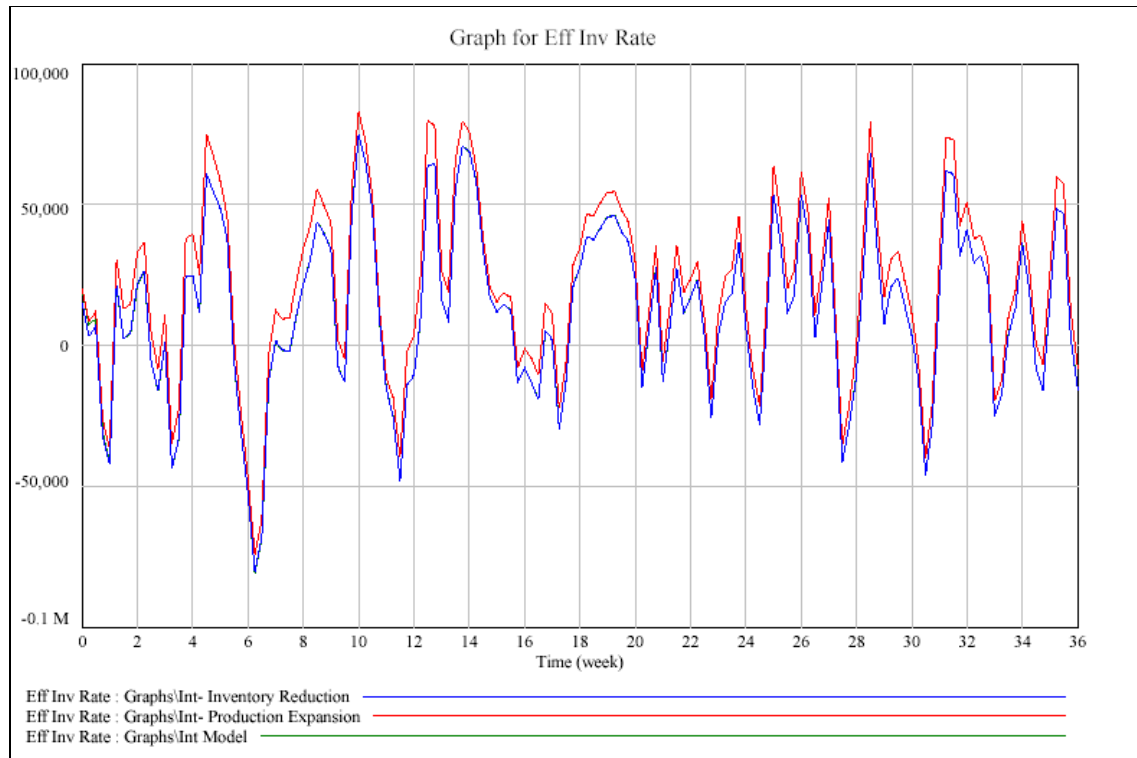
**Figure 48: Mdx Beer Game 6- Effective Inventory Measure**

Lead time indicators, illustrated in figures 49 & 50, have indicated little saving in Mdx Beer Games 5 and 6. It is estimated at a reduction of 0.01 of a week for local markets and 0.04 of a week for international markets due to inventory reduction. While inventory amount has no direct impact on lead time, no further lead time reduction is expected to result from such inventory reduction.
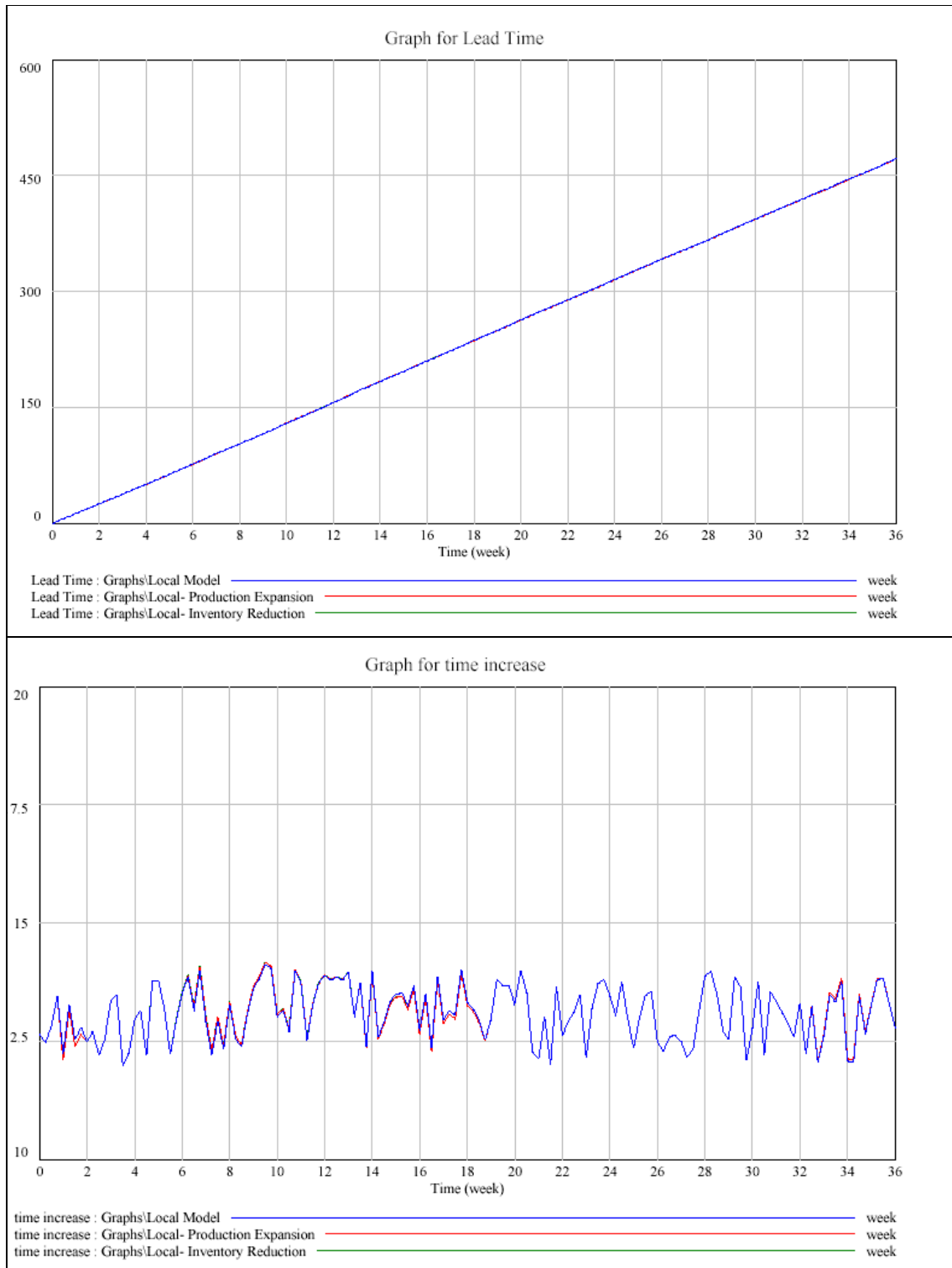
**Figure 49: Mdx Beer Game 5- Lead Time Measure**

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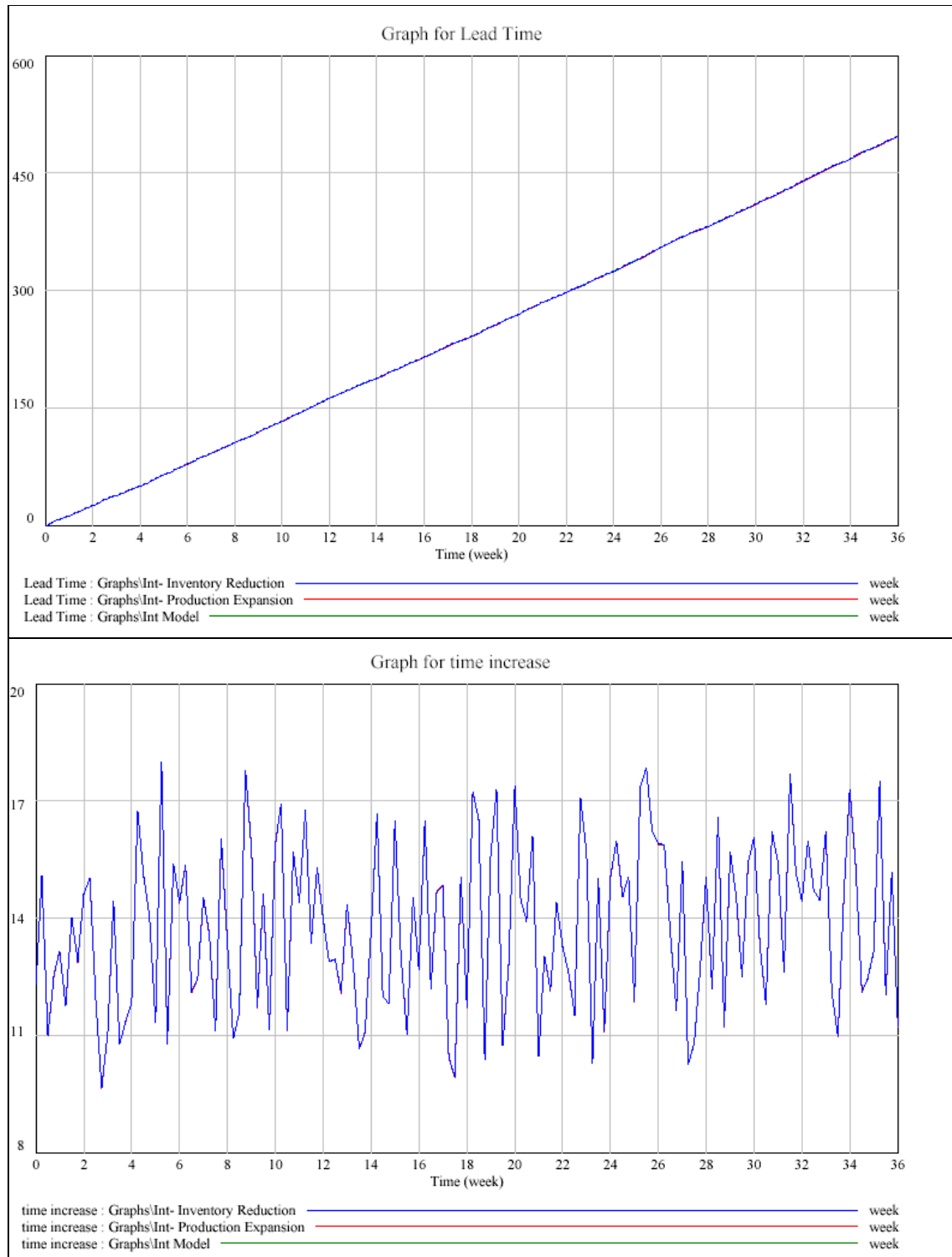
**Figure 50: Mdx Beer Game 6- Lead Time Measure**

Based on the proposed solution of inventory reduction in section [5.5.2], the perceived benefit of cost saving is limited. This reduction is beneficial while market demand is low then it turns to stock-out if the demand is higher.  Effective inventory has indicated a good

level may reach 200,000 towel units while the demand is low. When the demand becomes greater, inventory shortage is obvious. The reason behind that is that the production process can hardly cope or fulfill the rapidly incoming orders due to production constraints, adjustment delays and material delivery delays.

While inventory reduction is not considered as a value added strategy regarding existing unstable delivery terms and production capability, the next experiment will focus on delivery time to examine the impact of its reduction.

### 5.5.3. Procurement Time Reduction

In many industries, long delivery delays affect sales negatively while the management gain understandably of the situation (Forrester, 1991). Decision makers adopt a price reduction strategy to stimulate more sales. In **Mdx Beer Games 7 and 8**, different solutions were examined as alternative strategies for delivery reduction. This assumption eliminates the oscillation in procurement delivery which is caused by the uniform random distribution.

To satisfy local demand, procurement time is reduced for locally supplied materials. Two test values of reduction were used. A reduction to one week delivery, which represents 50% of the estimated procurement time, was tested. Another reduction to 0.5 week, which represents 25% of the estimated procurement' time, was tested as well. Different values were used to evaluate the impact of supply delivery reduction on the overall performance of the supply chain and how much it extends. Both values have not shown obvious performance improvement regarding cost or effective inventory indicators in Mdx Beer Games 7 and 8; Figures 51-53 indicate supply chain performance in Mdx Beer Game 7 and figures 54-56 indicate supply chain performance in Mdx Beer Game 8. Assuming a one week period for supply delivery contributes less to cost increment compared with 0.5 week as a test value. Despite that rapid delivery has positively reduced the amount of raw inventory at both sites leading to an increased flow of finished products into the inventories. Therefore, the holding cost of finished inventories has contributed to the total cost and did not show any reduction. The lead time indicator which is illustrated in figure 53, indicates that one week value saves 37 weeks of total time needed to fulfil the incoming order over experiment time while the test value of 0.5 week has indicated a saving which reaches 73 weeks of the same total time. Reduction is applied to delivery time of outsourced supplies fulfilling international orders. These outsourced supplies are

critical to the production process and it may take up to 1-8 week(s) to reach the manufacturing site. An estimated value of 4 weeks is set to determine its impact of on the product lead time and production processes. Delivery time reduction in this case is more beneficial to the textile producer. Cost reduction by $0.2 M which is combined with an effective inventory increment of 0.23 M towel unit is obtained due to decrease in delivery time. In addition, a lead time saving is estimated to reach 17 weeks by the end of experiment which is illustrated in figure 56. Effective inventory rate shows an increment with 13 towel units due to such time reduction.

To conclude, my pattern analysis points out that time reduction for outsourced supplies substantially affects the supply chain cost and product lead time. To improve the supply chain performance, there is a need to eliminate the oscillatory pattern of outsourced material delivery. Improved rate of order-to-delivery time and cost production can be achieved due to such reduction.



Graph for Total Costs

Total Costs : Graphs\Local Model
Total Costs : Graphs\Local- Procurement time Reduction (1 week)
Total Costs : Graphs\Local- Procurement time Reduction (0.5 week)
Total Costs : Graphs\Local- Production Expansion
Total Costs : Graphs\Local- Inventory Reduction
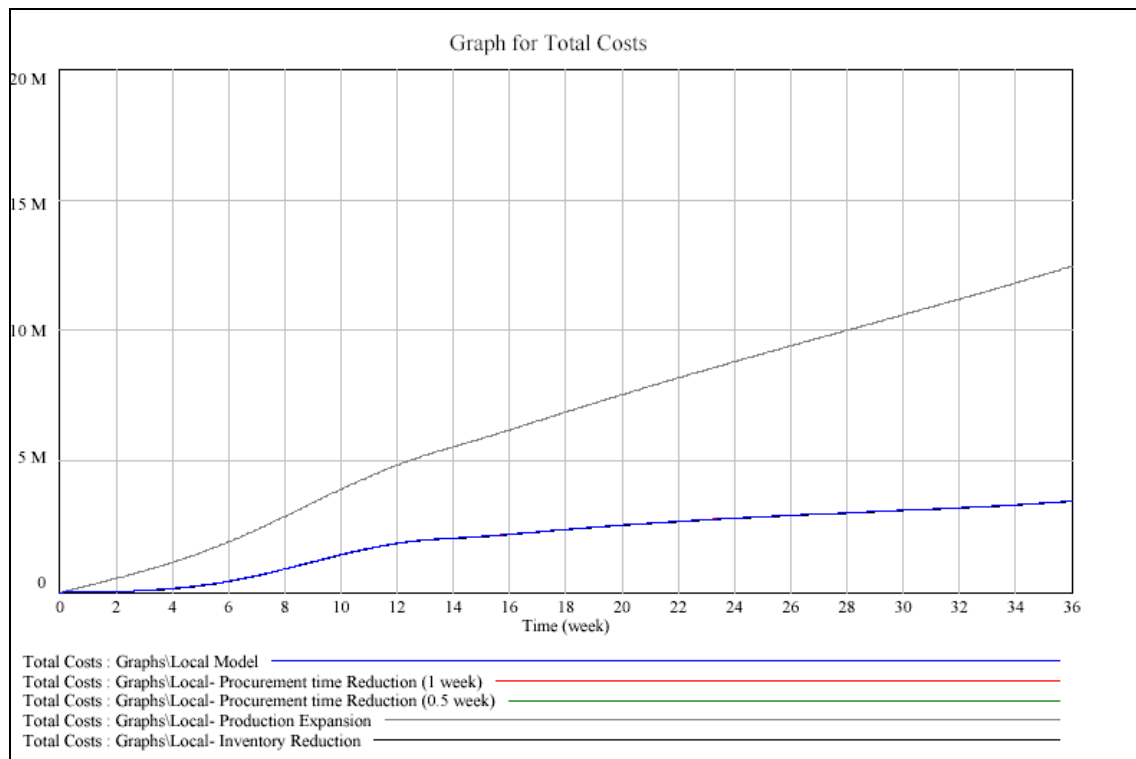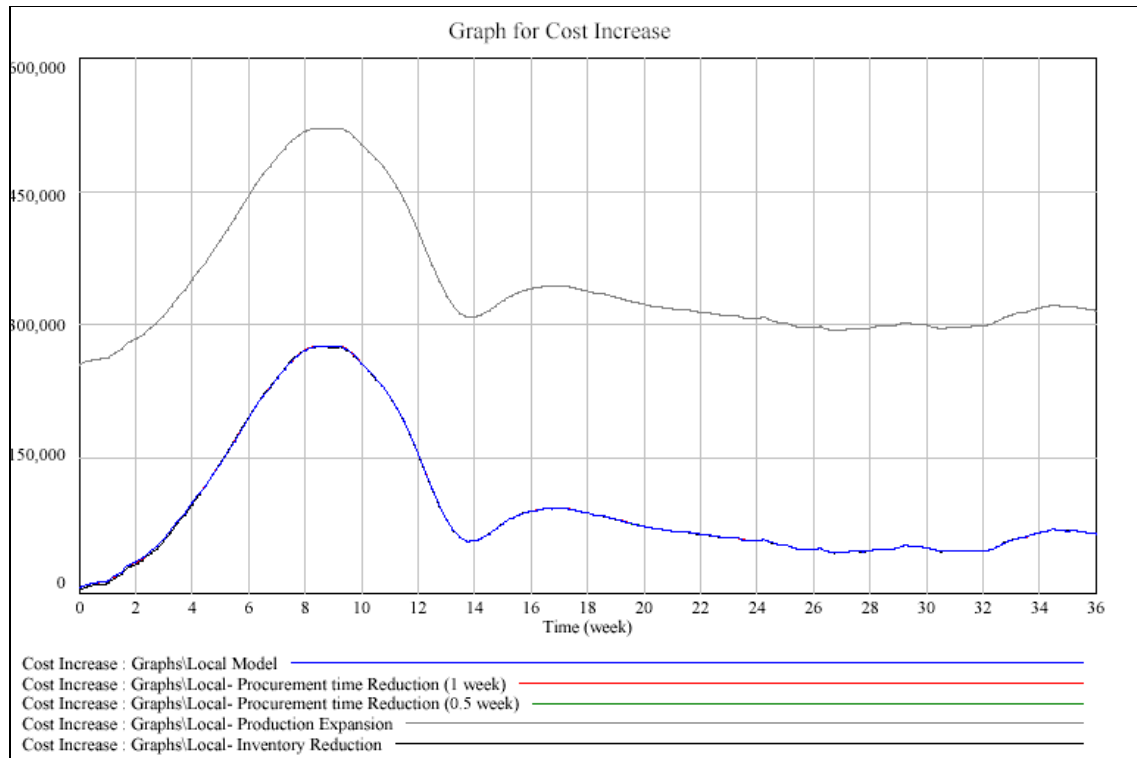
**Figure 51: Mdx Beer Game 7- Cost Measure**
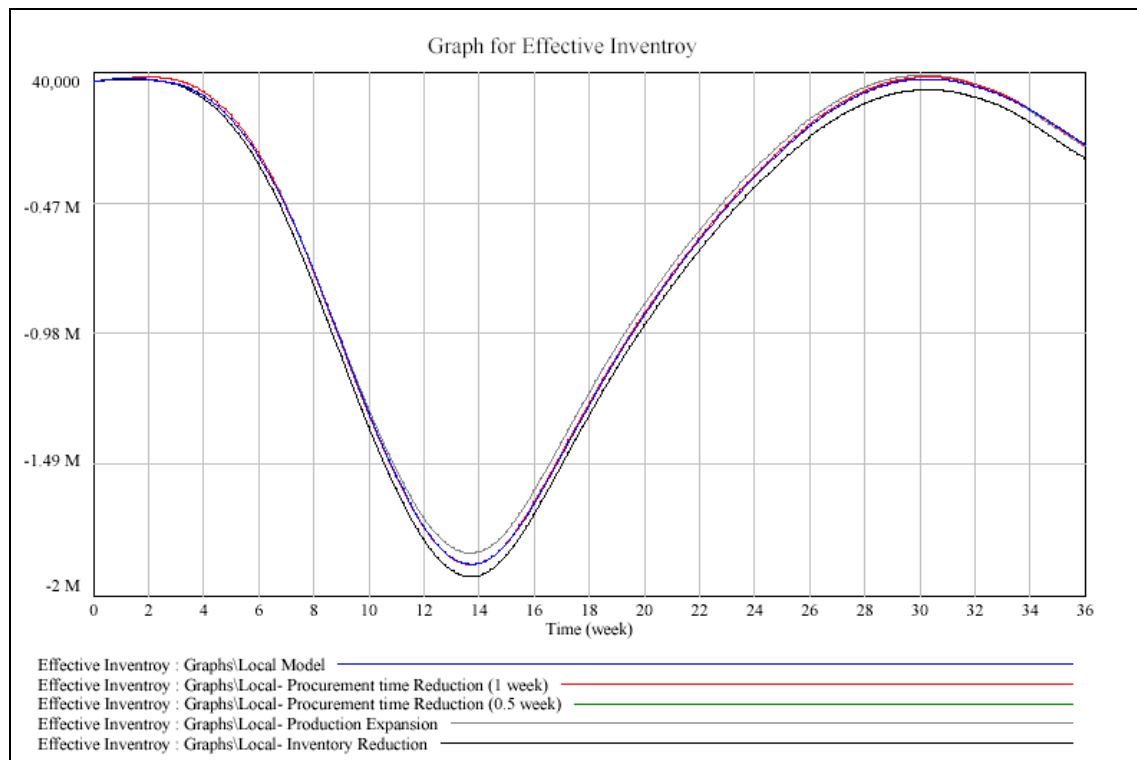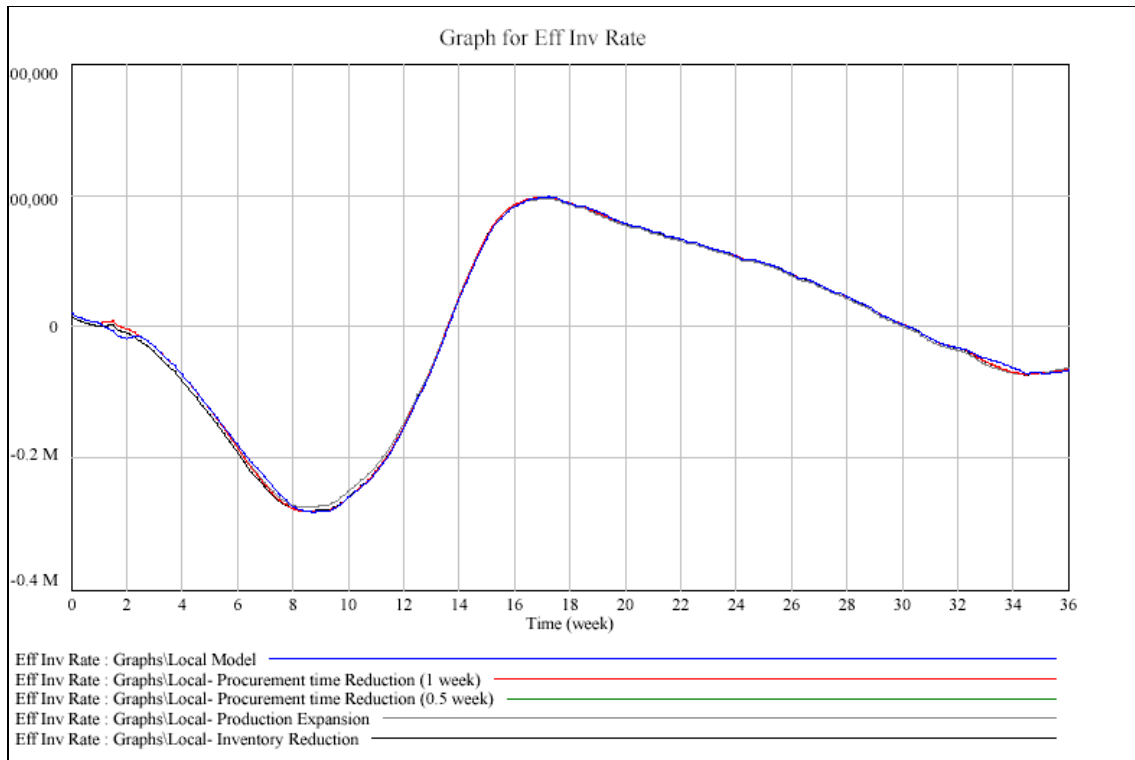
**Figure 52: Mdx Beer Game 7- Effective Inventory Measure**
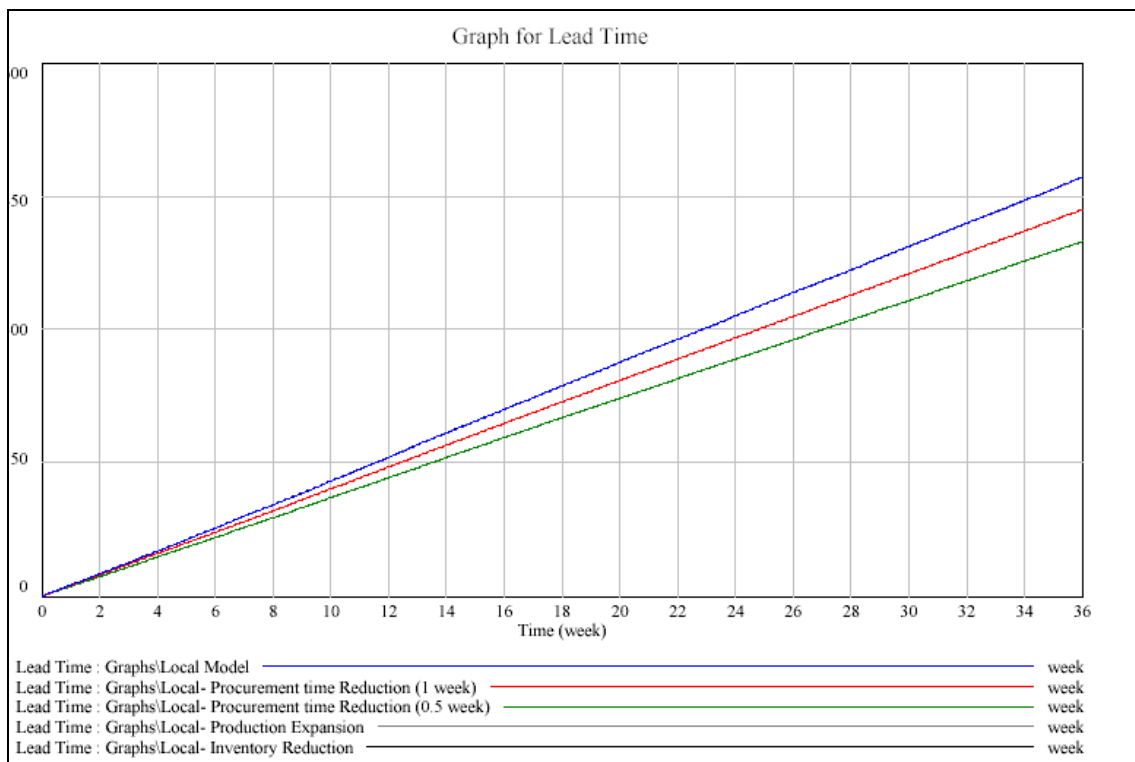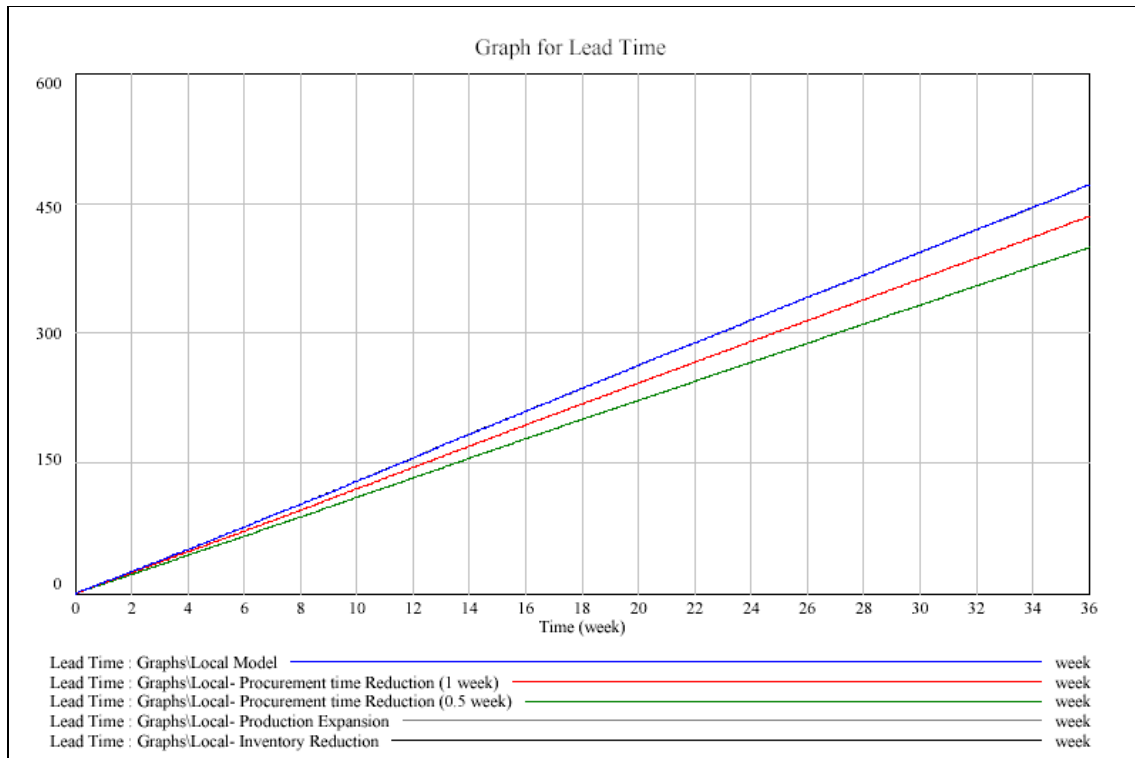
**Figure 53: Mdx Beer Game 7- Lead Time Measure**
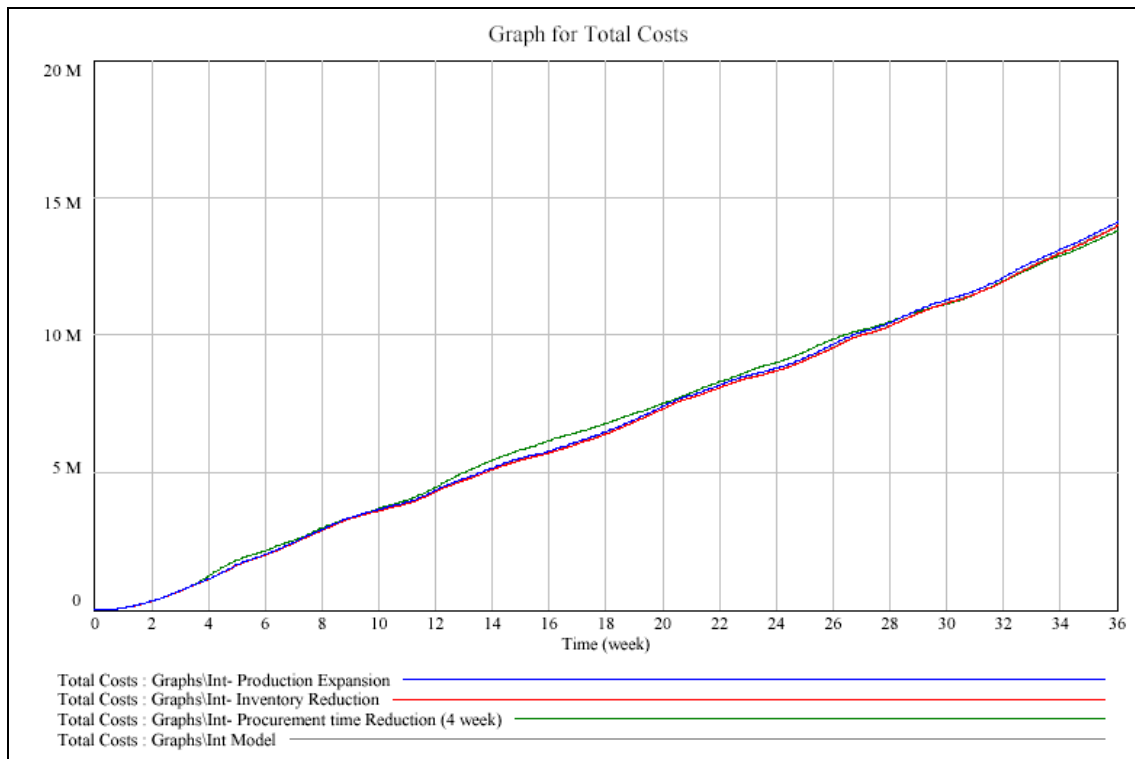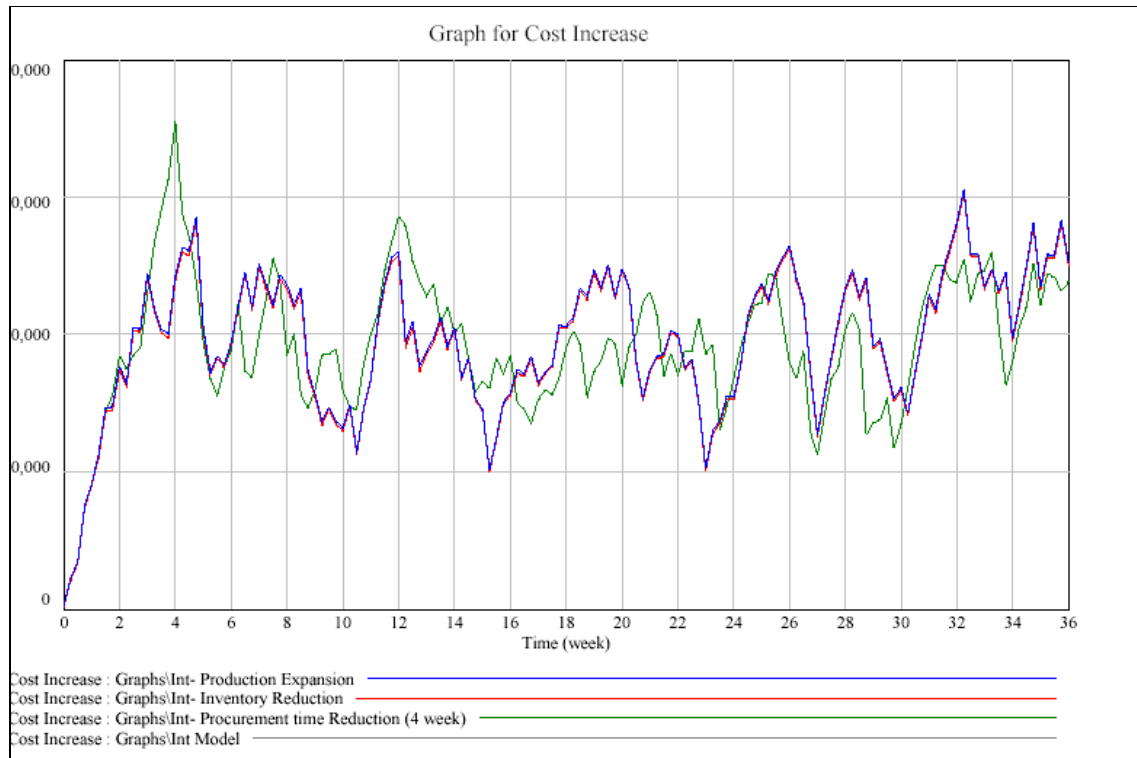
**Figure 54: Mdx Beer Game 8- Cost Measure**



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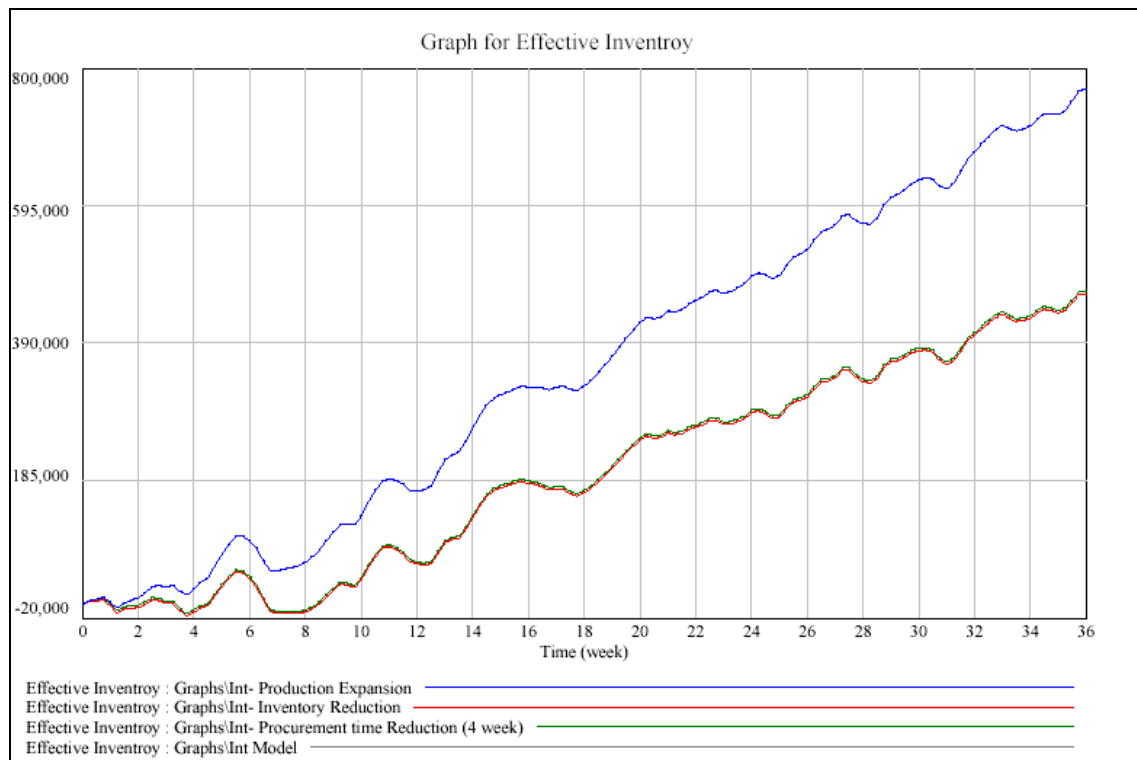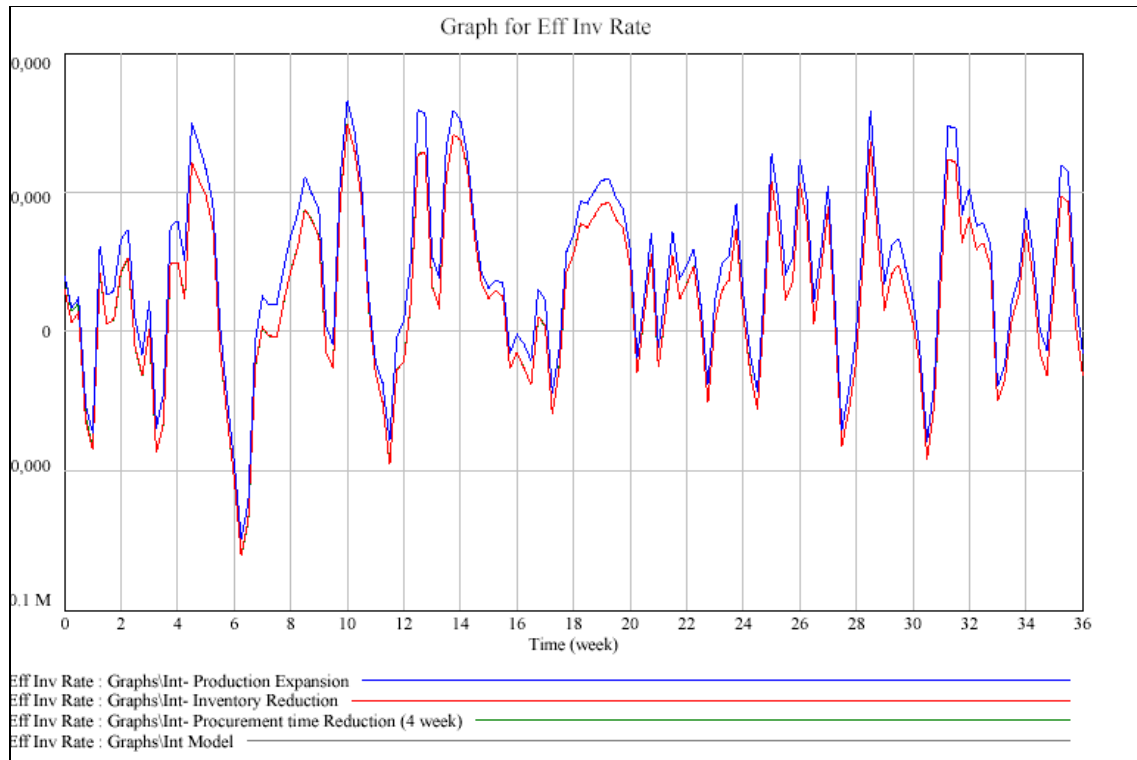
**Figure 55: Mdx Beer Game 8- Effective Inventory Measure**



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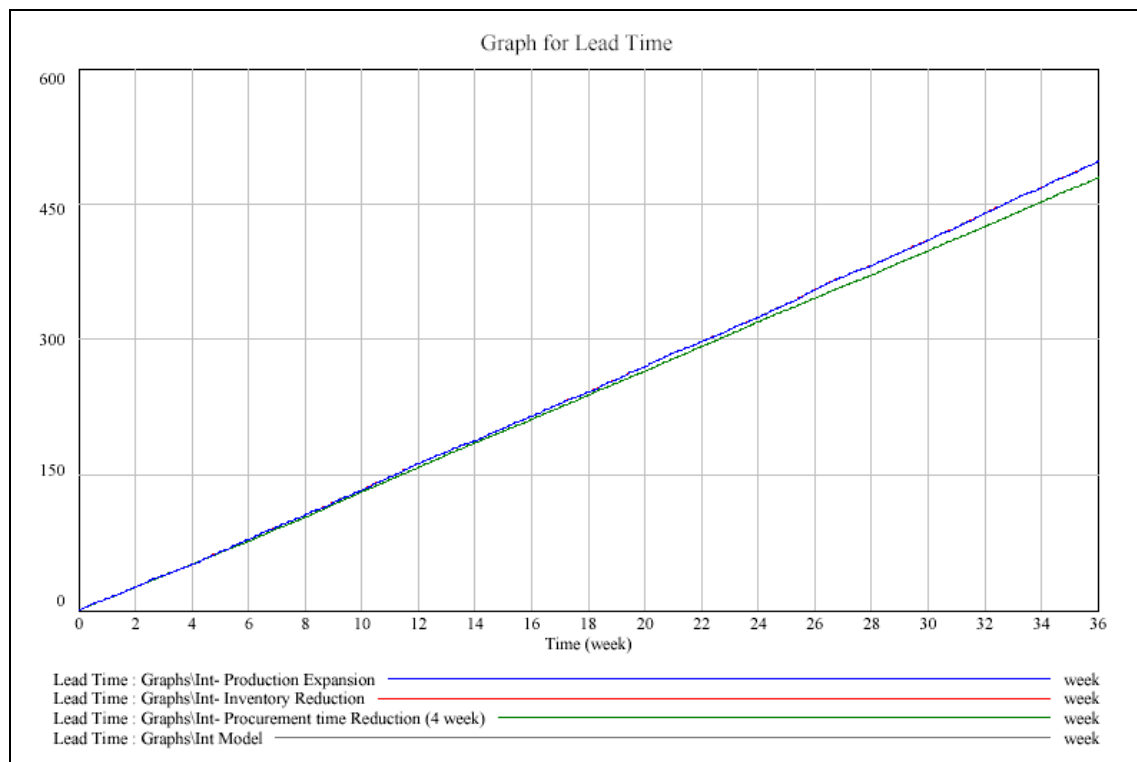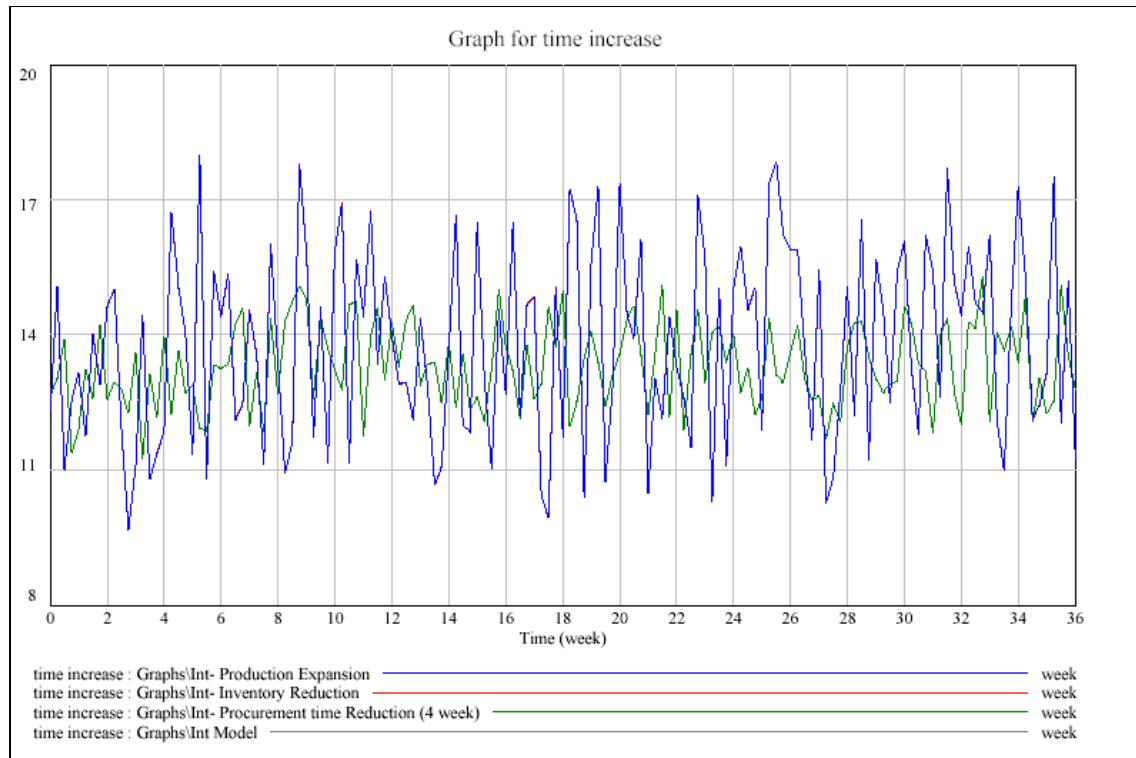
**Figure 56: Mdx Beer Game 8- Lead Time Measure**

This study examined situations of production expansion, inventory reduction and delivery time reduction showed a limited effect on supply chain performance improvement which means that the major issues that behind the experienced deficiencies were not defined by the above examined alternatives. Since the cost and responsiveness are major performance measures in the conducted beer game, policy which provides an obvious improvement according to both measures over the other alternatives would be considered as the best policy to be adapted by supply chain members. Focusing on internal organisational activities cannot ensure better performance for the entire chain. That is why the supply chain structure and communication will be investigated to test their effect on supply chain performance. Although respondents of case studies point out that supply chain design and collaborative platform are issues that initialise the supply chain deficiency cycle, they did not classify these issues as difficulties experienced by their organisations.

### 5.5.4. Supply Chain Visibility and Collaboration Pattern

Researchers Gunasekaran, et al. (2004) have pointed out the importance of the information sharing pattern and collaboration between partners in the entire chain. Lack of visibility and information sharing leads to a bullwhip effect or Forrester effect where demand

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distortion cause amplification and results in increased inventories (Liu and Kumar, 2003). Gunasekaran, et al. have indicated that long lead times and lack of information visibility across levels of a supply chain are the main reason behind the Forrester effect. Rapid responsiveness to customer demand can never be accomplished without accurate and timely information flow. Real time information sharing can enable an integrated chain where smooth product flow and timely information are merged (Singh, 1996). That urges the need for supply chain collaboration and a seamless supply chain where closer ties between partners exist and supply chain information is shared. Jones and Towill (1997) point out that poor pipeline for collaborative supply chain activities are obvious in supply chains.

A simulation experiment conducted by Joshi (2000) was used to examine supply chain performance under the condition of global information visibility and decision forecasting. This study concluded that the supply chain shows improved performance when those strategies were adopted. The proposed condition of Joshi's study will be tested using the supply chain under investigation to evaluate the effect of information visibility and information sharing on its performance.

Joshi (2000) had pointed out that information visibility is needed to eliminate the delay that occurs while passing order information within the chain, reducing individual decisions in critical supply chain issues and adopting customer-driven demand forecasting rather than independent partner estimation. Joshi simulated the beer game without and with information visibility and collaboration situations. Two different functions had been tested in the above situations. The FORECAST function provides a trend of extrapolation forecast of a future value. The SMOOTH function provides exponential smoothing of input depending on delay time input to the function. The study outcome concluded that the SMOOTH function produces a more uniform order patterns than the FORECAST function.

The visibility pattern proposed by Joshi has been adopted in my study. The proposed solution for current deficiencies was conducted in **Mdx Beer Games 9 and 10**. Based on Joshi's beer game, customer's demand is visible to all supply chain partners. Agreed on levels of inventory buffer are proposed to evaluate the effect of collaborative activities on supply chain performance. The applied model copes with proven work by Jones and Towill

(1997). They point out that feeding real-time sales' information to all supply chain partners leads to rapid responsiveness and reduced demand amplification.

Joshi 's beer Game, simulates existing supply chains when visibility is achieved, which is based on feeding order information into each supply chain level. The delay in passing order requests from one unit to another is eliminated. Order equation of each level is modified to rely on actual customer demand rather than amplified data as in equations (Mdx Beer Game 9-10, 22-27). Agreed on levels of inventory buffer are assumed in the beer game and are based on demand rate. The model assumes that the initial value of each inventory level is an estimate based on the lowest customer demand value. According to the case study under investigation, inventory initial value, S is set to include units which fulfill the minimum value of customer or international retailer demand. This value is converted into units of material at each production level (Mdx Beer Game 9-10, Equations 46-52). The same is applied to the case of fulfilling international market orders with regards to retailer demands. The figures 57-58 represent Mdx Beer Game 9 and 10 for both cases of local and international order fulfillment.
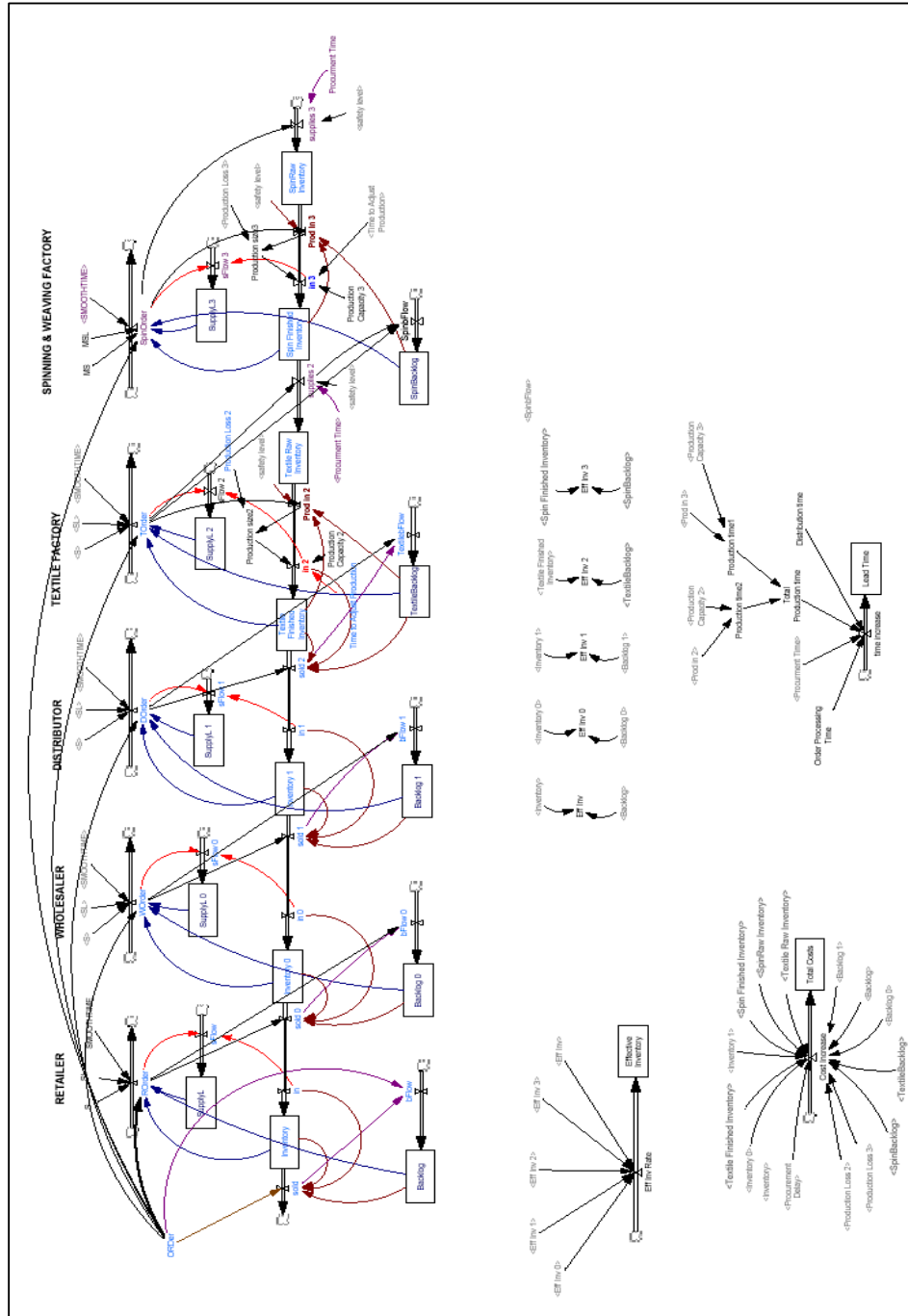
**Figure 57: Mdx Beer Game 9-Fulfill local orders under information visibility condition**

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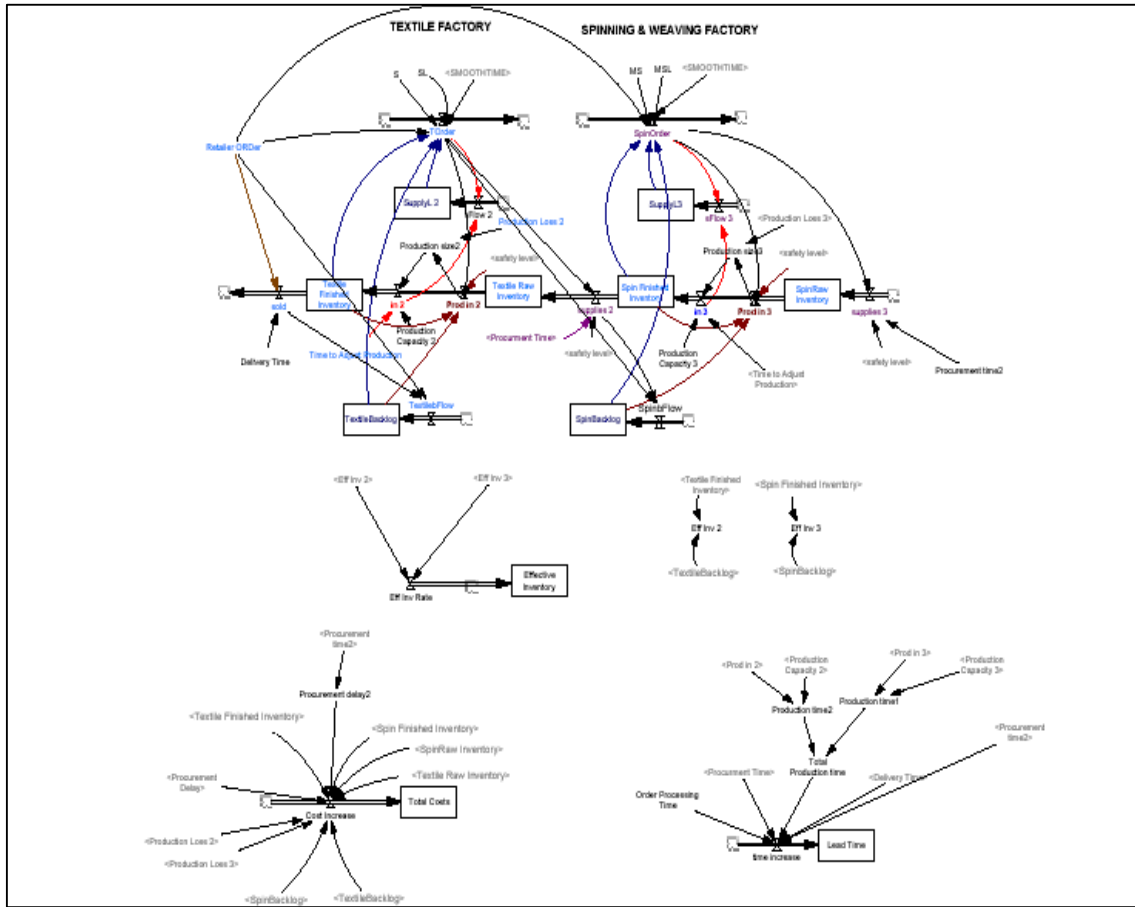
**Figure 58: Mdx Beer Game 10-Fulfill international orders under information visibility condition**

The elimination of the above mentioned delays in communication and collaborative planning activities have obviously reduced lead times and the total cost. Figures 59 and 60 represent the cost and inventory performance measures of Mdx Beer Games 9 and figures 61 and 62 represent the cost and inventory performance measures of Mdx Beer Game 10. Experiments adopting the information visibility condition indicated a reduced lead time in both international and local order fulfillment. This reduction of the lead time needed to fulfill incoming orders reaches 254 weeks in case of fulfilling local orders and about 177 weeks in case of fulfilling international market demands. Figures 63 and 64 represent the lead time measures for Mdx Beer Game 9 and 10. According to the lead time measure, elimination of order processing time leads to remarkable saving that is indicated at end of each experiment. Based on cost measures, information visibility adoption results in cost saving of $1.3 Million in case of fulfilling local market demands and $0.01 Million in the

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case of fulfilling international market demands. Reduction of backlog cost, smooth unsuspended production process and reasonable buffer inventories affect the cost saving positively. These results do not show up in the international market beer game. The reason is that the delay of outsourced material cannot guarantee unsuspended production processes, it causes inventory shortage and higher backlog. In addition, the delay of final product delivery affects the cost badly due to its effect of backlog cost. Final product delivery proves its significant effect in cost measure due to textile backlog reduction. Further beer game experiments were conducted to determine the effect of reducing outsourcing procurement delivery or final product delivery coupled with smooth information flow. Smooth information flow is achieved while eliminating the delay in order processing by feeding real customers' demand into each tier of supply chain. Beer games combine smooth information flow with reduced rate of final product delivery, which indicated a better supply chain performance. The beer game indicated that one week reduction of final product delivery, in case of supply chain visibility, can save $2.6 Million by end of the experiment. Combining both factors contributed positively to lead time reduction which reached 193 weeks in the lead time needed to fulfill incoming orders. This is presented in figure 64.

Effective levels of inventories along the chain by adopting agreed levels among partners, reduced the backlog along the chain with more than 2.4 M inventory units and indicated a good inventory level, which guarantees improved order responsiveness. This guarantees a reduced level of the bullwhip effect. Such inventory level is estimated based on actual demand rates.
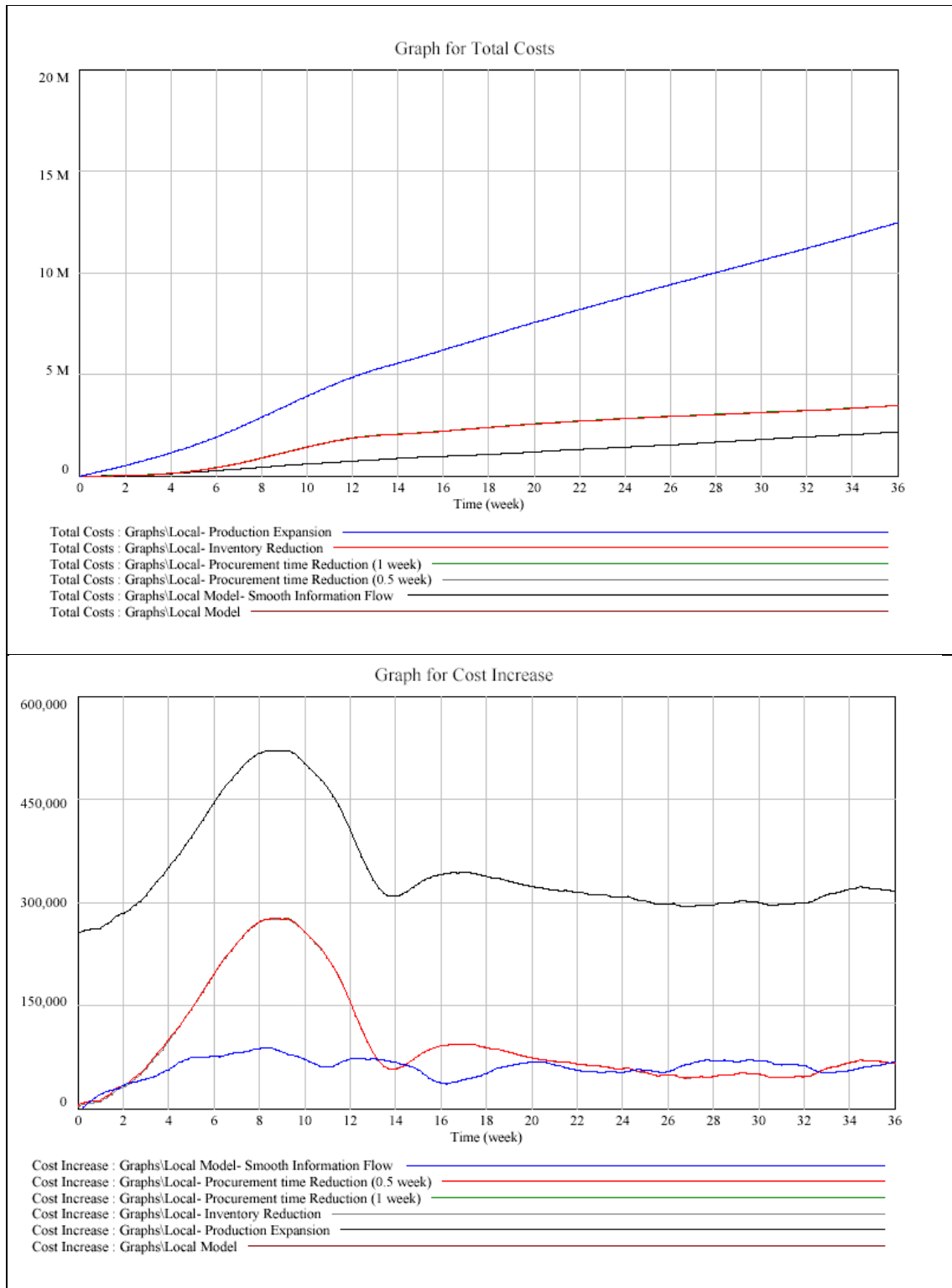
**Figure 59: Mdx Beer Game 9- Cost Measure**

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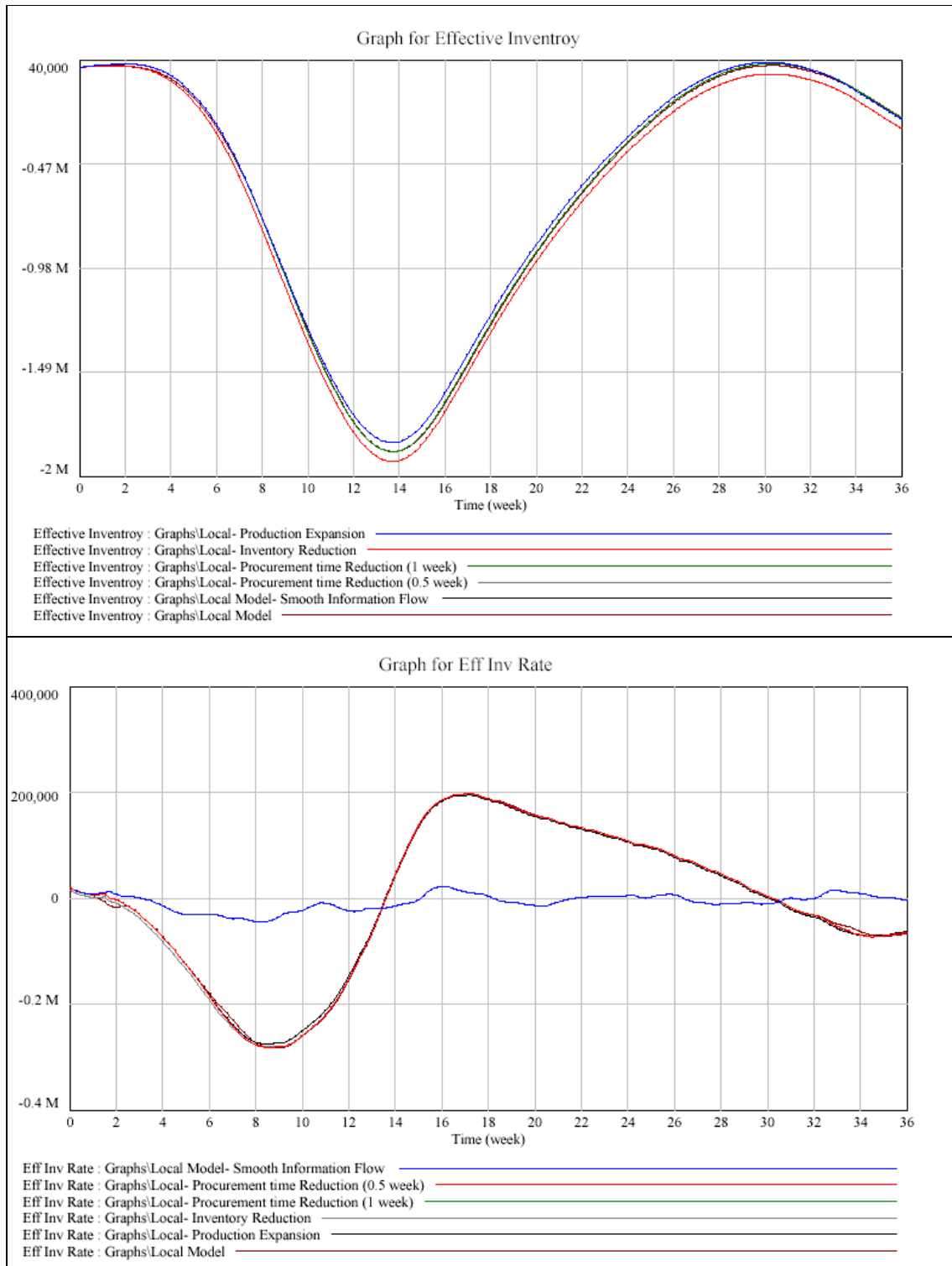
**Figure 60: Mdx Beer Game 9- Effective inventory Measure**
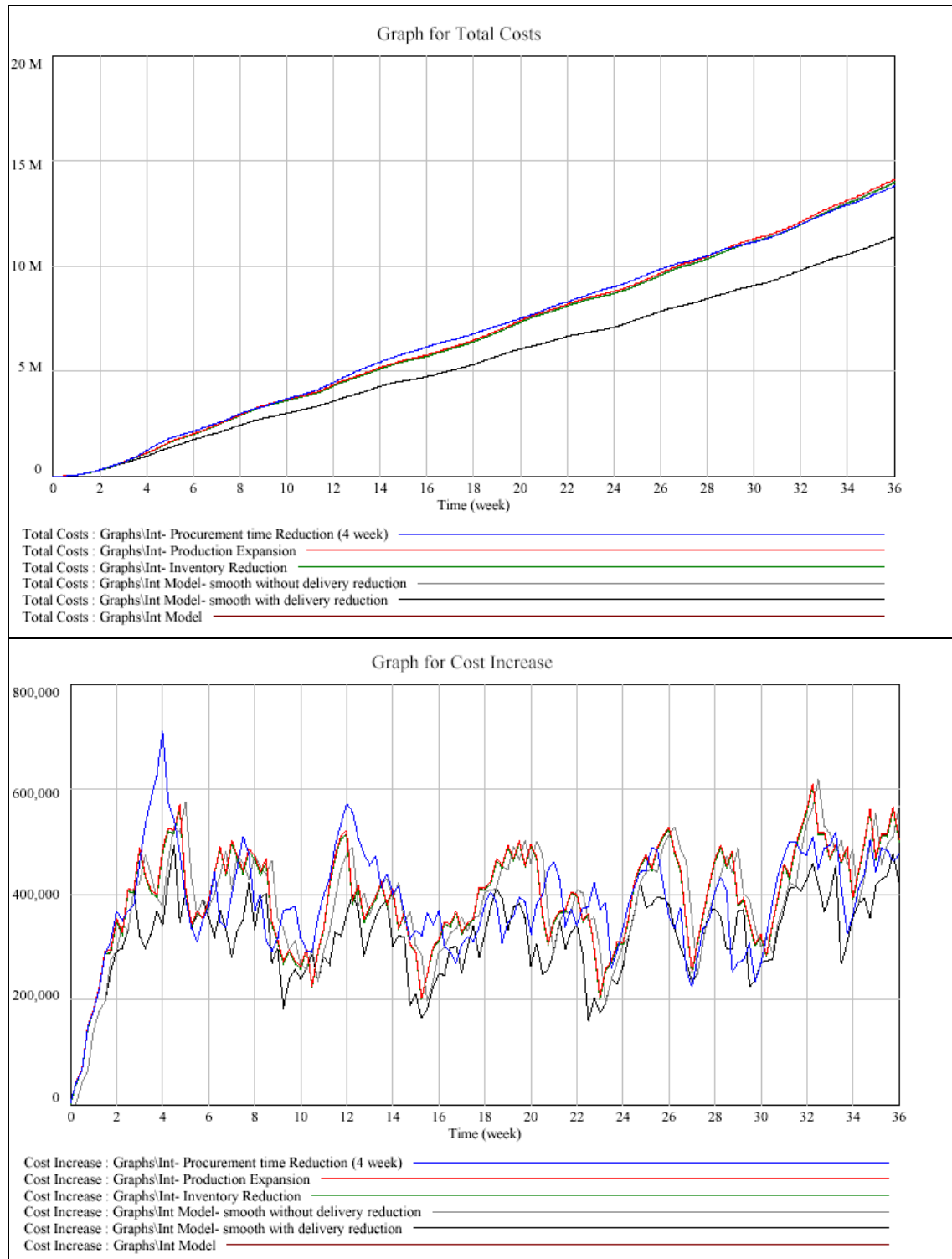
**Figure 61: Mdx Beer Game 10- Cost Measure**
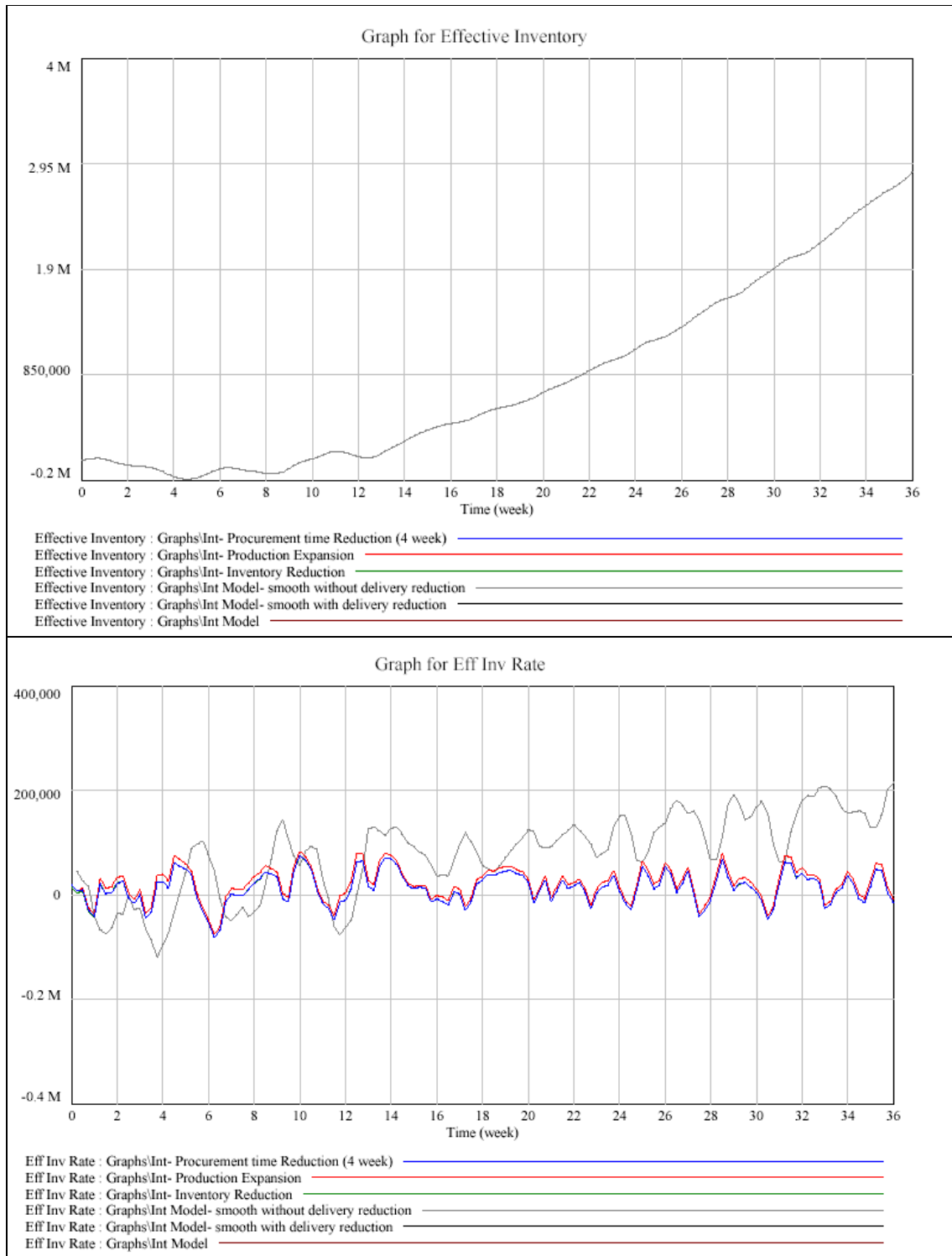
**Figure 62: Mdx Beer Game 10- Effective Inventory Measure**
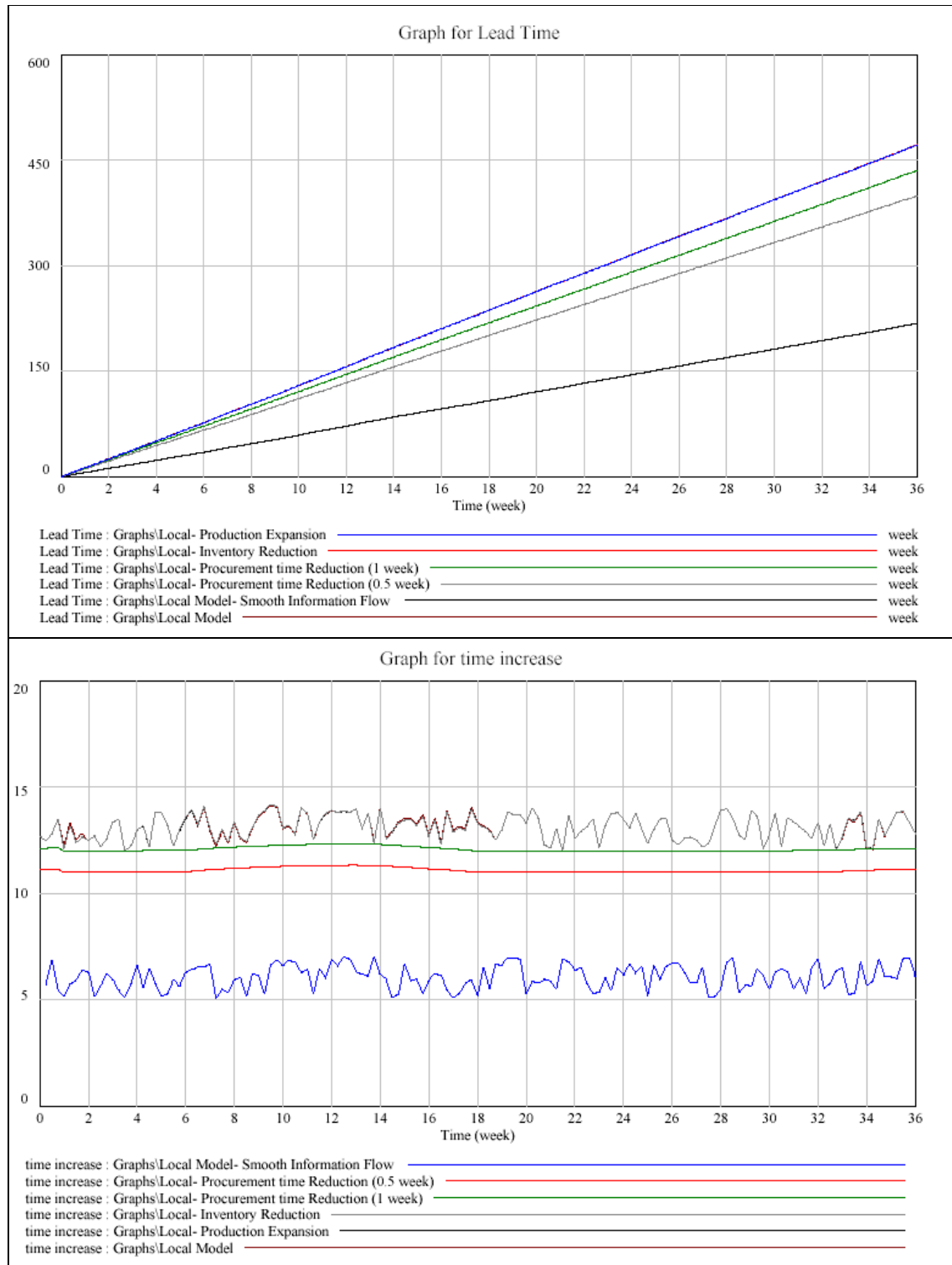
**Figure 63: Mdx Beer Game 9- Lead Time Measure**
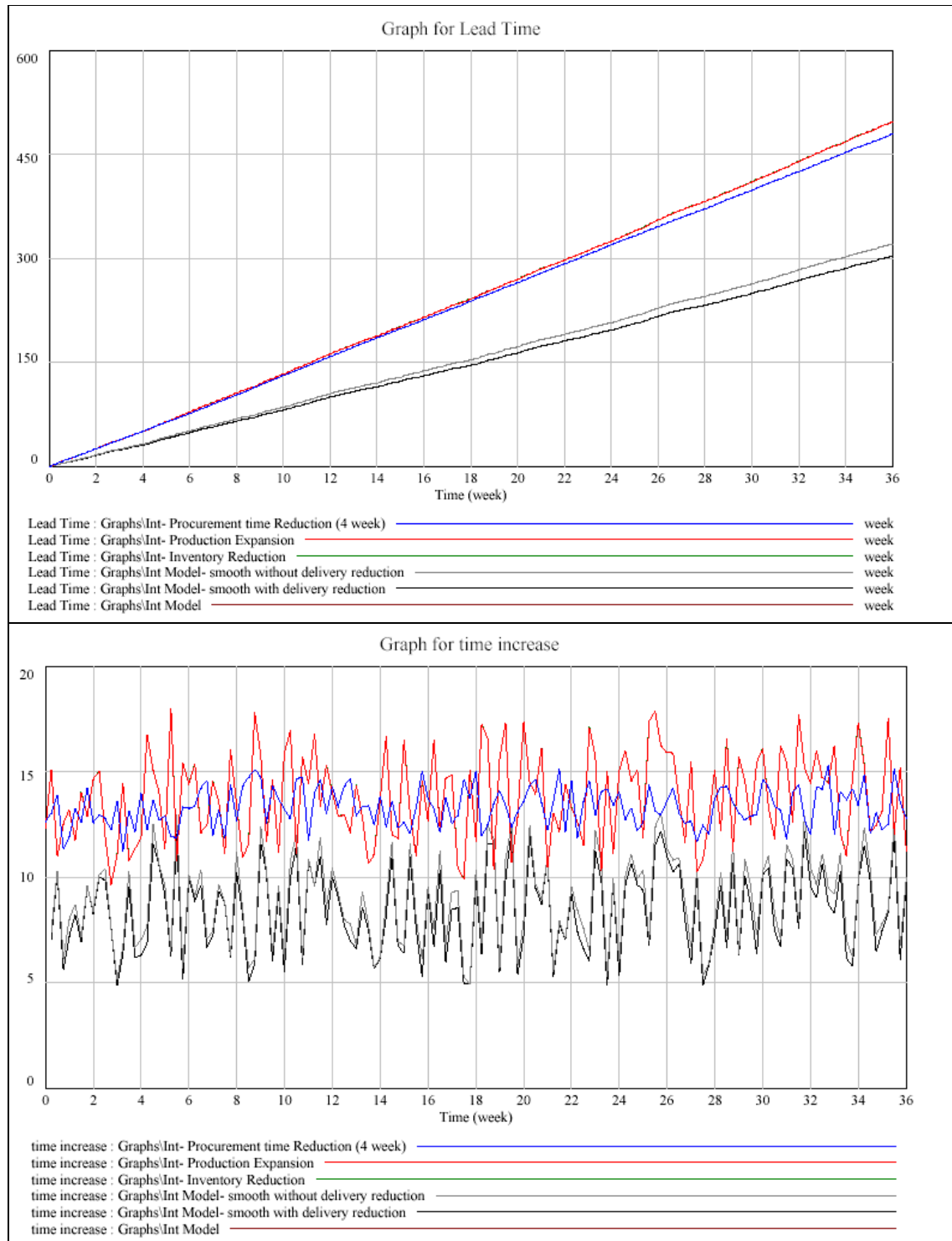
**Figure 64: Mdx Beer Game 10- Lead Time Measure**

Based on the above results, information visibility and collaboration offer saving in cost of 38% for local orders. The reduction of order processing time leads to an accumulated saving of 36% of international orders and 54% for local orders. The applied strategy has

reduced inventory shortage for local market during high demand weeks with $0.23 Million less than current chain performance. The figure 65 represents brief findings for each conducted scenario.

### 5.5.5. Model Validation

The lead time was neglected and/or underestimated as a measure for supply chain performance by industrial organisations in Egypt. Since the adapted beer game uses two main measures: cost and lead measures for supply chain performance, cost measures from the perspective of respondents focus on tangible issues rather than hidden issues. In this research, the cost measure considers hidden cost issues such as holding cost, lost sales opportunity and backlog cost. Due to the variation of measures used in real case studies from the measures adopted in this research, an obstacle in model validation using a real dataset was imposed.



**Different Policy Tested**

Policies related to Individual decision/ internal organisational deficiencies

**Best Tested Policy**

**Expanding Production's Capacity**

◦ 1000 units for production extension of textile producer
◦ Reduced rate of material loss during the production process

**Supply Chain Performance**
- High rate of cost increase
- limited effect on production time and limited lead time reduction
- Unjustified investment in machinery , increased holding cost : an increase of final product inventory without an appropriate rate of incoming order.

**Inventory Reduction**

◦ Reduced rate of inventory level to half the amount for both raw material and finished products inventories at the textile producer.**.**

**Supply Chain Performance**
- Limited cost saving in both cases
- Reduction of effective inventory levels
- Contributes to more backlog to fulfill demands of local customers.
- Not applicable with existing unstable delivery terms and production capabilities

**Procurement time Reduction**

◦ Local order fulfillment: domestic procurement delivery of one week and 0.5 week values.
◦ International order fulfillment: outsourced delivery time of 4 weeks

**Supply Chain Performance**

**Local Orders:**
- Obvious reduction of lead time with no improvement regarding cost and effective inventory measures.

**International Orders**
- More beneficial and had obvious performance improvement

**Information Visibility & Agreed on level of inventory**

° Feeding each tier of supply chain with actual demand and adopting an agreed on level of inventory keeping.

**Supply Chain Performance**
**Local Orders**
- Lead time reduction of 54%
- Cost reduction of 38%

**International Orders**
- Lead time reduction of 36%
- Cost Reduction of 19% when combined with a reliable logistic system

**Figure 65: Mdx Beer Game Results- Comparison between Different policies**

Model Validation is defined as "*establishing confidence in the usefulness of a model with respect to its purpose.*" (Barlas,1994). Validation is not about validating the resulted pattern of behaviour rather than the structure of model itself. There is a different

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philosophy of model validity; a holistic philosophy is more appropriate to match the system dynamic model which entails that "*No particular representation is superior to others in any absolute sense, although one could prove to be more effective. No model can claim absolute objectivity, for every model carries in it the modeller's worldview. Models are not true or false, but lie on a continuum of usefulness.*" (Barias and Carpenter, 1990). Greengerger et al. (1976) as well indicate that "*no model has ever been or ever will be thoroughly validated.. 'useful' 'illuminating' 'convincing' or 'inspiring confidence' are more apt descriptors applying to models than 'valid'*". A number of questions were defined by Sterman (2000) to assess the suitability of the model to the purpose. These questions, illustrated in Table 31, were adapted in this research to ensure the usefulness and integrity of the adapted beer game and in order match the purpose of this study.

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**Purpose, suitability and boundary**

**- What is the purpose of the model?**

It demonstrates a more realistic production-distribution cycle

**- What is the boundary of the model? Are the issues important to the purpose treated endogenously? What important variables and issues are exogenous? Are important variables excluded because there is no numerical data to quantify them?**

• Endogenous— dynamic variables involved in the feedback loops of the system such as: spin raw inventory, textile raw inventory, production input, production outcome, production time, domestic supplies replenishment, international supplies replenishment, lead time, effective inventory measure and lost sales opportunities

• Exogenous—components whose values are not directly affected by the system such as: delivery delay time, production loss, production capacity, safety level

• Excluded: supplier power, marketing expertise, economical condition.

**- Is the level of aggregation consistent with the purpose?**

Operational activities regarding production and procurement activity had been included to the distribution cycle to represent existing supply chain activities


**Physical and decision making structure**

**- Does the model represent disequilibrium dynamics or does it assume the system is or near equilibrium**

It represents disequilibrium dynamics due to demand amplification, oscillated pattern of delivery time

**- Are appropriate time delays, constraints and possible bottlenecks taken into account?**

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- Overseas and domestics delivery time was demonstrated using uniform distribution, Supplies replenishment is being affected by the delivery pattern, so discrete function is used to represent the actual supplies' replenishment.

- Production timing is considered in Mdx beer game based on production capacity constrains

- Delivering final product overseas is affected by with unreliable logistics system so discrete function was used to represent the actual product delivery.

**- Are people assumed to act rationally and to optimize their performance?**

Labour skills are considered when it comes to production time, so time to adjust the production is included to simulate the actual pattern of labour performance. At the same time, the actual pattern of performance of suppliers and unreliable service provided had been considered.

**Pragmatics and politics of the model**

**- What type of data was used to develop and test the model?**

Primary data source and field-based qualitative data, archival material and interviews

**- Are the results of the mode reproducible?**

The model represents the case of industrial supply in a developing country, which either plays the role of OEM or tries to fulfil its local market with domestic products. Another set of data value can be fed into the model to demonstrate the case of 2 tier production-distribution supply chain

**Table 31: Questions related to Model Usefulness and Purpose**

Different types of model testing were proposed by Forrester and Senge (1980). Barlas (1994) pointed that to validate a system dynamic model; the structure of the model has to be validated followed by the accuracy of the resulting behaviour. According to Barlas (1994), direct structure tests have to be conducted to compare model equations with real situation. It encompasses structure and parameter verification to match the model's structure and parameter with the real system (Forrester and Senge 1980). Another test is conducted to weigh up the structure indirectly. Defining parameters that had a great effect on the model and matching these sensitive parameters with real situations are used to assess structure oriented behaviour. Once the model structure is validated, the behaviour pattern can be tested to compare the system's behaviour with the real one. Tests which were defined by (Forrester and Senge 1980) were conducted on my adapted beer game and demonstrated in table 32.

| Test | Purpose of Test | Tools and Procedures |
|---|---|---|
| **Boundary Adequacy** | Important concept addressing production and procurement issues endogenous to the model such as (spin raw inventory, raw textile inventory, production input, production outcome, production time, domestic supplies replenishment, international supplies replenishment, lead time, effective inventory measure, lost sales opportunity) | Subsystem diagram, stock and flow map, direct inspection of model equation. |
| **Structure Assessment** | - The model structure is consistent with relevant knowledge of the system. The adapted beer game overcomes the inappropriate assumptions which are related to availability of raw materials anytime, unlimited production capacity, and random events exclusion such as delivery time. The Sterman's structure was modified in light of the observation of industrial companies.<br>- Level of aggregation: Operational real dataset was used in this model to represent production-distribution. | Interviews, expert opinion, archival material and direct inspection of the system process were conducted. |
| **Parameter Assessment** | - The values are consistent with numerical knowledge of the system.<br>- System input is based on real counterparts | Interviews and direct inspection of system process were conducted. |
| **Sensitivity analysis** | Numerical data of, behaviour and policy changes significantly over time | Different scenarios were conducted to indicate their effect on the pattern of behaviour:<br>- Change in policy of buffer keeping affects the behaviour of system.<br>- Change in assumption of fragmented supply chain platform affects model behaviour and numerical data<br>- Change in the production capacity affects the supply chain behaviour<br>- Change in the assumption of logistics service reliability affects the supply chain behaviour. |

| Test | Purpose of Test | Tools and Procedures |
|---|---|---|
| **System improvement** | The modelling process represents a realistic case of supply chain deficiency. testing the possible solutions to provide enhanced performance for existing supply chains | Lead time measure and hidden cost issues were included to measure the supply chain performance in each case<br>- Change in the pattern of information sharing and collaborative agreed-on buffer keeping policy enhances supply chain activity |

**Table 32: Test and Assessment of Dynamic Models**

## 5.6 Summary

The study results constitute a way of improving supply chain performance. Table 33 and 34 summarises simulation experiments conducted in my study. The following is the summary of this research's simulation outcome:

The solution with the best performance was represented in Mdx Beer Game 9 and 10 where the collaborative pattern was simulated to enable supply chain visibility. In order to achieve the best performance of textile producers in global markets, smooth information flow should be integrated with a more reliable logistics system for final product delivery. This can achieve both time and cost reduction for original equipment manufacturers. To accomplish this target, the willingness of partners to share data and collaborate in the supply chain is crucial. Although this collaboration is beneficial to all the chain's partners in the chain, firms are reluctant to share such information, which may be caused by lack of trust and privacy issues. This refers us to issues discussed in the interview results; organisations are more concerned with activities inside their boundaries and how to improve them rather than collaborative activities.

While there are multiple factors that influence supply chain performance and introducing non-linearity into the system, factors related to external environment such as delivery issues cannot be considered as controlled factors by Egyptian textile producers. While these factors may impose instability and oscillations in the system, collaborative activities would enable a chain's participant to overcome the effect of this delay.

| Proposed Solution | Cost Measure | Lead Time Measure | Effective Inventory measure |
|---|---|---|---|
| Mdx Beer Game 3: Production Capacity Extension | *Increment of $225,000 or $9 M* | *Reduction of 0.08 Week* | *Increment of 0.007 M Unit* |
| Mdx Beer Game 5: Inventory Reduction | *Increment of $ 0.012* | *Reduction of 0.01 Week* | *Reduction of 0.0535 M* |
| Mdx Beer Game 7: Procurement Delay Reduction | *Reduction to one week & 0.5 week values: Increment of $ 0.002* | *Reduction to One week causes Reduction of 37 week; Reduction of 0.5 week causes a decrease by 73 week..* | *Reduction to one week & 0.5 week values: no change on effective inventory.* |
| Mdx Beer Game 9 : Information Visibility & Collaboration | *Reduction of $ 1.307 M* | *Reduction of 254 Weeks* | *Reduction with 0.0005 Unit* |

**Table 33: Local order fulfillment**

| Proposed Solution | Cost Measure | Lead Time Measure | Effective Inventory measure |
|---|---|---|---|
| Mdx Beer Game 4: Production Capacity Extension | *Increment of $ 380.000 or $ 9.13 M* | *Reduction of 0.22 week* | *Increment of 302.348 unit* |
| Mdx Beer Game 6: Inventory Reduction | *Reduction of $ 0.03 M* | *Reduction of 0.04 Week* | *Reduction of 3.832 units* |
| Mdx Beer Game 8: Procurement Delay Reduction | *Reduction of $ 0.2 M* | *Reduction of 17 Week* | *Increment of 13 unit* |
| Mdx Beer Game 10: Information Visibility & Collaboration combined with one week of delivery reduction | *Reduction of $ 2.62 M* | *Reduction of 193.76 Weeks.* | *Increment of 2.4 M units.* |

**Table 34: International order fulfillment**

# Chapter Six

## Discussion

### 6.1 Introduction

Results from this study have pointed out many difficulties that the textile sector in different industrial zones face. The degree of importance of each issue differs, according to its effect on organisation' performance, was defined. Most textile fabric producers pay attention to internal organisation activities regardless of external factors. Discussion of both internal and external issues is included in this chapter. The effect of problems related to ICT capabilities and culture are also investigated based on the survey findings.

*"What can a country like Egypt learn from the success of the East Asian countries in using the apparel industry to drive export-led growth?"* Egypt has plenty of resources, low cost labour and an attractive location near international markets that could support vital industries such as textiles and apparel (Magder, 2005). At the same time, it has not achieved rapid growth in global markets compared to that achieved by Asian countries. Although international brands such as Gap, Guy Laroche, Pierre Cardin and Tommy Hilfiger are made in Egypt under license (American Chamber in Egypt,2006), most of other brand investors did not turn on their offshore units there, although Egypt has value added features represented in geographical location which facilitates access to European markets. Some of those investors utilise a number of Egyptian mills as OEM units to procure and provide its global retailers with finals products (Magder, 2005). It is obvious that, base on these facts and the dramatic increase of international sourcing, Egyptian textile fabric contributes only a limited share of global markets. Despite its strategic location that supports rapid product delivery and good access to global markets, Far East countries have proven their success through providing competitive service and they have obtained the lion's share of international markets. A fragmented platform, which is tied to older technologies and correlated with a poor logistic system, has negatively affected the significant value provided by Egyptian textile producers. Competitive advantages of Chinese fabrics have led foreign investors to extend their supply chain and establish manufacturing units offshore there. The challenges of overseas sourcing is investigated by Bowersox et al., (2005) who consider that providing materials with predefined quality, protecting its intellectual property, maintaining a good relation with suppliers, providing reliable delivery and overcoming government restrictions are main issues to be

encountered by foreign investors. These issues do affect product lead times and total costs, which are critical measures of supply chain performance.

A number of these issues do exist in the Egyptian industrial sector and do affect their performance. Various barriers are interrelated and have prohibited Egyptian textiles from entering global markets. Internal deficiencies coupled with external issues cause such problems. Difficulties experienced in the textile industry are explored in the textile industry. Methods for data collection and outcome validation are discussed in the chapters on Empirical Findings. The relevance of the finding of this study to industrial reports and predecessor studies is discussed in the next section to indicate similarities to industrial sectors in other countries.

## 6.1. Internal Activities

Domestic producers used to provide the local market with standard products and limited varieties, regardless of customer preferences. This situation differs if the end customer is another business placing orders for tailored product specifications. In this case, the producer is able to tailor patterns or design specifications, with no need to procure special outsourced supplied materials. This traditional product cannot maintain the firm's market share in the domestic arena due to low-price Chinese fabrics that compete in their local market. Some spinning producers were obliged to operate imported spins at their units to overcome operational cost and survive in such markets. This led industry players to pay more attention to globally-supplied fabrics and their quota in order to maintain their export rate. Multi-Fibre agreements, followed by QIZ, are channels that allow Egyptian fabrics to get into global markets. While quality constraints were encountered by domestic producers as a barrier to fulfil local market needs (El-Haddad, 2005), the process of procurement and production activities have become more complicated when it comes to international market fulfilment due to quality constraints and demand variety. Quality constraints and uncertainty in transport are issues being raised as major obstacles facing producers. Global leading firms necessitate local manufacturing units to import their supplies to fit pre-defined quality criteria (Magder, 2005), which did impose more difficulties in adopting a buy-to-order customisation strategy to fulfil global demands. Managers do not pay attention to assessing procurement pitfalls despite their importance and their effect on production, which could hardly drive improvements to a firm's performance (Blanchard, 2007). Paquette, the author of *Sourcing Solution*, defines sourcing as: "*to locate the one company out there that can provide needed products better than anyone else*" (Blanchard,

2007). This emphasis is more on the need to assess supplier performance. The empirical study proves that Egyptian producers did not consider their suppliers as business partners whose performance could affect the producer's internal activities. Transition toward a customisation approach should be coupled with the ability to fulfil demand variations within lead time and cost constraints (Ahlstrom and Westbrook, 1999). Limited availability of the main material (Egyptian cotton) and long lead of imported procurement have interfered to prevent short lead times and affect the significant value provided by producers. An attempt to reduce the time of procurements has proven its impact on order fulfilment time. My simulation experiment indicates that reducing the procurement time by one week saves 36 week of total time needed to fulfil local orders. Additionally, reducing the time of overseas procurement to reach 4 weeks saves 17 weeks of lead time in case of fulfilling international order. Since the lead time measure is negatively affected by the delay of overseas procurement, simulating the case of overseas procurement reduction has enhanced the responsiveness rate to customer order. An obvious cost reduction of $ 0.2 M is concluded based on this scenario, in case of international demand fulfilment. Deploying a more reliable logistics system could provide the producer with a time saving advantage while moving to overseas supply is mandatory to overcome the gap of domestic procurements especially of the main material (i.e. cotton). The limited availability of Egyptian cotton is due to the governmental strategy of exporting cotton to global markets where its significant value will be beneficial for foreign fabrics. It is considered by the government as a way of promoting Egyptian cotton products to consumers worldwide due to its well-known quality (EgyTex, 2006). The applied strategy has caused a real gap in supplies to many domestic producers. Most firms in the private sector have been redirected to import their cotton, which may in turn affect quality.

Selection criteria of suppliers in Egyptian industry rely on price criteria unless unique supplies are available. Suppliers who provide low cost advantages cannot ensure reliable procurement activities. Case studies in the Indian supply chain have indicated various factors for supplier management. Factors such as: quality, IT resources, speed, delivery performance, cycle time, reliability, and product availability should be merged with price to measure the supplier performance. The Indian study does believe that closely working with a small base of suppliers is the correct practice to change behaviour (Mohanty and Deshmukh, 2005 page: 68). Nelson et al. describe that: "*Reduction in the supply base from thousands to hundreds of excellent supplier will continue as intra –enterprise alliance*

*focus on proven and strong performer*" (Blanchard, 2007). Paying consideration to supplier quality does positively affect cost measures (Porter, 1998). Since cost measure impacts location, Dell keeps its procurements near to Dell assembly plants. My empirical study indicates that the Egyptian textile producers have focused only on the price issue regardless of delivery terms and other issues related to supplier-oriented performance. While the decision is not about dealing with the one who offers the cheapest price, other factors such as distance, labour force, quality and delivery terms should be involved to influence such decisions. Long lead times of overseas supplier may lead textile producers to look backward to domestic supplier and encourage vertical integration to reduce lead times as much as possible. Collaboration between domestic producers could ensure meeting the quality constraints for the final product, as well as reducing the delivery time, ensuring supply availability. It might also be extended to adopt a Just-In-Time strategy with inventory reduction. Considerable powers from the supplier's side has negatively affected the chance of further collaboration between the partners in Egyptian textile industry as it did in UK clothing industry (Adewole, 2005). Vertical integration may result in a small number of overseas suppliers, which is limited to chemicals and unique resources.

Case study analysis indicates that production and procurement issues are equally important in supply chain deficiencies. Survey results indicate the importance of these issues despite the respondents not pointing out such issues as major causes of supply chain deficiency. The ISM model, which is based on case study analysis shows the same results and illustrates production and procurements issues as consequences of fragmented platform and the poor structure of existing supply chain. The limited driving power and dependencies of these issues have been reflected in recently occurring stages of supply chain deficiency. This explanatory study refers to industrial organisation in textiles and focuses on operational and internal issues rather than issues occurring outside its boundaries. To optimise the supply chain activities from respondent's perspectives, production and procurements issues should be addressed. Based on the Yin and Khoo (2007) classification of supply chain optimisation levels, managerial levels focus on operational objectives to improve supply chain activities.

Adopting Lam and Postles' (2006) idea of differentiating between functional and innovated product texture, textile fabrics production as an innovated product needs a

diversity of procurements and requires a rapid production cycle to match the volatile demand. To target a short lead time for order fulfilment, respondents recommend that firms should trigger production and procurements issues.

With rapid market changes, the possibility of maintaining a small buffer of inventory is diminished. The individual patterns of organisation inside the chain support that. Each producer in the chain has his own strategy to adopt, regardless of partners' needs or requirements. Therefore, the role of the supplier is limited to replenish inventory, based on a partner's order. Automated inventory replenishment or JIT approach is not applicable in the investigated industry due to lack of collaboration and supplier performance. Diversity of needs and instability of demand did not encourage major players in the textile industry to reduce their buffer. Uncertainty of demand is merged with price fluctuation to raise buffer size, regardless of effect on cost. The situation is different in developed countries; leading firms such as Dell keep a buffer for a few days. Dell depends on a multi-vendor hub to ensure the supplies needed for a two-hour production schedule (Blanchard, 2007). Dell believes "*keep your friends close and your supplier closer*" (Blanchard, 2007). Therefore, its suppliers maintain procurement inventory near to Dell assembly plants. While Dell believes that you should "*do whatever it takes to move inventory*", leading firms in an unstable market could not achieve that. Although collaboration with a supplier could enable the partner's to overcome market instability and offer perceived benefits to both firms, the trust issue is inferred to prevent that in Egyptian industry as it does in the Turkish one (Orala, Koglub and Erdisc, 2003). The simulation experiments used in this study have indicated that individual decisions made by a firm to reduce inventory are not effective in supply chain performance, unless they are a coupled collaborative strategy between members for the sake of inventory reduction. As for the case of individual decisions, the simulation experiment indicates that an inventory reduction of the textile producer to half the amount in case of local order fulfilment leads to a cost increase of $ 0.012 M, since it does not provide a sufficient level of inventory needed to ensure backlog coverage. The individual decision of inventory reduction does provide a small saving of 0.01 week for the lead time measure in such cases. Simulating the case of fulfilling international orders under the same scenario of individual inventory reduction indicates a limited positive impact. A cost reduction of $ 0.03 M is indicated due to the reduction of effective inventory level by 3,832 units. This reduction is coupled with a lead time saving of 0.04 week. Although the scenario of inventory reduction has proven its positive effect in case of fulfilling international orders, the rate of saving is so limited and could hardly

convince the management level to adopt such a solution in case of local order fulfilment. Small saving of lead time measure could hardly be seen as performance improvement for the managerial level. Inventory reduction has recorded a better impact while there is a pre-defined theme of inventory replenishment and information sharing between the partners. Inventory reduction is possible when supply chain linkage is good enough so it can provide information to replace physical buffer (Porter,1990). This study has proved that the knowledge of original inventory level across the chain to match the pattern of actual orders is more beneficial since the partners are willing to establish links across the chain. Conducting an experiment to simulate the scenario of supply chain collaboration and adopt an agreed up-on level of inventory amount has proved its positive impact on cost issue. Despite the fact that collaboration scenario has a different direction of impact on effective inventory measures, for both local or international markets, it has shown cost reduction in both cases. It has led to an increased rate of 2.4 M units for effective inventory in the case of an international order fulfilment while it did illustrate a reduced rate of 0.005 M units in case of local order fulfilment. The enhanced system behaviour for the collaborative pattern should encourage the Egyptian firms to adopt it and overcome the cultural barrier. Another fact that should be taken in consideration by Egyptian producers is that incorrect storage of cotton supplies and low market demands had led to an obvious rate of material wastage. Just-In-Time might be applicable by producers to overcome wastage; but it is impractical due to delivery delay and unstable production conditions. Vender-managed inventory can be an alternative to adopt and allow small buffer advantage. In VMI, the vendor is authorised to manage the client inventory of agreed-upon stock-keeping units. Preserved benefits from VMI are indicated in reduced inventory, improved customer service and reduced order cycle time. VMI is used as "*a means of optimising supply chain performance in which the supplier has access to the customer's inventory data and is responsible for maintaining the inventory level required by the customer*" (SeeBeyond, 2001). Deploying such a strategy provides visibility across the supply chain and ensures better performance due to short lead time. The barrier that might prevent Egyptian firms from adopting this approach is represented in lack of trust between partners. Lack of collaboration is a consequence of an information holding strategy instead of sharing. The same situation is applicable to supply chains in Korea (Han, Kwon, Bae and Sung, 2002).

Since Egyptian producers do not pay attention to the cost factor and maintain large buffers of supplies to guarantee smooth operations, downstream partners should pay attention to

held inventory and distribution time. Timing is a critical factor and does impact global competitive advantage for each firm, providing the right product in the right time is the major objective of each supply chain (Leo and Kelly, 2001). Timing can provide the firm with a long and short term cost advantage (Porter, 1990). The simulation experiment used in this study confirms that a reduction of final product delivery time will be beneficial to firms that adopt a mass customisation approach to fulfil international orders. It shows a positive effect on both lead time and cost measures. For instance, a reduction of a final product delivery of one week will result in $ 2.61 M cost reduction and 20 week reduction of lead time. On the other hand, while uncertainty is imposed on delivery time due to supplier performance and logistic performance, the company attempts eliminate its effect of production delay and store as much supplies as possible for next few months. But when it comes to a special requirement, a long lead time is indicated for imported supplies. Replenishment policy is enacted by producers to replace any reduction in inventory. The huge inventory amount kept by a firm is an indicator of asset growth. Despite that, inventory reduction is supposed to be obvious while adopting customisation (Prasad et al., 2005), demand variation combined with limited availability of local supplied cotton, fluctuating procurement prices and an unreliable logistics system have contributed to diminishing this advantage by domestic producers. Based on my empirical study, diversity of procurements is considered an extremely important barrier for mass customisation success, even more than mass production approach. This emphasises the need for conducting collaborative activities with suppliers to achieve success. The above mentioned study, which was concerned with mass customisation and mass production differentiation, indicates the need of information exchange, integrated platform with supplier and correlated operations as a requirement for customisation deployment. Simulating the case of supply chain visibility and collaborative pattern proved the same results. Focusing on internal organisational behaviour could not provide performance improvement, unless it was coupled with an integrative approach across the chain.

Downstream partners could consider approaches such as cross-docking. A cross-docking approach is used by global manufacturers worldwide to capture the advantage of inventory shift. "*Vendor compliance program give more control and visibility into what's coming into their systems*" (Blanchard, 2007). Cross docking is more concerned with the ability to receive and re-deliver products with limited time constraints. While cross docking could save time consumed in distribution and eliminate the need for inventory buffer,

applicability of this approach depends on the close relationship between partners and information sharing which do not exist.

Production facilities could not be excluded as a major barrier. The need for further investment in machinery and recent production technology are indicated as obstacles by the main players in textile exports. While Eritrean manufacturing does suffer from old machinery, which exceeds more than 25 years (Voordijk, 1999), Egyptian public sector firms indicate the same problem, which prohibits large textile producers from meeting an expected productivity. Age and limited capabilities of most of machinery in the public sector result in disabling long times staple cotton processing. Fragmented IT infrastructure, limited production capabilities and lack of trust between partners have restricted communications between partners about inventory replenishment and led to different individual patterns of production within one chain. These issues are considered indiscernible to textile chain in Egyptian industry and have caused more supply chain deficiencies. This emergence of the need for "*industrial upgrade*" as described by Magder (2005) where manufacturing units have to extend their capabilities to provide the global markets with international standards. Extending the production capacity for one of the producers cannot ensure cost reduction across the chain unless there is an obvious increment in incoming order rate. Given a machinery expansion cost of $ 250,000 to produce additional 1000 units per week, the expansion scenario reports an increased cost rate of $ 225,000 in case of fulfilling local orders and $ 380,000 to fulfil international demand. A reduced rate of lead time was concluded due to this expansion. The reduction is estimated to reach 0.08 week while fulfilling local demands and 0.22 week for international demands. Since there is no tangible benefit to be preserved as a consequence of such expansion, extending production capacity became unrealistic for decision makers. Adopting an integrative approach for product design and manufacturing could provide the chain partners with more tangible and time-reduction benefits rather than expanding one of partners' capabilities. The outcome of this scenario cannot diminish the facts related to old machineries existing in Egyptian mills and their need for a replacement. The need for recent production technologies is urgent to upgrade public sector capabilities, which are more deficient than those of private sector. Public firms admit that the older technologies used could not offer the market varieties at an acceptable quality today. Currently, €19.5 M of EU funding to restructure the spinning industry is being used by the Ministry of Investment. This fund supports restructuring the sector and retraining workers, whilst the

remainder is being used to privatise and modernise the public sector firms in Egypt. (AME Info, 2008). On the other hand, a number of producers attempt to get the benefit of tariff exemption on textile machinery and spare parts through the QIZ framework to upgrade existing capabilities.

From this study, expanding one partner's capability could not guarantee better supply chain performance. I can argue that capability extension is not sufficient for "an Industrial upgrade". As a prerequisite of this upgrade, the extension should be combined with a redesign of the supply chain operation in order to integrate interrelated activities across the chain and improve its productivity. By adopting a *"make to order"* strategy, more attention should be paid to single customers. A customer-centric approach is the reason behind the success of Dell. While buy-to-order and make-to-order adoption entails greater productivity and smaller lead time by Egyptian firms, manufacturers have to adopt flexibility and information collaboration with partners in their performance measures. Deploying a collaborative approach in design and manufacture processes as applied in collaborative product life cycle management will indeed improve supply chain performance. Management of product life cycle can provide "*quick, concurrent, coordinated and highly interactive development of the product and associated process through the collaboration of manufacture, supplier and customer*" (Blanchard, 2007). This approach requires a technological backbone between partners, development tools in addition to a willingness to collaborate (Ross, 1990- Page: 215). This can ensure a quality requirement that matches global demand and customer-driven specifications. In case of its adoption, production synchronisation will be beneficial to both producers. Although its embedded feature of real-time information exchange can enable process synchronisation and resource optimisation (Ross.1990, pp. 217), success of such application depends on the willingness to collaborate rather than on technological investment.

To compete in a global chain, partners have to integrate their activities to represent cross-functional operations across the entire chain. Integration imposes collaborative planning and forecasting between partners using efficient networks (Attorna,1998 pp.330). This can offer the best performance whilst providing rapid responsiveness to increased demand. Deploying an e-business model that could integrate the cycle of product design and development has enabled IBM to capture customer order and initialise the procurement, manufacturing and distribution cycle. The integrated frame did overcome some experienced pitfalls where the production team were involved by the end of the chain

(Blanchard, 2007). Deploying such integration between interrelated activities inside a textile chain is needed. Production facilities at each producer should not be isolated; sharing of production schedules between partners can provide them with better visibility to determine when procurements are needed and how long it needs for the final product to reach downstream partners.

The situation in Egypt differs from that of a developed country like the UK, while a number of SME's in the UK clothing industry are reluctant to invest in applications that can facilitate their interactions with partners due to the high cost needed (Adewole, 2005), leading firms in Egyptian textile industry did not indicate their intention to implement such applications. My study has proved that despite lack of well-developed IT infrastructure, which is considered as one of the major issues leading to supply chain deficiency in the investigated sector, respondents did not pay attention to such issues. Applications with limited capabilities are commonly used in Egyptian firms for automation purpose, further implementation for systems that would enable collaborative activities are still further behind. Lean manufacturing is another promising approach that can eliminate waste, reduce inventory and increase profit. The underlying principle of lean manufacturing is to develop partnership with partners to maintain small buffer of variation and allow concurrent flow to support reduction of time. More than 300 managers indicate that backsliding to old ways of working is the main obstacle behind implementing lean manufacturing, which also exists in the Egyptian textile sector (Blanchard, 2007,page: 97). There is a need to break the traditional way of doing business and face global challenges as a "*united chain*". Collaborative activities coupled with extended production capabilities could enable producer to produce their own brand name. Currently, Egyptian firms play the role of OEM (Original Equipment Manufacturer): they work within constraints that may state pre-defined supplies used in production and provide specifications of product under foreign brand. What prevents these firms from providing their own brands to global markets? It is harder to provide "Made in Egypt" products than provide "100% Egyptian cotton" fabrics. Well—known cotton and low-cost-labour aspects are feasible to be deployed by Egyptian firms to provide their domestic trademark globally. Collaborative strategies between partners should exist to facilitate the transition of the role of Egyptian mill from OEM to OBM (Original Brand Manufacturer). Samsung

executive vice president of global marketing describes the role of Samsung as OEM *"we were nobody. We were down at the commodity level ".*

Although Asian OEMs are currently supplying the global world with 40% of its needs, their capabilities of manufacturing, logistical and quality control expertise encourages a number of OEM units there to be re-directed into providing fabrics under domestic trademarks. The OEM role has helped these mills to be on-track and aware of international specifications and requirements. Asian companies believe that "*executives devote much more time to pricing and distribution than branding*". To turn into the OBM role requires quality commitment. Branding strategies do need collaborative and long-term planning. Investment in design, innovation and more resources are mandatory for firms to provide their domestic brands globally. Meeting the preferences of international markets was an issue that Honda faced and resulted in a failure of their first production in US market (Wreden, 2004). Since the conducted case studies in the Egyptian textile industry point to the lack of investment in R&D despite its perceived value, it emphasises that Egyptian firms could not move toward brand provision unless there is a comprehensive vision of a partner's role in the unified supply chain system. This vision should also be coupled with technological investment. This can ensure a rapid responsiveness to customer demand and meeting the quality standards of global markets. Long-term benefits can be perceived through providing trademark rather than commodities by OEM units. (Textile & Apparel in China, 2008).

Labour productivity is dependent on workspace conditions. The textile industry is the main contributor to the overall workforce in Egypt, with 30% of employment. International investors are expanding aboard to get the benefits of low labour costs besides production and marketing advantages. Most foreign firms that are re-directed to Egyptian mills and place their production there are looking for the availability of low-cost labour. Low-cost labour does maintain a competitive advantage to promote Egyptian textile fabrication. By 2003, labour cost had contributed positively to production, and Egypt was seen as a competitive country of the lowest cost (ITMF International Production Cost Comparison). India and Turkey have occupied top ranks within different categories by 2008, while Egypt could achieve the lowest cost in the weaving of ring yarn, which is similar to the other five countries (ITMF's International Production Cost Comparison 2008).

This indicates the need to pay more attention to the labour force in a powerful industry. Low- cost labour (around US$60 a month, Bharat Book Bureau, 2007) can provide value added in  a competitive global market (EgyTex,2008), but it cannot ensure high performance and skills needed for production or reduced material usage. A large producer which contributes 60% of Egypt textile exports has indicated that this issue is a major barrier. Trained and multitasked labour is needed to provide competitive lead time advantage for Egyptian fabrics in global markets. Multi-functional labour will be capable of handling customised production rapidly regarding machinery setting and re-configuration (Orala, Koglub and Erdisc, 2003). My empirical study confirms the need to pay more attention to the labour force in the investigated case studies. Medical insurance and preventive procedures should be provided by Egyptian authority to produce a safe workspace for more than 18 Million workers. Investment in the labour force will be beneficial when combined with employing well-known cotton to produce a qualified global product. Egyptian authority should pay attention to the labour force in a powerful sector such as the textile sector especially after two big factories were plagued in 2007 (Paul Schemm, Middle East).

Most of the time spent in procurement is spent on transportation (Blanchard, 2007). In addition to conflicting individual decisions and strategies inside the entire chain, the logistics service occupies the least important degree recognised by Egyptian firms. Delivery time is dispersed; a large buffer is used to overcome its effect on internal activities. Large firms employ their own logistics system to overcome issues related to third party participation. Investigation of Egyptian textile sector does shows similarity with that in Hong Kong (Lam and Postle, 2006).  Both do focus on their organisational activities regardless of the effect of suppliers' logistics system on their operations. They neglect its importance although it has for long been considered as a major determinant of business excellence and rapid responsiveness. My empirical study proves that overseas deliveries are more attested due to the country's infrastructure and the reliability of existing logistics systems. Magder (2005) has described logistics, transport and shipment as challenges facing exporters in Egypt. Geographical proximity of Egypt to Europe could not provide significant advantages while existing logistical issues exist. The high cost of transportation and poor infrastructure are obstacles facing exporters in Egypt. Tariffs impose one more difficulty for logistics facilities. High tariffs on imported production input, which were reduced in the 2004 regulation, had reached 10-30% before (Algomhuria Newsletter,

2004). This imposed more challenges on textile fabrics producers to procure their overseas supplies, and so they attempted to find a way out through global agreements. Through the QIZ frame, firms can get advantages of tariff elimination on textile machinery and spare parts as well as the benefit of reduction on yarn tariffs from 30% to 12%, and those on fabrics were reduced from 45% to 22%.

Transportation plays a vital role, both to deliver final product and to receive supplies. It has a great effect on product lead time. Many Egyptian firms pay less attention to this issue, though it is important and affects their supply chain. A survey conducted by an Aberdeen group of 286 firms to get feedback on their experienced pitfalls of product transportation. The outcome indicates that collaborative product transport between partners and carrier can provide a great effect on the supply chain performance. The need for concurrent activities across supply chain functions is demonstrated as an outcome of the Aberdeen study. Re-defining the best route for product delivery is necessary to time and cost optimisation. When it comes to choosing a logistics carrier, it is not about how cheaper service provision is but rather how reliable it is (Blanchard, 2007). The producers in the Egyptian textile industry employ the logistics provider either for local or international shipment based on price issues, regardless of the service reliability. Large players in industry normally own their logistics system to ensure its reliable shipment and avoid possible delay, while SMEs could not adopt the same solution.

Deploying Transportation Management Systems (TMS) offers organisations an increased level of visibility into its delivery but at the same time cost up to millions dollars (Blanchard, 2007). The investment of such applications can provide long-term benefits to the deploying firm. These applications are impractical to implement within the current fragmented platform and poor IT capabilities. More concern should be redirected to restructuring platforms of the supply chain and deploying IT systems that could change the current pattern of individual operations into associated and function-oriented operations.

## 6.2. External Environment Issues

The Egyptian firm is faced by a number of challenges that reduce its exports or expansion in local markets. This study indicates several external issues that interfere and cause existing deficiencies. These issues are represented in governmental policies, which are

coupled with market stability and county infrastructure to create a group of obstacles besides the existing organisational deficiency.

Foreign investment share in Egypt is 11.3% in 2009. It shows an increased rate of 1.3% more than in 2008. (Periodic Report Jan 2009/2008- Ministry of Investment, Egypt) New establishment in spinning and weaving sector was overwhelmed by huge competition from Chinese fabrics in local market. Reduction from 40 to 25 companies was noticed in the sector by 2007-2008 (Periodic Report Jan 2008- Ministry of Investment, Egypt). At the same time, textiles and apparel have shown a very low export rate in 2006. The declining rate was followed with gradual increase to reach 100% in some fabrics by 2008. Fibre import rates and other supplies have indicated the same pattern and show in 2008 an increased rate with 400%. (CAPMAS Report, Ministry of Trade and Industry, 2008). After the Multi-Fibre quota phase-out, QIZ has provided a replacement vacuum of Egyptian producers to reach global markets. This explains the recent growth of textile exports. Despite this the government's encouragement of new investments; a number of obstacle are there which makes investors reluctant. To see behind these figures, the government role and polices will be explored in more details.

The investigation of governmental policies and strategies in a powerful sector like textiles indicates inconsistent and misleading policies. The government could not save their industry in the face of Asian competition even in its local markets. The sudden tariff reduction which was conducted by the government in 2004 could not enable Egyptian firms to overcome a huge flow of Chinese fabrics into local markets. Lack of effective safeguards in face of a Chinese well-developed textile industry could not "*maintain the stability of production lines and employment*" that the government was looking for (Algomhouria Newsletter, 2004). Additionally, the government focused on new establishments and how to capture foreign or Arab investment without paying attention to the existing platform and limited capabilities of a major industry such as textile.

Plans for industrial upgrade coupled with supportive business climate should be given more consideration by the government as my empirical study indicates. To find a way out and get the benefit of a reduction on machinery and production input, my empirical study has illustrated a high participation and concern by firms toward global agreements such as QIZ. Organisations have been redirected to capture and maintain their quota in global

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markets. The respondents indicate that limited marketing capabilities and lack of governmental role encouraged these firms to join the QIZ. Global agreements provide these firms with the opportunity to maintain their market share in the global market while they could not maintain their domestic market share.

Regarding the firms owned by the state, these firms suffer from unplanned activities, which is more obvious in the public sector than the private one. This results in a large amount of fabrics being stored in public sector inventories without any promise for marketing. The need to restructure and innovate public firms emerges to be conducted by either privatisation or upgrading. That's why spinning companies in the private sector nowadays have became the leaders for the Egyptian fabrics export (EgyTex, 2003).

The limited infrastructure of the country has caused some deficiencies in sector performance. Environmental factors, pointed out by Voordijk (1999) in Eritrea are similar to Magder findings (2005) in Egypt. The findings of my empirical study also match such barriers and their effect on supplies and product delay. Instead of dealing with these factors, each firm attempts to turn around with another preventive policy that could ensure non-suspended operations. However, the limitation of poor infrastructure can hardly be avoided when it comes to reaching international markets. High operating costs due to road transport, the need for road maintenance, and poor and unreliable information about logistics schedules disrupt shipment operations. In addition, airport infrastructure is insufficient to properly handle air cargo exports, which result in additional delays. So firms are re-directed to sea shipments for handle their exports, which is much slower but more reliable.

Logistics systems and the infrastructure of a country can promote one region rather than another, so it could capture the interest of foreign investors. When a firm is extending its chain globally, smooth product delivery and procurement of supplies are mandatory to be provided (Blanchard, 2007). The World Bank provides investors with a Logistics Performance Index to measure the logistics "friendliness" of countries. The index provides objective data on the performance of logistics chain key components (World Bank, 2007). Logistic friendliness defines accessibility and availability of international freight operations to and from a specific country. According to Blanchard (2007), this index considers the rate of international business corruption as well as access to information,

customs and other border agencies, physical infrastructure and development of logistics service.  The overall outcome of this index shows that Egypt is ranked 97 among 150 countries with a value 2.37 out of 5.  The index indicates a poor rank for custom, infrastructure and international shipment activities. Domestic logistics cost is the best sub-factor that Egypt offers versus poor infrastructure. Regarding its competitors, India and China scored 3.07 and 3.2 out of 5 respectively.

However, a "*fragmented and underdeveloped Chinese logistic system*" that was confirmed by EFT research service (Blanchard, 2007- Page: 168) did not prohibit foreign companies from investing there. Since the approximate location of Egypt can provide a value added to investor, the need for smooth logistic services can redirect foreign firms to other competitors.  (Blanchard, 2007). Re-placing next of distribution points near a seaport can be an alternative to be considered by the Egyptian firms as a way of reducing lead time. To summarise the role of infrastructure in investigated industry sector, the poor infrastructure imposes more logistic delay in lead time, which in turn may impose production delay and a delay of final product delivery. Port efficiency was not indicated while government monopoly in maritime transport is terminated. Currently, the private sector operates most maritime activities, which includes loading, supplying, ship repair, and container handling (The Office of the United States Trade Representative, 2006).

Providing up-to-date information regarding the industry sector is the responsibility of the government. My empirical study indicates that employing out-dated resources for forecasting leads firms to overestimate their need to face unexpected demand and capture any possible opportunities for sales. A leading player in the Egyptian textile sector, which provides more than 60% of Egypt-US exports record, relies on an out-dated source of CAPMAS information. Real-time information and updates about global market demand, preference, population rate and international standard should be provided by the government. A study conducted by the Agricultural Trade Expansion Support Program (2005) in Egyptian textile and apparel industry indicated a lack of information by relevant authorities. The projection and plan of further expansion of textile and apparel industry sub-sectors, except cotton production, are missing. Furthermore, other information related to quantity operations is not available. The study has indicated as well that the government and industrial agencies did not pay attention to the informal establishment at industry and does not keep record of their number, output volume or amount of employment.

Managerial levels blame the government for its misleading strategies. These strategies impose more difficulties to fulfil textile procurement. While the Ministry of Agriculture removed restrictions on exporting cotton in 2004, it did commit to making cotton varieties more available for local mills (The Office of the United States Trade Representative, 2006). The Gap in the needs for cotton requirements is indicated by Egyptian firms. These firms turned to procure most of their cotton supplies from overseas, which prohibits the value added of Egyptian cotton quality. This surge rate was represented in $530 M by 2008 for imported cotton. (Import & Export Report-Ministry of Trade and Investment, 2008). Although Egyptian cotton enjoys a well-known quality, Egyptian firms can rarely employ long and medium-long staple cotton, due to the high export rate and high production capabilities needed for their processing. The government believes that the "*Egyptian cotton logo on home furnishings, such as sheets, towels, and bed linens, and on other textiles in the United States would be beneficial*". The inconsistent policy which was conducted by the government leads a conflict of goals between Egyptian firms and the government.

While local procurements were reduced due to the limited availability of Egyptian cotton, high quality cotton was rarely employed by local firms to produce Egyptian fabrics. At the same time, while the interest of foreigners to invest in Egyptian textile mills is due to the well-known quality of Egyptian cotton and the availability of low cost labour, excluding an attractive factor that is associated with material quality cannot ensure the survival of Egyptian fabrics in global markets. Therefore, the government should pay more attention to long-term benefits rather than short-term ones. The Egyptian cotton trademark, which was launched in 2001 to promote Egyptian cotton products to consumers worldwide (EgyTex, 2006), could not ensure the surge of Egyptian fabrics exports due to lack of cotton availability. Since there is an increase in US exports by Egyptian firms, which is due to the QIZ agreement, The Egyptian fabrics should sustain their value added advantage of employing high quality Egyptian cotton to maintain their market share after quota phase-out. This may encourage Egyptian firms to provide domestic brands and become OBM. Instead of adopting the role of OEM, that is providing the global market with domestic built in-components under an international brand or exporting their quota of cotton to global market, the government should pay more attention to save the identity of Egyptian fabrics, and to provide an appropriate business climate and to make resources to achieve that.

**6.3 Supply Chain Communication**

Since the supply chain is defined as a network of organisations which includes linkages between upstream and downstream partners (Christopher, 1992), communication between business partners is considered as a key factor for supply chain optimisation. This research programme shows that existing platform of supply chain in textile industry suffers from poor communications and exchange of information. It is obvious that organisations inside the chain could not manage a coordinated flow of information which can trigger the material movement. Limited IT infrastructure limits the firm capabilities and does not provide a good platform for data sharing inside the organisation. Companies are used to exchanging information with their partners by using telephone calls, letters, telex, faxes. Through that real time communication is mandatory between partners to adopt customisation approaches, the respondents of my empirical study did not consider that enhancing communication with their business partners as a critical issue which may affect supply chain performance. Companies do not pay attention to establishing long-term communication with their partners. The reasons behind that might be demonstrated by the fear to commit themselves with large firms; it could also be a trust issue or poor infrastructure. Conflicting business cultures, inconsistent goals and values interfere when considering business collaboration as a value added advantage. Pooling resources and sharing business plans are still far behind for organizations in the textile sector. While there is no common vision or commitment for further collaboration between the chains' partners, communication is more likely to be "Ad-hoc" transitions. Regarding Liu and Kumar's (2003) classification of Inter-Organisational Information Systems (IOS) communication, sequential communication channels are demonstrated in the case of textile producers. The order of information is moving upstream and is being exchanged in a one-way form, while physical goods are moving downstream to reach the customers. The customer order is being transferred to reach the supplier site. Demand forecasting and collaborative activities are excluded from partner communications. Each partner handles the forecasting process on individual basis. Consequently, there are multiple sources of demand forecasting in the same chain, which impose difficulties in integration. Reliance on different sources of forecasting led to demand amplification, which in turn caused data distortion. Therefore, many researchers emphasise the need to feed each supply partner with the actual demand using a centralised hub. This should be merged in pre-defined channels for communication between partners to ensure smooth information flow. It is proved in the literature that visible information could trigger the movement of goods and

provide the supply chain with improved performance. My simulation experiments confirm that lack of information visibility leads to having individual patterns inside the entire chain and increase the level of decision uncertainty, which negatively affects supply chain performance. Simulating the scenario of partner collaboration and information visibility leads to better supply chain performance for both international and local demand fulfilment. Reduction of cost by $1.307 M coupled with a lead time reduction of 254 weeks is found when fulfilling local demands. As for fulfilling international demand, a saving of 177 week in total lead time is indicated while simulating the same scenario of collaboration. This study concludes that enabling information visibility under the scenario of partner collaboration provides the supply chain with tangible and intangible benefits. Although the success of such a scenario depends on the willingness to share the data, textile firms in Egypt are reluctant to share such data with their partners due to data confidentiality. Respondents to my empirical study did not indicate a need to enhance their communication means with business partners. External supplier pressure and trust issues were highly indicated during the empirical study as major interfering issues. Respondents illustrate that keeping large stock will ensure un-suspended production activities. In the same time, it avoids the external pressure associated with suppliers and takes off the communication cost and burden. On the other hand, the problematique structure based on my empirical study and structured using ISM approach, indicates that lack of communication and integration between partners is one of the major issues that led to existing deficiency, while the respondents did not emphasis its importance. This contradictory fact could refer to the lack of awareness about the supply chain concept and the perceived benefits behind its collaboration. From the perspective of respondents, there is no need to invest in systems or commit with business partners while their operations can be handled in the traditional way. "Ad-hoc" transactions could fit their supply requirements and large buffer could secure their needs during unexpected demands or instability of procurement prices or delivery.

Therefore, the manual communication channel is not the only barrier for lack of information visibility. The comprehensive understanding of supply chain concept and the willingness to share information have been inferred to prohibit such communication between business partners and change it to an "Ad-hoc" one. Willingness to collaborate and commit with business partners is mandatory to solve that out. Supply chain structure

and re-design should advance such business collaboration. That is why the next section is going to discuss an issue related to supply chain design and structure.

## 6.4 Supply Chain Design and Structure

Supply chain is best defined as a network or a web to handle supply chain activities. To enhance communication in a supply chain, supply chain entities should be first visualised and the possible communication channels in between should be pre-defined. Identifying supply chain participants and processes that should be coordinated is mandatory to manage supply chain activities (Lambert and Cooper, 2000). Supply chain design deals with establishing an efficient platform needed to handle supply chain operations and responds rapidly to customer demands. Therefore, defining the required infrastructure for the supply chain, allocating production mills, distribution centres and transportation nodes should match the customer requirement and consider how to respond rapidly to these requirements (Sharifi et al., 2006). The current situation points to the existence of poor supply chain structure and emergent need for supply chain re-design. Consequently, poor communication channel and data amplification are obvious in these supply chains. Since the literature emphasised the importance of supply chain structure and indicated that data distortion can be eliminated with alternate design of traditional supply chain (Christiaanse and Kumar, 2000), this research programme has paid attention to the issue of supply chain design, despite the fact that respondents to the empirical study did not consider it as an interfering issue in their operations. The respondents claim that dealing with business partners is limited to inventory replenish or product delivery, and that there is no need for further interactions. None of respondents would be able to define their supply chain partners whom they had established a long-term collaboration with. Dealing with low-cost suppliers and delivering the final product where there is a chance to capture any market opportunity is the main concern for these organisations. This emphasises poor supply chain design which exists in Egyptian textile supply chains. Although poor supply chain design had been indicated by respondents to occur in the earliest stages of supply chain deficiency, a comprehensive understanding of supply chain structuring is not clear enough, since it is not based on a common vision or long-term collaboration. This issue is more correlated with the awareness of the supply chain concept and the comprehensive understanding of its perceived values. My simulation experiments contradict the perspective of textile producers in Egypt and confirm that collaborative supply chain design and smooth information flow is quite enough to provide an obvious improvement in

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supply chain performance. The problematique structure of ISM approach confirms the driving power of this issue and its high dependency. This manifests the need to re-structure and design existing textile supply chains in Egypt. Sharifi (2006) summarized a number of considerations to follow in supply chain design. Regarding these considerations, to re-design the existing supply chain in textile sector, the Egyptian producers should start from domestic and global market requirements. Analysing such requirements will provide decision makers with a comprehensive understanding of user requirement in textile fabrics. Based on these requirements, supply chain partners should define a set of measurements for supply chain performance. These measures could be: cost-effective activities, rapid responsiveness to customer order and high quality constraints. Defining supply chain entities, placing their operations and indicating the links in between should match this market analysis. Supply chain structure in Egyptian textile sector has defects pointed out by Sharifi et al. (2006). These issues are: unclear value proposition, supplier power and unwillingness to communicate between the partners.

A similar framework proposed by International Trading Organisation (Basmaci, 2003) emphasises the need for an integrative platform to establish a collaborative pattern between the partners." Integrative mechanisms" of supply chain design proposed by Basmaci (2003) should be based on common visions and objectives. Therefore, collaboration between partners is a mandatory issue to adopt between the textile fabrics providers. The importance of partner collaboration and the barriers that face its implementation are being discussed in next section.

## 6.5. Collaboration and Cultural issues

Cultural issues have interfered to affect organisation policy and their readiness for changes. These cultural issues were more obvious during study data collection. Companies are reluctant to explore any issues related to their organisational performance and especially their deficiencies. The same applied to their policy with partners, which resulted in a fragmented platform of supply chain. Lack of information sharing between even domestic partners in Egyptian has negatively affected supply chain performance as it exists in Hong Kong (Lam and Postle, 2006). The trust issue is the main barrier behind that (Adewole, 2005).

The current situation of textile fabrics in Egypt shows that cultural issues affect the firm's perception towards collaborative activities and adoption of IT applications to achieve that. Culture issues and lack of awareness about IT benefits interfered in investing in innovated solutions, not only between partners but even inside organisational boundaries. The concept of extended enterprise is needed to implement the automated process and ensure smooth operation across the chain. Firms should be familiar with the extended enterprise approach which integrates the suppliers, instead of excluding them as external parties.

Optimising supply chain activities within the textile sector could be managed with a collaborative pattern between partners, as Ross (2003) recommends. Supply chain linkages indicate by Porter (1998), as discussed in the introductory chapter, should be considered by textile producers. Egyptian partners inside the single chain need to establish more effective ways to handle transactions rapidly through electronic communications and get benefit from Egypt's geographic advantages and its position near global markets.

As Bentz pointed out, being unfamiliar with the concept of collaboration, Egyptian mangers did not indicate their intention to move towards collaborative activities (Blanchard, 2007), consequently managerial commitment or team-oriented activities will hardly exist. Managerial commitment is an important pillar to support such collaboration, as Fawcett, O. M. (2006) indicated. While short term planning and activities-orientated focus represent the status of existing textile supply chain, based on Yin and Khoo's (2007) classification of SCM, Supply chain design and collaborative demand planning approach do not capture the interest of managerial levels for implementation. Focusing on short-term profit redirects many Egyptian firms to keep away from implementing strategic solutions that might address long-term benefits. Since the expansion of sales may require a larger inventory to achieve short-term profit, inventory reduction is a strategic objective which can be employed for long-term benefits. This conflict between long and short term objective was explored by Yin and Khoo (2007) and employed to define what Egyptian firms pay attention to. On the level of SCM maturity levels which were defined by Trkman et al. (2007), the textile chain in Egyptian industry represent the second level where supply chain processes are defined but were not adopted. Organizational operations are still conducted traditionally on individual basis.

According to the evolution stages of supply chain management development (Ross, 2003), textile firms in Egypt can be aligned to the first stage where the effect of logistics activities is excluded and a lack of integration among supply chain nodes exists. Optimising logistics activities and adopting a move towards collaborative operation are hardly considered as further strategic opportunities for these firms. Cultural issues are considered leading factors in the lack of collaborative operations in developing countries, this matches what Blanchard (2007) pointed out as cultural differences. Collaboration is still unknown in low-cost countries. Therefore, many studies indicate the differences of supply chain implementation and requirement regarding the environment for implementation. Developing countries have different requirements due to an unstable economy, poor technological capabilities, limited infrastructure and lack of trust between partners (Orala et al., 2003; Han et al., 2002).

Trust issues between supply chain partners are part of an unpredictable pattern of behaviour which is similar to the Kwon and Suh's (2005) study. This leads us to conclude that it is not about deploying a best-of-shelf SCM package; it is more about trust and ability to commit. Purchasing an ERP module by a leading player in textiles was not coupled by a willingness to share or facilitate co-ordination with supplier. Information confidentiality prohibits the value added of such module implementation and thus was used for calculation purposes. It is not restricted to IT adoption and limited capabilities of platform that do face textile industry optimisation, rather it is their willing to collaborate and share information. To optimise supply chain activities, commitment from both parties' coupled with trust between supply chain trading partners, is needed. IT tools are mandatory to integrate such platform at such a stage.

The four steps of a business partner defined by Maister and discussed in introductory chapter are not available in the Egyptian environment. More precisely, they are not considered as prerequisites for win-win achievements. Efficiency is measured in various ways: according to the environment of implementation which embeds cultural differences (Simchi et al., 2008). While rapid responsiveness measures are employed in developed countries, these measures are excluded in developing countries due to uncontrollable and frozen external factors. The belief that an efficient channel for communication is vital is not yet accepted. Late deliveries can be considered as a major issue by developed countries, while it is not vital in developing countries. The same applies for the

collaboration concept. Benefits expected behind partner collaboration could support firms to overcome difficulties of external environment. Awareness of such benefits should be promoted by the Ministry Industry at the governing country.

There is a need to change the beliefs related to large inventory buffer as "*indictor for assets growth*" rather than being an" *additional holding Cost*". In addition, looking at a long lead time as "*uncontrollable and being managed with more inventory*" rather than exploring factors behind it is important to figure out if it is related to external factors or existing supplier performance. Resistance to change is a perquisite for IT changing investment. All these beliefs interfere to impose an "*information holding*" policy rather than "*information sharing*".

Limited opportunities of collaboration between partners prevent the perceived advantages that can be gained through it. Rapid responsiveness and reduced lead time can be achieved if partners decide to integrate with each other. Especially when it comes to a customised product, build-to-order or make-to-order strategies which are deployed by an Egyptian mill to fulfil local and global markets can show better performance when a supply chain platform is integrated. This study has indicated that cost and lead time reduction are obtained by a supply chain platform. Collaborative and integrated operations in addition to supplier integration are indicated as requirements for the customisation approach (Prasad et al., 2005). Even if lead time reduction is not considered by Egyptian firms as a critical measure to fulfil local orders, foreign investors are not willing to place their offshore activities there without optimising the order's lead time.

The proposed structure of supply chain platform can provide more control on supply delivery, patterns of behaviour and an increased level of visibility. This structure can ensure the best behaviour regarding tested solutions for the involved partners and suppliers. The Aberdeen group and the Magazine of Logistics Today reveal that the challenges related to supplier management are: reliability of order fulfilment, failure to provide accurate and timely information, increased lead time and difficulties in integration due to technical capabilities (Blanchard, 2007). These issues should be considered by producers as vital measures for existing supplier performance. Each partner focuses on its internal performance and look at the performance of other partners as an uncountable pattern. Communication between producers and suppliers is illustrated in inventory

replenishment without any sort of information sharing. Long lead time is considered to be manageable with high kept inventory. Even if a supplier indicated a pitfall through a long lead time or reduced reliability, cost measures did not prevent the producer from switching to other possible alternatives.

My study has proved that an individual pattern between textile partners and inconsistent strategies in addition to lack of collaboration opportunities negatively affect supply chain performance. Partners inside the entire chain did not indicate collaborative vision of lead time reduction or rapid responsiveness. They neglect the effect of supplies delay, logistic reliability or supplier performance, and substitute that with a large inventory buffer. The study findings prove what Ross (2003) indicated, that internal function re-engineering and its redundancy elimination provide limited benefits, unless this re-engineering process links firms to their partners.

There is a need to overcome barriers of collaboration, which were defined by Blanchard (2007). These barriers are represented in: technology and data barriers, difficulties in measuring performance, unclear value proposition, data security and lack of trust. Unfortunately, all these difficulties are obvious in the textile industry and do need a lot of efforts by organisations to be eliminated. According to Lam and Postle's (2006) study, an SCM resource centre was developed in Hong Kong based on a survey indicating the lack of awareness about the SCM concept. Egypt needs to establish an authority that can propagate the SCM concept as Hong Kong did and encourage organisations to further collaborate. A number of steps are defined by Blanchard to activate the collaboration approach. First of all, collaboration with a partner should fit into a given firm's strategy. Qualifying partner collaboration and evaluating its behaviour will ensure best performance among available solutions. An information system can play an important role in providing real time information between partners.

### 6.6. IT capabilities

While SCM is described as a "*tactical and strategic management philosophy that seeks to network the collective productive capabilities and resource of intersecting supply channel systems through the application of internet technologies in order to synchronise channel capacities and deliver customer value*" (Ross, 2003), the availability of synchronised and automated channels were not proven by study findings. While it is hard for an SME in UK

clothing industry to change the traditional way of doing business and pay attention to IT capabilities (Adewole, 2005), most Egyptian textile producers do have a similar issue. Issues related to high technology cost impose significant difficulty for that.

El Sayed and Westrup (2003) conducted a study to investigate the attitudes of Egyptian firms toward IT development. This study relied on one case and statements of a governmental vision to conclude a promising future for IT development and adoption by Egyptian firms. The current environment does not indicate that Egyptian firms are more willing to deploy a promising IT application for collaborative activities. These firms do not indicate willingness for data sharing which is needed as a primarily step for investments in further IT collaborative applications. Fragmented platforms inside organisations could hardly ensure an integrated platform inside that chain. Egypt represents low-level readiness for e-business which was defined by Economist Intelligent Unit (Tanburn and Singh, 2001). The study indicates that developing countries have lately implemented ICT in spite its well-known benefits. Culture issues related to resistance toward change and awareness of IT implementation are also playing a major role to prevent its rapid adoption. McConnell indicated in his studies (2000 and 2001) the need to enhance connectivity, human capital, e-business climate in addition to e-leadership and information security (Rizk, 2004).

This study confirms what Salman (2004) found about state-of-art IT perspectives in developing countries. Many of the issues such as: lack of basic business automation, poor management skills and lack of e-commerce integration are most obvious in the Egyptian textile sector. Poor infrastructure limits communications inside organisational boundaries. The study does not agree with Simchi et al. (2008) that availability of information systems tools, POS and automation tools exist in retailers' sites. Leading firms can provide a good infrastructure for an efficient system depending on the selection of the right ISP and package. SDLC should be followed to develop a built-in application. This can ensure user involvement, accurate requirement and specification of hardware and needed infrastructure. Pre-estimation of ROI is badly needed before deploying best-off-shelf application to ensure its compatibility and adequacy of implemented environment.

While developing countries have technological dependence on developed countries, neglecting cultural and economic issues, and supply chain requirements leads to the failure of technology transfer. Ergonomics should be considered, as it provides adjustment of

foreign into local practices to cater for the country's culture. The study indicates that cultural factors should capture more attention prior to the adoption of information system applications in Egyptian industry, which is similar to the Turkish case. In addition to environmental and infrastructure considerations, Erensal and Albayrak (2008) have conducted a study in Turkey and defined a number of cultural factors that affect technology transfer. These factors include: attitudes towards work, technology and working habits which are obvious in the Egyptian sector as well.

The IT application is limited to automate some internal activities such as procurement, finance and HR in leading firms. Adopting best-off-shelf or customised application is limited to leading firms. SMEs could hardly cover their expenses to extend their budget for IT investments. Applications of office automation are the only systems used. The main issue facing these firms is that there is no predefined strategy or plan for information system implementation. The reason behind that is that long-term planning is not regarded by managerial levels as much as focusing on short-term return. The powerful sale force of IT companies may lead senior managers to implement their prompted systems without estimating their ROI. Defining appropriate infrastructure, hardware compatibility and needed functionality may arise during the implementation phase due to an inaccurate implementation plan and lack of customer involvement. While firms in developing countries are function-oriented rather than integrative-approach oriented, IT implementation in such firms was used for automation process. Leading firms with large budgets customise IS applications to simulate the manual system.

IT adoption without process re-design cannot ensure full utilisation of IT features and capture its promising benefits. Business processes should be restructured to represent the collaborative pattern between organisations in the chain and reduce non-value added activities. Current environments do not reflect such facts. Collaborative processes inside the organisation boundaries were not automated and information is not shared due to data sensitivity. IT applications, when applied to individual organisations were not deployed for integrated platform facilitates. The re-designing of business processes can provide the Egyptian industry with full utilisation of IT capabilities. Resistance toward change in the process cycle has badly interfered to prevent value added characteristics of IT implementation. Confidentiality of data divided the entire case studies into a fragmented platform where each boundary is limited with data security and sensitivity. The deployed

systems are illustrated in a simple form of data entry and storage. Periodic reports or queries are dreams for many firms behind adopting information systems in future. Costs of investment in addition to management or employee resistance are the main barriers for IT implementation in many firms.

Salman (2004) had indicated a number of barriers that prevent implementing efficient supply chain in a developing country such as Bangladesh. These barriers are indicated by the huge investment of EDI, cultural barriers for further collaboration and re-engineering the supply chain through a combination of information technology and business process improvement. These issues are as applicable to Egyptian industry as those in Bangladesh. The findings indicate different priorities of IT barriers in developing countries different from those which Jharkharia and Shankar (2005) found in developed countries. Lack of trust, low priority and poor IT infrastructure are the most important issues that lead to such deficiency. Deploying IT capabilities for integrative channels with suppliers is not considered as far by textile firms. IT investment should be placed in company strategy for the long term.

IT implementation is a strategic tool that imposes not only IT development between partners but also process improvement along the chain (Auramo et al., 2005). While many firms are aware of IT importance, value added features of decision or executive support are still invisible and are not considered by managerial levels. Technology may mean office support tools for many firms. IT awareness and hidden capabilities should be more prompted in industrial fields. Perceived benefits regarding decision making and collaboration capabilities should be prompted as well. Its implementation should be combined with the availability of information. This awareness should be coupled by cultural change towards an integrative approach. This combination will enable the deployment of Collaborative Planning, Forecasting and Replenishment (CPFR) applications. While applicability of JIT is impossible due to poor country infrastructure, the vendor-managed inventory is an efficient approach to reduce inventory buffer along the chain. Electronic collaboration between partners can provide better visibility through the chain and can ensure smooth supplies or products delivery. Recent government permission of GPS gadget usage (Al-Ahram weekly, 2009) can provide value added advantages to logistic partners to optimise their deliveries through a possible integration and improved visibility inside the chain. Through real-time sharing of points of sales transactions,

companies can optimise their forecasting and replenishment decision regarding real dataset. Internet technologies can provide a perfect platform to host such collaboration. The proposed IT deployment can be integrated with an e-commerce gate that can easily capture global interest for offshore placement. The marking portal can provide firms with more access to global markets and their needs.

Prompting the concept of integrated platform discussed above can facilitate the move towards domestic brand providers rather than playing the role of OEM. This integrated platform can ensure rapid responsiveness to global market needs and provide a better service. Such implementation will reduce product delivery duration and reflect cost reduction in addition optimising lead time. Unfortunately, facts point out that providing a customised product requires an integrated information system to link the internal work-groups along the chain (Silveira, Borenstein and Fogliatto, 2001), Firms in textile sector did not pay attention to establish automated channels with their partners. Willingness to collaborate and share data is missing and should be antecedent to deploying an integrated technological platform between partners.

# Chapter Seven

## Conclusion

### 7.1. Introduction

Organisations attempt to maximise their profit and sales as well as maintain high market share. Focusing on internal activities to enhance the efficiency of such activities does not ensure performance excellence if the linkage between these activities and the partners' role is neglected. Supply chain integration plays a vital role in that, a synchronous supply chain can guarantee high performance levels for its encompassed activities. To accomplish these targets, many issues have to be addressed. These issues vary from material handling delay, long lead time, high production cost, large inventory buffer, poor product quality and consequently, increased cycle time. To tackle supply chain issues in developing countries, supplementary factors related to their economical strength, culture factors, degree of supply chain integration, managerial and marketing expertise and IT infrastructure have to be combined with generic supply chain issues.

### 7.2. Research Overview

The main objective of this research is to define the challenges that face implementing successful supply chains in Egypt and to propose solutions that might improve supply chain performance there. The dependencies of these challenges are indicated and the stages of supply chain deficiency in Egyptian textile sector are represented. The study addresses the following research questions:

1. *"What are the challenges that face the successful implementation of the supply chain in Egyptian Textile sector?"*

   A-*"What is the cycle of supply chain deficiency in the Egyptian Textile industry?"*

   B-*"What are the major deficiencies that lead to other supply chain deficiencies in the Egyptian Textile sector?"*

   C- *"What are the minor deficiencies that occur as consequences of other supply chain deficiencies in the Egyptian Textile sector?"*

   D- *"Do the external issues aggravate the internal deficiencies of supply chain activities in the Egyptian textile sector?"*

2. *"What is the best solution that can provide the textile supply chain in Egypt with rapid responsiveness and cost reduction?"*

In order to address these questions, this research investigated a number of issues such as supply chain activities, IT role in these supply chain activities, the degree of supply chain integration, information flow visibility and partner collaborative activities. Environmental issues were examined in the study to ascertain organisation performance and collaboration issues. The study related a number of these issues to existing deficiencies. Cultural issues in addition to the role of the supporting infrastructure and the government are dominant issues.

The conducted empirical study for exploratory purposes validates the qualitative finding with quantitative approaches. A mixed method was adopted in this research programme for initiation and complementarily purposes. The study hypotheses were initialised based on the exploratory case study and tested using structured surveys. An in-depth explanation of the deficiencies was revealed through case studies. Open-ended interviews and structured surveys were used as a source of evidence to reach the study findings. Simulation experiments were then run to examine the effect of internal deficiencies on supply chain performance. Inventory reduction, procurement time and production expansion were considered as possible alternatives to provide solutions. The outcome of simulation experiments shows a contradictory finding that does not match the respondent's perspectives. Furthermore, a collaborative pattern of supply chain design was tested to indicate its impact on supply chain performance. This pattern proved to have a positive impact on cost, lead time and inventory reduction.

**7.3 Research Life Cycle**

The research defined an initial theoretical proposition based on a literature survey due to lack of research in the investigated environment. This proposition indicates the fact that the *"lack of seamless information flow is a major issue which leads to other supply chain deficiencies"*. An exploratory case study was conducted to investigate the relevance of this proposition to the investigated supply chain deficiencies in the investigated sector and reveal the hidden propositions. The issues concluded from case study conduction and their weight were structured using ISM methodology to indicate their dependencies and driving power. A stage based model of supply chain deficiency was indicated based on ISM structuring. A framework of supply chain deficiencies and their leading issues was developed based on this model. Issues related to supply chain design and integration have proved to be major issues that have led to the existing deficiencies while the large

inventory buffer and the limited market share were confirmed to be consequence of other supply chain deficiencies. In order to generalise the outcome, a number of hypotheses were initialised and tested using a survey approach. A set of hypotheses was used to indicate whether each issue could be considered as a leading or non-leading issue in the existing supply chain deficiencies in the Egyptian textile sector. Another set of hypotheses was used to validate the stage of supply chain deficiencies. The framework of supply chain deficiencies in the Egyptian textile industry was restructured to indicate the validated outcome of the empirical study. At this stage, the research could provide a validated answer to the main research question" *What are the challenges that face the successful implementation of the supply chain in Egyptian Textile sector?"* The framework indicates the important internal deficiencies that were concluded from this empirical study. Issues related to supply chain infrastructure and partnership prove their significance on supply chain performance while internal deficiencies are a consequence of lack of supply chain awareness and fragmented supply chain infrastructure there.

A simulation technique was used to the impact the policy change on existing supply chain performance. A number of alternative solutions were proposed and tested using the system dynamic approach. The impact of individual decisions of organisations inside the supply chain was tested to show its effect on supply chain cost and responsiveness measures. How the unreliable logistics had badly affected the cost and responsiveness of supply chain was demonstrated in the simulation experiments. The effect of feeding each supply chain tier with actual demand was also examined using the system dynamic approach and indicated its obvious improvement of supply chain cost and responsiveness. Based on different simulation experiments, the research could reach a proper answer to the question of *"What is the best solution that can provide the textile supply chain in Egypt with rapid responsiveness and cost reduction?"* Enabling a smooth information flow across the chain proved its' positive impact on supply chain cost and responsiveness measures. The individual pattern of behaviour did not prove its significance in opposition to a collaborative pattern amongst the partners. Focusing on internal deficiencies could not provide the partners with an improved pattern of behaviour. Collaborative decisions could enable the industry worker to overcome the negative effect of governmental role and the country's infrastructure.

**7.4 Knowledge Contribution**

This work provides solid causal bases for supply chain deficiencies in the Egyptian textile sector. The research contributions are demonstrated as following:

1- Stage-based model for supply chain deficiency in Egyptian Textile sector;

    A- Define major and minor issues that lead to existing deficiencies of the textile industry supply chain in Egypt;

        1. Supply chain design, integration and IT infrastructure are considered as major issue that lead to existing deficiencies of the textile industry supply chain in Egypt despite the low level assigned of their importance

        2. Production and procurement issues are considered as dependant one on poor supply chain design, IT infrastructure and unreliable forecasting despite the high level assigned of their importance

        3. Prove the lack of awareness of supply chain concept in Egyptian industries and importance of partnerships.

    B- Define dependency and driving power among internal deficiencies in the Egyptian textile supply chain

2- Framework indicates supply chain deficiencies and their leading factors in Egypt.

    A- Define how the role of the government aggravates the internal deficiencies of the textile supply chain in Egypt.

    B- Define how the country's poor infrastructure aggravates the internal deficiencies of the textile supply chain in Egypt.

3- Test the possible policies that can be conducted by textile fabricators and define their impact on supply chain cost and responsiveness;

    A- Prove that the individual decisions of supply chain partners cannot bring about improvement to supply chain cost and responsiveness;

    B- Prove the negative impact of an unreliable logistic system on supply chain responsiveness and cost measures.

    C- Test the impact of improving the internal deficiencies of supply chain on supply chain responsiveness and cost measures.

        a. Prove that the policy of expanding the production' capacity cannot bring about improvement to supply chain cost and responsiveness;

        b. Prove that the individual policy of inventory reduction cannot bring about improvement to supply chain cost and responsiveness;

    D- Test the impact of the collaborative pattern among supply chain partners and prove its positive impact on supply chain responsiveness and cost measures.

The study concludes that textile producers did not understand the actual causes behind their industry deficiencies. The management there focus mainly on internal deficiencies related to manufacturing and procurement operations while neglecting entirely the importance of establishing a long partnership and its effect on their internal operations. This study pointed out that government decision affected the textile industry in Egypt adversely. The nonsense of exporting excellent cotton had affected the textile industry in Egypt negatively. This led to an obvious gap in cotton procurements and redirects the domestic producers to outsource their needs of poor quality cotton. This study emphasises as well that awareness of supply chain concepts and collaborative issues is missing in the investigated environment. Focusing on end-customer and how to optimise lead time does not arouse the interest of these producers. Responding rapidly to customer' demands while maintaining a small buffer and low cost operations is a target for industrial organisations in developed countries. Facts confirm that firms in developing countries focus more on tangible cost issues rather than on rapid responsiveness and hidden costs. The managerial levels in these firms address such targets with attempts to reduce labour wages, downsize or minimise supply costs rather than deal with a large kept buffer. In contrast, an increased buffer represents asset growth from a managerial perspective. In spite of the fact that integrative activities with partners could easily ensure reduced buffer and reliable procurement, the concept of collaborative channels and information sharing is excluded. Realisation of the organisational role in the entire chain is not indicated as a priority.

The empirical studies used confirm that textile fabricators in Egypt are not aware of the main issues causing the existing deficiencies. The outcome of the case studies and the conducted survey are matched to confirm that issues related to production and diversity of procurement are important and had a great effect on supply chain performance. These indicated that supply chain structure and design are not an issue that the Egyptian textile fabricators suffer from. Issues related to delivery performance and inventory size are given a low priority by the textile fabricators. The case studies and survey conducted through this study indicate a contradictory outcome when matched with the simulation outcome. While the empirical study's respondents indicated production and procurements issues as major causes to supply chain deficiencies, simulation experiments show a contradictory outcome in that issues related to supply chain design and integration are major causes behind the

existing supply chain performance. The simulation experiments prove that restructuring the supply chain to indicate a collaborative pattern between partners and to enable visible information flow along the chain has improved supply chain performance. The simulation outcome is matched to the other study contributions. For example, Joshi (2000) proved the same finding in his study. He confirmed that visible information flow across the chain provides the chain with the best performance. Joshi used different scenarios of simulation experiments to reach the same conclusion. Towill (1991 and Towill, et.al. (1992) confirmed that using simulation experiments that smooth information flow across the chain is the most effective strategy to be adopted in the supply chain. Jones and Towill (1997) concluded that feeding each tier of the supply chain with real order information could reduce the order's amplification across the chain and provide an improved supply chain performance. Jones and Towill's findings were proved in this research to be the most effective solution for existing supply chain deficiencies in the textile sector. The importance of supply chain design and the need for its restructuring was concluded from this study and matched is keeping with what Harrison (2001) and Freiwald (2005) emphasised. They indicated in their studies that the supply chain design and structure should be addressed to investigate the links between different supply chain activities and ensure a good performance. The great effect of cross operations and collaborative pattern on supply chain performance has been proved by Freiwald (2005). This study also indicates that the reduction of order lead time affects the Egyptian textile fabricators performance positively as Magder (2005) proved in his study. External issues related to the limited infrastructure of the country and poor governmental involvement are proved, by both the research in hand and Magders', to aggravate supply chain deficiencies in textile sector. To face the global competition, the government has to support the textile industry and ensure the availability of domestic producers' procurements of the well-known Egyptian cotton. Promoting an Egyptian cotton trademark globally will not get a valuable return while the Egyptian mills could not employ this cotton and have to import high quality materialsn from abroad. Government has to consider these issues while constructing their own policies. The study reached a number of recommendations which the Egyptian government should take into consideration. These recommendations are represented in the following:

- Establish a governmental authority to be responsible for the industrial supply chain. This authority should deal with providing needed resources and legal consultation to these partners. The authority should handle the question of how to overcome

issues related to partner collaboration. This authority should broadcast awareness and of the importance of the supply chain concept to the Egyptian industrial sectors.

- The government should provide a source of updated information regarding the current state of their industrial sectors, available resource and raw material. This information should be centralised for the concerned governmental authorities and the organisation in the associated industrial sectors. Comprehensive studies regarding global competition and how to face this competition should be provided by the governmentally assigned authority. Providing toolkits for industrial sectors to deal with external issues regarding market instability and high competition is a major role that should be carried out by the industrial authority.

- The government should work closely with their industrial organisation when it comes to industrial planning and policy issues. In particular when related to their available resources planning which may affect the procurement issue of domestic' producers. The tariff on exports and imports should be defined based on existing market conditions and the industrial growth rate. This could solve the conflict in goals between the government and their industrial sectors and create more transparency.

- The government should investigate the mean of improving the surrounding business climate for existing industrial organisations. A comprehensive study regarding their experienced issues and financial commitments should be developed to improve the performance of the industrial sector.

- Environmental issues related to the country's infrastructure and existing logistics systems should be addressed by the government. A maintenance plan and the provision of more facilities to overcome these issues is urgently needed

The outcome of the work can be employed by governmental authorities to address such difficulties and accelerate the growth of this sector globally. The examination of different scenarios to enhance supply chain performance and test each alternative provides a comparison that will be beneficial to sector participants and may affect their strategic decisions. The thesis provides a fundamental approach for investigating deficiencies in developing countries that might be extended by other researchers to investigate other defective sectors both in Egypt and in other developing countries.

### 7.5. Study Limitations

1. This work attempts to cover most of the issues related to deficiencies internally or externally; However, internal supply chain activities represent the main part of this study. The relevance of external issues and their impact on internal activities are indicated. The role of environmental issues could be extended and investigated in-depth by other researchers.

2. Due to the confidentiality of the empirical data needed for this research, the researcher faced many difficulties and much resistance in data collection, which resulted in a relatively small sample size of firms willing to contribute. The simulation could not be validated because of the un-availability of real output data.

3. The researcher used a modified traditional Beer Game to simulate the existing deficiencies. The effect of environmental issues such as supplier-power, procurement prices and limited marketing expertise were not modelled in this study.

### 7.5. Further Research

The following are seen to be important to the success of Egyptian supply chains:

1.  The investigation of the effect of the cultural issues related to collaboration issues and the supply chain concept is needed in developing countries. The research indicates the importance of these issues and their effect on organisational activities. Therefore, investigating the industrial context in developing countries should be coupled with exploration of the cultural issues surrounding the understanding of supply chain concepts. Further investigation of the supply chain concept and vision from developing countries' perspectives is necessary

2.  A comprehensive study of supply chain implementation to produce a toolkit for developing countries is needed. Due to the limited capabilities of these countries, industrial organisations have problems in overcoming environmental barriers and in the limited infrastructure of the country. Governmental policy and plans should be indicated as supporting pillars needed for appropriate business climate. The surrounding economic issues of developing countries which greatly affect organisational behaviour should be investigated in-depth in to order indicate the effect of their instability on organisational behaviour.

3. There is a need to address issues of business process reengineering and design as critical issues facing developing countries in adjusting their supply chain performance, rather than focusing on the importance of IT capabilities.  IT capabilities would not be beneficial to organisational performance unless they follow a re-designing and engineering process for existing business activities.

4. There is a need to investigate the barriers related to adopting a build-to-order strategy. Can the industrial sectors in developing countries provide an appropriate level of service rapidly when adopting build-to-order? Since diversity of procurements and stability of delivery are indicated as vital factors to the strategy's success, the question is raised as to the applicability of employing this strategy.

5. There is a need to examine the issues related to a traditional Beer Game and how to address these issues to develop a more realistic one. The global supply chain and the role of the participants should be further emphasised in supply chain models.

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**Dear Respondent,**

**The main objective of this survey is to investigate problems face Textile sector in Egypt. These problems related to production, materials supply and products marketing. Filling this Questionnaire will not require any personal information about respondent or financial information about your company. Dealing with this information will be based on Ethical Policy.**

**Thanks for your participation**

**The Researcher**

1. **Which of the following are problems facing your organisation?**

| Problem | Strongly Agree | Agree | Natural | Disagree | Strongly Disagree |
|---|---|---|---|---|---|
| There is no pre-defined channels for dealing with Suppliers | | | | | |
| There is no Integration between departmental information systems or with their supplier's information system. | | | | | |
| Inaccurate and unreliable demand Forecasting is a problem face product marketing | | | | | |
| Diversity of procurement & instability of material prices are major procurement problems face your organization | | | | | |
| Long delivery is major problem face supplying materials. | | | | | |
| Large inventory volume and increased holding cost either for raw materials or finished products are problem faced your organization. | | | | | |
| High production cost and production delay time are major production barrier | | | | | |
| Limited local and international market share is problem face finished product marketing | | | | | |
| Poor IT infrastructure or limited IT capability is major problem face our organisation | | | | | |
| Investing in expensive information system which was incompatible with organisational needs is major problem face your | | | | | |

2. **Rank the following problem according to their importance (1 is the most important & 10 is the lest important)**

| Problem | Rank |
|---|---|
| No- predefined supply chain channels | |
| Rely on separate information systems either inside organization or with their suppliers | |
| Poor deployed IT infrastructure | |
| Inaccurate and unreliable demand Forecasting | |
| Procurement Volume & Material Price Fluctuation | |
| Long delivery term | |
| Large inventory volume & cost (raw materials and finished) | |

| Increased production cost and time | |
|---|---|
| Limited market share (Locally and internationally) | |
| Non-justified IT investment | |

3. **Rank the following problem according to their occurrence (1 is the first occurred & 10 is the last occurred)**

| Problem | Rank |
|---|---|
| No- predefined supply chain channels | |
| Rely on separate information systems either inside organisation or with their suppliers | |
| Poor deployed IT infrastructure | |
| Inaccurate and unreliable demand Forecasting | |
| Procurement Volume & Material Price Fluctuation | |
| Long delivery term | |
| Large inventory volume & cost (raw materials and finished) | |
| Increased production cost and time | |
| Limited market share (Locally and internationally) | |
| Non-justified IT investment | |

4. **Which of the following problem cause another? You can assign more than one as a cause; use the assigned numbers to indicate each problem causes.**

| No | Problem | Cause |
|---|---|---|
| 1 | No- predefined supply chain channels | |
| 2 | Rely on separate information systems either inside organization or with their suppliers | |
| 3 | Poor deployed IT infrastructure | |
| 4 | Inaccurate and unreliable demand Forecasting | |
| 5 | Procurement Volume & Material Price Fluctuation | |
| 6 | Long delivery term | |
| 7 | Large inventory volume & cost (raw materials and finished) | |
| 8 | Increased production cost and time | |
| 9 | Limited market share (Locally and internationally) | |
| 10 | Non-justified IT investment | |

5. **Does Your Firm adopt?**

- Mass Customisation Strategy
- Mass Production Strategy
- Mixed Strategy

**6. Which sector does your Firm relate to?**

- Public Sector
- Private Sector

7. What is the production capacities of your Mills:……………………..………...

8. What is the monthly sales rate of your firm (Range) :…………………..……...

9. Please indicate the industrial zone that your firm follows:……………………..

**10. In your opinion, is there any other problem facing your organisation rather than problems mentioned above?**

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**11. Do you have any further recommendation to solve these problems?**

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## Appendix B: Statistical Analysis

### Reliability test

Cronbach's Alpha above 0.5 refers to satisfactory level of internal consistency in the three sections of questionnaire. It measures the interitem consistency, which answers to what degree the questioned items are independent measures of the same concept

Section One:

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| 0.610 | 10 |

Section Two:

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| 0.576 | 10 |

Section Three

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| 0.523 | 9 |

Section Four

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| 0.562 | 2 |

Overall reliability

**Reliability Statistics**

| Cronbach's Alpha | N of Items |
|---|---|
| 0.620 | 31 |

**Test Data Distribution**

The result illustrates a normally distributed data for these measures while the Asymp.
Significance exceeds 0.05 value.

**One-Sample Kolmogorov-Smirnov Test**

| | N | Normal Parameters | | Most Extreme Differences | | | Kolmogorov-Smirnov Z | Asymp. Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Absolute | Positive | Negative | | |
| There is no pre-defined channels for dealing with Suppliers | 32 | 2.66 | 1.335 | 0.187 | 0.174 | -0.187 | 1.056 | **0.214** |
| There is no Integration between departmental information systems or with their supplier's information system. | 32 | 2.91 | 1.353 | 0.186 | 0.186 | -0.127 | 1.053 | **0.218** |
| Poor IT infrastructure or limited IT capability | 32 | 2.69 | 1.091 | 0.205 | 0.205 | -0.144 | 1.157 | **0.137** |
| Inaccurate and unreliable demand Forecasting | 32 | 3.50 | 1.295 | 0.182 | 0.123 | -0.182 | 1.027 | **0.242** |
| Diversity of procurement & instability of material prices | 32 | 3.88 | 1.040 | 0.204 | 0.144 | -0.204 | 1.155 | **0.139** |
| Long delivery | 32 | 3.47 | 1.218 | 0.200 | 0.167 | -0.200 | 1.131 | **0.155** |
| Large inventory volume and increased holding cost either for raw materials or finished products | 32 | 3.44 | 1.268 | 0.184 | 0.184 | -0.172 | 1.041 | **0.229** |
| High production cost and production delay time | 32 | 4.00 | 0.916 | 0.219 | 0.156 | -0.219 | 1.237 | **0.094** |
| Limited local and international market share | 32 | 3.50 | 1.270 | 0.184 | 0.131 | -0.184 | 1.043 | **0.227** |
| Investing in expensive information system which was incompatible with organizational needs | 32 | 2.94 | 1.268 | 0.208 | 0.208 | -0.174 | 1.174 | **0.127** |

## Descriptive Data

Mean is used to measure the interval measure. Bold issues refer to the elements with highest mean as tendency measure.

**Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| There is no pre-defined channels for dealing with Suppliers | 32 | 1 | 5 | 2.66 | 1.335 |
| There is no Integration between departmental information systems or with their supplier's information system. | 32 | 1 | 5 | 2.91 | 1.353 |
| Poor IT infrastructure or limited IT capability | 32 | 1 | 5 | 2.69 | 1.091 |
| Inaccurate and unreliable demand Forecasting | 32 | 1 | 5 | 3.50 | 1.295 |
| **Diversity of procurement & instability of material prices** | **32** | **2** | **5** | **3.88** | **1.040** |
| Long delivery | 32 | 1 | 5 | 3.47 | 1.218 |
| Large inventory volume and increased holding cost either for raw materials or finished products | 32 | 1 | 5 | 3.44 | 1.268 |
| **High production cost and production delay time** | **32** | **2** | **5** | **4.00** | **0.916** |
| Limited local and international market share | 32 | 1 | 5 | 3.50 | 1.270 |
| Investing in expensive information system which was incompatible with organizational needs | 32 | 1 | 5 | 2.94 | 1.268 |
| Valid N (listwise) | 32 | | | | |

## 1. <u>One sample T-Test (test value=3.5)</u>

A t-test is a parametric test used to determine the significance of the differences between the mean of the sample and a specified value. Element with high significance that did not exceed 0.05 are the confirmed results.

**One-Sample Test**

| | Test Value = 3.5 | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | | | | 95% Confidence Interval of the Difference | |
| | T | df | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| **There is no pre-defined channels for dealing with Suppliers** | **-3.576** | **31** | **0.001** | **-0.844** | **-1.32** | **-0.36** |
| **There is no Integration between departmental information systems or with their supplier's information system.** | **-2.483** | **31** | **.019** | **-0.594** | **-1.08** | **-0.11** |
| **Poor IT infrastructure or limited IT capability** | **-4.214** | **31** | **0.000** | **-0.812** | **-1.21** | **-0.42** |
| Inaccurate and unreliable demand Forecasting | .000 | 31 | 1.000 | 0.000 | -0.47 | 0.47 |
| **Diversity of procurement & instability of material prices** | **2.041** | **31** | **0.050** | **0.375** | **0.00** | **0.75** |
| Long delivery | -.145 | 31 | 0.886 | -0.031 | -0.47 | 0.41 |
| Large inventory volume and increased holding cost either for raw materials or finished products | -.279 | 31 | 0.782 | -0.062 | -0.52 | 0.39 |
| **High production cost and production delay time** | **3.088** | **31** | **0.004** | **0.500** | **0.17** | **0.83** |
| Limited local and international market share | .000 | 31 | 1.000 | 0.000 | -0.46 | 0.46 |
| **Investing in expensive information system which was incompatible with organisational needs** | **-2.509** | **31** | **0.018** | **-0.562** | **-1.02** | **-0.11** |

## 2. <u>One sample T-test (test value=3)</u>

**One-Sample Test**

| | T | Df | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| There is no pre-defined channels for dealing with Suppliers | -1.457 | 31 | 0.155 | -0.344 | -0.82 | 0.14 |
| There is no Integration between departmental information systems or with their supplier's information system. | -.392 | 31 | 0.698 | -0.094 | -0.58 | 0.39 |
| Poor IT infrastructure or limited IT capability | -1.621 | 31 | 0.115 | -0.312 | -0.71 | 0.08 |
| **Inaccurate and unreliable demand Forecasting** | **2.184** | **31** | **0.037** | **0.500** | **0.03** | **0.97** |
| **Diversity of procurement & instability of material prices** | **4.761** | **31** | **0.000** | **0.875** | **0.50** | **1.25** |
| **Long delivery** | **2.178** | **31** | **0.037** | **0.469** | **0.03** | **0.91** |
| Large inventory volume and increased holding cost either for raw materials or finished products | 1.951 | 31 | 0.060 | 0.438 | -0.02 | 0.89 |
| **High production cost and production delay time** | **6.177** | **31** | **0.000** | **1.000** | **0.67** | **1.33** |
| **Limited local and international market share** | **2.227** | **31** | **0.033** | **0.500** | **0.04** | **0.96** |
| Investing in expensive information system which was incompatible with organisational needs | -0.279 | 31 | 0.782 | -0.062 | -.052 | 0.39 |

## 3. One sample T-test (test value=2)

**One-Sample Test**

| | Test Value = 2 | | | | | |
|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | |
| | T | df | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| There is no pre-defined channels for dealing with Suppliers | 2.782 | 31 | 0.009 | 0.656 | 0.18 | 1.14 |
| There is no Integration between departmental information systems or with their supplier's information system. | 3.790 | 31 | 0.001 | 0.906 | 0.42 | 1.39 |
| Poor IT infrastructure or limited IT capability | 3.566 | 31 | 0.001 | 0.688 | 0.29 | 1.08 |
| Inaccurate and unreliable demand Forecasting | 6.552 | 31 | 0.000 | 1.500 | 1.03 | 1.97 |
| Diversity of procurement & instability of material prices | 10.203 | 31 | 0.000 | 1.875 | 1.50 | 2.25 |
| Long delivery | 6.823 | 31 | 0.000 | 1.469 | 1.03 | 1.91 |
| **Large inventory volume and increased holding cost either for raw materials or finished products** | **6.411** | **31** | **0.000** | **1.438** | **0.98** | **1.89** |
| High production cost and production delay time | 12.354 | 31 | 0.000 | 2.000 | 1.67 | 2.33 |
| Limited local and international market share | 6.681 | 31 | 0.000 | 1.500 | 1.04 | 1.96 |
| Investing in expensive information system which was incompatible with organisational needs | 4.181 | 31 | 0.000 | 0.938 | 0.48 | 1.39 |

Section two:

## Descriptive Data

Mean is used to measure the interval measure. Bold issues refer to the elements with highest mean as tendency measure.

**Descriptive Statistics**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Pre-defined channels for dealing with Suppliers | 32 | 1 | 5 | **2.44** | 1.390 |
| Integration between departmental information systems or with their supplier's information system. | 32 | 1 | 5 | **2.75** | 1.524 |
| Reliability of Demand Forecasting | 32 | 1 | 5 | **3.34** | 1.382 |
| **Diversity of procurement & material prices** | **32** | **2** | **5** | **3.97** | **0.897** |
| Supplies Delivery | 32 | 1 | 5 | **3.03** | 1.282 |
| Inventory volume and holding cost either for raw materials or finished products | 32 | 1 | 5 | **2.97** | 1.576 |
| **Production cost and production delay time** | **32** | **2** | **5** | **3.97** | **0.861** |
| **Market share of local and international marketplace** | **32** | **2** | **5** | **3.94** | **0.948** |
| IT infrastructure and IT capability | 32 | 1 | 5 | **2.94** | 1.390 |
| Information system investment | 32 | 1 | 5 | **2.78** | 1.581 |
| Valid N (listwise) | 32 | | | | |

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## Test data distribution

The result illustrates a normally distributed data for these measures while the Asymp. Sig. exceeds .05.

**One-Sample Kolmogorov-Smirnov Test**

| | N | Normal Parameters Mean | Normal Parameters Std. Deviation | Most Extreme Differences Absolute | Most Extreme Differences Positive | Most Extreme Differences Negative | Kolmogorov-Smirnov Z | Asymp. Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| Pre-defined channels for dealing with Suppliers | 32 | 2.44 | 1.390 | 0.193 | 0.193 | -0.150 | 1.093 | **0.183** |
| Integration between departmental information systems or with their supplier's information system. | 32 | 2.75 | 1.524 | 0.189 | 0.189 | -0.149 | 1.067 | **0.205** |
| Reliability of Demand Forecasting | 32 | 3.34 | 1.382 | 0.197 | 0.192 | -0.197 | 1.115 | **0.166** |
| Diversity of procurement & material prices | 32 | 3.97 | 0.897 | 0.218 | 0.204 | -0.218 | 1.236 | **0.094** |
| Supplies Delivery | 32 | 3.03 | 1.282 | 0.164 | 0.164 | -0.150 | .930 | **0.353** |
| Inventory volume and holding cost either for raw materials or finished products | 32 | 2.97 | 1.576 | 0.214 | 0.199 | -0.214 | 1.210 | **0.107** |
| Production cost and production delay time | 32 | 3.97 | 0.861 | 0.202 | 0.182 | -0.202 | 1.143 | **0.147** |
| Market share of local and international marketplace | 32 | 3.94 | 0.948 | 0.212 | 0.182 | -0.212 | 1.202 | **0.111** |
| IT infrastructure and IT capability | 32 | 2.94 | 1.390 | 0.188 | 0.188 | -0.150 | 1.061 | **0.210** |
| Information system investment | 32 | 2.78 | 1.581 | 0.221 | 0.221 | -0.170 | 1.248 | **0.089** |

1.  **One sample T-Test (test value=3.5)**

t-test is a parametric test used to compare the mean of each variable with 3.5 value which represent the Agree Level in the likert scale. Element with high significance that did not exceed 0.05 are indicate in bold.

**One-Sample Test**

| | Test Value = 3.5 | | | | | |
|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | |
| | T | df | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| **Pre-defined channels for dealing with Suppliers** | **-4.325** | 31 | **0.000** | **-1.062** | **-1.56** | **-0.56** |
| **Integration between departmental information systems or with their supplier's information system.** | **-2.784** | 31 | **0.009** | **-0.750** | **-1.30** | **-0.20** |
| Reliability of Demand Forecasting | -0.640 | 31 | 0.527 | -0.156 | -0.65 | 0.34 |
| **Diversity of procurement & material prices** | **2.955** | 31 | **0.006** | **0.469** | **0.15** | **0.79** |
| Supplies Delivery | -2.068 | 31 | 0.047 | -0.469 | -0.93 | 0.00 |
| Inventory volume and holding cost either for raw materials or finished products | -1.907 | 31 | 0.066 | -0.531 | -1.10 | 0.04 |
| **Production cost and production delay time** | **3.081** | 31 | **0.004** | **0.469** | **0.16** | **0.78** |
| **Market share of local and international marketplace** | **2.610** | 31 | **0.014** | **0.438** | **0.10** | **0.78** |
| **IT infrastructure and IT capability** | **-2.290** | 31 | **0.029** | **-0.562** | **-1.06** | **-0.06** |
| **Information system investment** | **-2.572** | 31 | **0.015** | **-0.719** | **-1.29** | **-0.15** |

## 2. <u>One sample T-Test (test value=3.0)</u>

**One-Sample Test**

| | Test Value = 3.0 | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | | Sig. (2-tailed) | Mean Difference | 95% Confidence Interval of the Difference | |
| | T | df | | | Lower | Upper |
| Pre-defined channels for dealing with Suppliers | -2.290 | 31 | 0.029 | -0.562 | -1.06 | -0.06 |
| Integration between departmental information systems or with their supplier's information system. | -0.928 | 31 | 0.361 | -0.250 | -0.80 | 0.30 |
| Reliability of Demand Forecasting | 1.407 | 31 | 0.169 | 0.344 | -0.15 | 0.84 |
| Diversity of procurement & material prices | 6.106 | 31 | 0.000 | 0.969 | 0.65 | 1.29 |
| Supplies Delivery | 0.138 | 31 | 0.891 | 0.031 | -0.43 | 0.49 |
| Inventory volume and holding cost either for raw materials or finished products | -.0112 | 31 | 0.911 | -0.031 | -0.60 | 0.54 |
| Production cost and production delay time | 6.366 | 31 | 0.000 | 0.969 | 0.66 | 1.28 |
| Market share of local and international marketplace | 5.593 | 31 | 0.000 | 0.938 | 0.60 | 1.28 |
| IT infrastructure and IT capability | -0.254 | 31 | 0.801 | -0.062 | -0.56 | 0.44 |
| Information system investment | -0.783 | 31 | 0.440 | -0.219 | -0.79 | 0.35 |

### 3. <u>One sample T-Test (test value=2.0)</u>

**One-Sample Test**

|  | Test Value = 2 | | | | | |
|---|---|---|---|---|---|---|
|  |  |  |  |  | 95% Confidence Interval of the Difference | |
|  | T | df | Sig. (2-tailed) | Mean Difference | Lower | Upper |
| Pre-defined channels for dealing with Suppliers | 1.781 | 31 | 0.085 | 0.438 | -0.06 | 0.94 |
| Integration between departmental information systems or with their supplier's information system. | 2.784 | 31 | 0.009 | 0.750 | 0.20 | 1.30 |
| **Reliability of Demand Forecasting** | **5.500** | **31** | **0.000** | **1.344** | **0.85** | **1.84** |
| Diversity of procurement & material prices | 12.409 | 31 | 0.000 | 1.969 | 1.65 | 2.29 |
| **Supplies Delivery** | **4.550** | **31** | **0.000** | **1.031** | **0.57** | **1.49** |
| **Inventory volume and holding cost either for raw materials or finished products** | **3.478** | **31** | **0.002** | **0.969** | **0.40** | **1.54** |
| Production cost and production delay time | 12.938 | 31 | 0.000 | 1.969 | 1.66 | 2.28 |
| Market share of local and international marketplace | 11.558 | 31 | 0.000 | 1.938 | 1.60 | 2.28 |
| IT infrastructure and IT capability | 3.816 | 31 | 0.001 | 0.938 | 0.44 | 1.44 |
| Information system investment | 2.796 | 31 | 0.009 | 0.781 | 0.21 | 1.35 |

**Descriptive Data**

Median is used to measure the tendency of ordinal scale. Elements with low medium represent the elements occur in the earliest stages while highest medium represent element occurs in latest stages.

|  | Rank | Median |
|---|---|---|
| Supply chain Integration | 1 | 2.00 |
| Supply Chain Design | 1 | 2.00 |
| IT Infrastructure | 2 | 2.50 |
| Demand Forecasting | 3 | 3.00 |
| Delivery Terms | 4 | 5.00 |
| Procurement Volume & prices Fluctuation | 4 | 5.00 |
| Production cost & time | 4 | 5.00 |
| Market Share | 5 | 6.00 |
| Inventory Cost | 5 | 6.00 |

## Mann-Whitney U: Two-Independent-Samples Test (public and private sectors)

It is used to illustrate the difference between public and private sectors in ranking the stages of supply chain deficiency. No difference is indicated in this test since Asymp. Sig exceed 0.05

**Test Statistics[b]**

| | Mann-Whitney U | Wilcoxon W | Z | Asymp. Sig. (2-tailed) | Exact Sig. [2*(1-tailed Sig.)] |
|---|---|---|---|---|---|
| Supply chain Integration | 54.000 | 64.000 | -.119 | 0.906 | 0.934[a] |
| Supply Chain Design | 25.500 | 431.500 | -1.783 | 0.075 | 0.082[a] |
| Demand Forecasting | 31.000 | 437.000 | -1.457 | 0.145 | 0.169[a] |
| Delivery Terms | 51.500 | 61.500 | -0.261 | 0.794 | 0.805[a] |
| Procurement Volume & prices Fluctuation | 51.000 | 457.000 | -.290 | 0.771 | 0.805[a] |
| Inventory Cost | 34.500 | 44.500 | -1.260 | 0.208 | 0.230[a] |
| Production cost & time | 44.000 | 450.000 | -0.694 | 0.488 | 0.527[a] |
| Market Share | 53.500 | 459.500 | -0.145 | 0.884 | 0.891[a] |
| IT Infrastructure | 48.000 | 58.000 | -0.469 | 0.639 | 0.680[a] |

## Mann-Whitney U: Two-Independent-Samples Test ( Mass production and mass customisation strategies)

It is used to illustrate the difference between firms adopt Mass production and mass customisation strategies in ranking the stages of supply chain deficiency.

**Test Statistics[b]**

| | Mann-Whitney U | Wilcoxon W | Z | Asymp. Sig. (2-tailed) | Exact Sig. [2*(1-tailed Sig.)] |
|---|---|---|---|---|---|
| Supply chain Integration | 16.000 | 37.000 | -1.074 | 0.283 | 0.345[a] |
| Supply Chain Design | 20.500 | 56.500 | -0.465 | 0.642 | 0.662[a] |
| Demand Forecasting | 16.500 | 52.500 | -1.014 | 0.311 | 0.345[a] |
| Delivery Terms | 15.000 | 36.000 | -1.182 | 0.237 | 0.282[a] |
| Procurement Volume & prices Fluctuation | 20.500 | 41.500 | -0.463 | 0.643 | 0.662[a] |
| Inventory Cost | 13.000 | 34.000 | -1.489 | 0.137 | 0.181[a] |
| Production cost & time | 17.500 | 38.500 | -0.857 | 0.391 | 0.414[a] |
| Market Share | 22.500 | 43.500 | -0.197 | 0.844 | 0.852[a] |
| IT Infrastructure | 20.500 | 41.500 | -0.466 | 0.641 | 0.662[a] |

a. Not corrected for ties.

b. Grouping Variable: production strategy

Section four:

## 1. Descriptive data

**Sector Frequency:**

**Sector**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Public | 4 | 12.5 | 12.5 | 12.5 |
| | Private | 28 | 87.5 | 87.5 | 100.0 |
| | Total | 32 | 100.0 | 100.0 | |
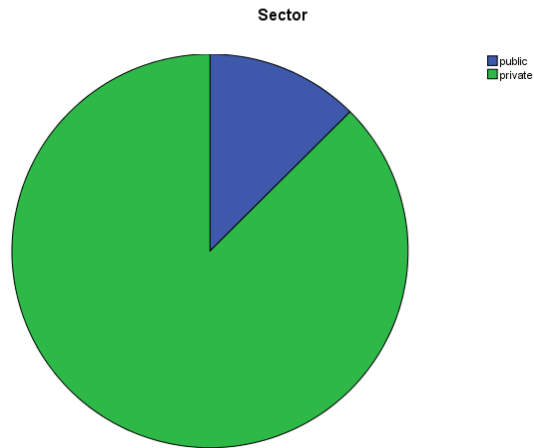
Sector

**Sectors- Frequency**
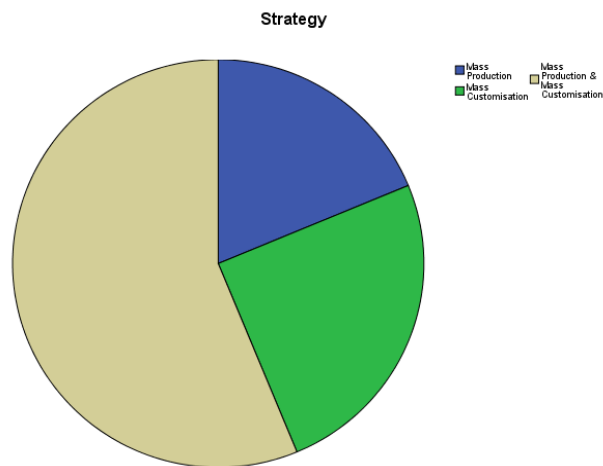


Strategy

**Applied production policy- Frequency:**

**Strategy**

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | Mass Production | 6 | 18.8 | 18.8 | 18.8 |
| | Mass Customisation | 8 | 25.0 | 25.0 | 43.8 |
| | Mass Production & Mass Customisation | 18 | 56.2 | 56.2 | 100.0 |
| | Total | 32 | 100.0 | 100.0 | |

**Sector * Strategy Crosstabulation**

| Count | | | | | |
|---|---|---|---|---|---|
| | | Strategy | | | |
| | | Mass Production | Mass Customisation | Mass Production & Mass Customisation | Total |
| Sector | public | 4 | 0 | 0 | 4 |
| | private | 2 | 8 | 18 | 28 |
| Total | | 6 | 8 | 18 | 32 |

**Supply chain deficiencies: Differences between mass customisation and mass production**

**Group Statistics**

| | Strategy | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| There is no pre-defined channels for dealing with Suppliers | M P | 6 | 2.83 | 1.329 | 0.543 |
| | M C | 8 | 2.62 | 1.506 | 0.532 |
| There is no Integration between departmental information systems or with their supplier's information system. | M P | 6 | 2.83 | 1.472 | 0.601 |
| | M C | 8 | 3.00 | 1.195 | 0.423 |
| Poor IT infrastructure or limited IT capability | M P | 6 | **2.67** | 1.033 | 0.422 |
| | M C | 8 | **2.25** | 0.707 | 0.250 |
| Inaccurate and unreliable demand Forecasting | M P | 6 | 2.67 | 1.211 | 0.494 |
| | M C | 8 | 3.12 | 1.642 | 0.581 |
| Diversity of procurement & instability of material prices | M P | 6 | **2.83** | 0.983 | 0.401 |
| | M C | 8 | **4.25** | 0.886 | 0.313 |
| Long delivery | M P | 6 | **3.50** | 1.225 | 0.500 |
| | M C | 8 | **4.12** | 0.991 | 0.350 |
| Large inventory volume and increased holding cost either for raw materials or finished products | M P | 6 | 3.67 | 1.506 | 0.615 |
| | M C | 8 | 3.38 | 1.598 | 0.565 |
| High production cost and production delay time | M P | 6 | 3.83 | 0.753 | 0.307 |
| | M C | 8 | 4.00 | 1.195 | 0.423 |
| Limited local and international market share | M P | 6 | 3.50 | 1.225 | 0.500 |
| | M C | 8 | 3.38 | 1.188 | 0.420 |
| Investing in expensive information system which was incompatible with organisational needs | M P | 6 | 3.50 | 1.225 | 0.500 |
| | M C | 8 | 3.12 | 1.246 | 0.441 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | 95% Confidence Interval of the Difference | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| There is no pre-defined channels for dealing with Suppliers | Equal variances assumed | 1.261 | .284 | 0.269 | 12 | 0.793 | 0.208 | 0.775 | -1.480 | 1.897 |
| | Equal variances not assumed | | | 0.274 | 11.589 | 0.789 | 0.208 | 0.760 | -1.455 | 1.871 |
| There is no Integration between departmental information systems or with their supplier's information system. | Equal variances assumed | 0.875 | 0.368 | -0.234 | 12 | 0.819 | -0.167 | 0.712 | -1.717 | 1.384 |
| | Equal variances not assumed | | | -0.227 | 9.507 | 0.825 | -0.167 | 0.735 | -1.815 | 1.482 |
| Poor IT infrastructure or limited IT capability | Equal variances assumed | 0.713 | 0.415 | 0.899 | 12 | 0.386 | 0.417 | 0.463 | -.593 | 1.426 |
| | Equal variances not assumed | | | 0.850 | 8.393 | 0.419 | 0.417 | 0.490 | -.705 | 1.538 |
| Inaccurate and unreliable demand Forecasting | Equal variances assumed | 1.138 | 0.307 | -0.574 | 12 | 0.576 | -0.458 | 0.798 | -2.197 | 1.281 |
| | Equal variances not assumed | | | -0.601 | 11.999 | 0.559 | -0.458 | 0.763 | -2.120 | 1.203 |
| Diversity of procurement & instability of material prices | Equal variances assumed | 0.171 | 0.686 | -2.827 | 12 | **0.015** | -1.417 | 0.501 | -2.509 | -.325 |
| | Equal variances not assumed | | | -2.782 | 10.237 | 0.019 | -1.417 | 0.509 | -2.548 | -.286 |
| Long delivery | Equal variances assumed | 0.286 | 0.603 | -1.057 | 12 | 0.311 | -0.625 | 0.591 | -1.913 | .663 |
| | Equal variances not assumed | | | -1.024 | 9.483 | 0.331 | -0.625 | 0.611 | -1.996 | .746 |
| Large inventory volume and | Equal variances assumed | 0.021 | 0.888 | 0.346 | 12 | 0.735 | 0.292 | 0.843 | -1.544 | 2.127 |

| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|
| increased holding cost either for raw materials or finished products | Equal variances not assumed | | | 0.349 | 11.271 | 0.733 | 0.292 | 0.835 | -1.540 | 2.124 |
| High production cost and production delay time | Equal variances assumed | 2.726 | 0.125 | -0.298 | 12 | 0.770 | -0.167 | 0.558 | -1.384 | 1.050 |
| | Equal variances not assumed | | | -0.319 | 11.758 | 0.755 | -0.167 | 0.523 | -1.308 | .974 |
| Limited local and international market share | Equal variances assumed | 0.010 | 0.920 | 0.192 | 12 | 0.851 | 0.125 | 0.650 | -1.291 | 1.541 |
| | Equal variances not assumed | | | 0.191 | 10.729 | 0.852 | 0.125 | 0.653 | -1.317 | 1.567 |
| Investing in expensive information system which was incompatible with organisational needs | Equal variances assumed | 0.062 | 0.807 | 0.561 | 12 | 0.585 | 0.375 | 0.668 | -1.081 | 1.831 |
| | Equal variances not assumed | | | 0.563 | 11.031 | 0.585 | 0.375 | 0.666 | -1.091 | 1.841 |

# Supply chain deficiencies: Difference between public and private firms

**Group Statistics**

| | VAR00020 | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| There is no pre-defined channels for dealing with Suppliers | 1 | 4 | **3.50** | 1.000 | .500 |
| | 2 | 28 | **2.54** | 1.347 | .254 |
| There is no Integration between departmental information systems or with their supplier's information system. | 1 | 4 | **3.75** | .957 | .479 |
| | 2 | 28 | **2.79** | 1.371 | .259 |
| Poor IT infrastructure or limited IT capability | 1 | 4 | 2.75 | 1.258 | .629 |
| | 2 | 28 | 2.68 | 1.090 | .206 |
| Inaccurate and unreliable demand Forecasting | 1 | 4 | 2.25 | 1.258 | .629 |
| | 2 | 28 | 3.57 | 1.345 | .254 |
| Diversity of procurement & instability of material prices | 1 | 4 | 3.25 | 1.500 | .750 |
| | 2 | 28 | 3.86 | 1.044 | .197 |
| Long delivery | 1 | 4 | 3.50 | 1.732 | .866 |
| | 2 | 28 | 3.36 | 1.283 | .242 |
| Large inventory volume and increased holding cost either for raw materials or finished products | 1 | 4 | **4.00** | 1.414 | .707 |
| | 2 | 28 | **3.25** | 1.351 | .255 |
| High production cost and production delay time | 1 | 4 | **4.25** | .957 | .479 |
| | 2 | 28 | **3.79** | 1.067 | .202 |
| Limited local and international market share | 1 | 4 | 3.25 | 1.500 | .750 |
| | 2 | 28 | 3.46 | 1.319 | .249 |
| Investing in expensive information system which was incompatible with organisational needs | 1 | 4 | **3.50** | 1.000 | .500 |
| | 2 | 28 | **2.86** | 1.297 | .245 |

**Two Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | | | | | | | Std. Error | | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Difference | Lower | Upper |
| There is no pre-defined channels for dealing with Suppliers | Equal variances assumed | 1.782 | .192 | 1.371 | 30 | .181 | .964 | .703 | -.472 | 2.401 |
| | Equal variances not assumed | | | 1.719 | 4.721 | .150 | .964 | .561 | -.504 | 2.433 |
| There is no Integration between departmental information systems or with their supplier's information system. | Equal variances assumed | 1.107 | .301 | 1.351 | 30 | .187 | .964 | .714 | -.493 | 2.422 |
| | Equal variances not assumed | | | 1.772 | 4.966 | .137 | .964 | .544 | -.438 | 2.366 |
| Poor IT infrastructure or limited IT capability | Equal variances assumed | .003 | .957 | .121 | 30 | .905 | .071 | .592 | -1.139 | 1.281 |
| | Equal variances not assumed | | | .108 | 3.674 | .920 | .071 | .662 | -1.833 | 1.976 |
| Inaccurate and unreliable demand Forecasting | Equal variances assumed | .477 | .495 | -1.849 | 30 | .074 | -1.321 | .715 | -2.781 | .138 |
| | Equal variances not assumed | | | -1.947 | 4.048 | .122 | -1.321 | .679 | -3.197 | .554 |
| Diversity of | Equal variances assumed | 1.753 | .196 | -1.034 | 30 | .309 | -.607 | .587 | -1.806 | .592 |

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| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|
| procurement & instability of material prices | Equal variances not assumed | | | -.783 | 3.428 | .484 | -.607 | .776 | -2.910 | 1.695 |
| Long delivery | Equal variances assumed | 1.623 | .212 | .200 | 30 | .843 | .143 | .713 | -1.314 | 1.600 |
| | Equal variances not assumed | | | .159 | 3.486 | .883 | .143 | .899 | -2.506 | 2.792 |
| Large inventory volume and increased holding cost either for raw materials or finished products | Equal variances assumed | .363 | .552 | 1.034 | 30 | .309 | .750 | .725 | -.731 | 2.231 |
| | Equal variances not assumed | | | .998 | 3.825 | .377 | .750 | .752 | -1.375 | 2.875 |
| High production cost and production delay time | Equal variances assumed | .294 | .592 | .822 | 30 | .417 | .464 | .565 | -.689 | 1.617 |
| | Equal variances not assumed | | | .894 | 4.144 | .420 | .464 | .519 | -.958 | 1.887 |
| Limited local and international market share | Equal variances assumed | .107 | .746 | -.300 | 30 | .767 | -.214 | .715 | -1.675 | 1.246 |
| | Equal variances not assumed | | | -.271 | 3.694 | .801 | -.214 | .790 | -2.482 | 2.054 |
| Investing in expensive information system which was incompatible with organisational needs | Equal variances assumed | .860 | .361 | .947 | 30 | .351 | .643 | .679 | -.744 | 2.030 |
| | Equal variances not assumed | | | 1.154 | 4.586 | .305 | .643 | .557 | -.828 | 2.114 |

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# Occurrence stages of supply chain deficiency
## Differences between private and public firms

**ks**

| | Supply chain Integration Sector | | | Supply Chain Design Sector | | | Demand Forecasting Sector | | | Delivery Terms Sector | | | Procurement Volume & prices Fluctuation Sector | | | Inventory Cost Sector | | | Production cost & time Sector | | | Market Share Sector | | | IT Infrastructure Sector | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total |
| N | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 |
| Mean Rank | 16.00 | 16.57 | | 24.12 | 15.41 | | 22.75 | 15.61 | | 15.38 | 16.66 | | 17.75 | 16.32 | | 11.12 | 17.27 | | 19.50 | 16.07 | | 17.12 | 16.41 | | | 14.50 | 16.79 | |
| Sum of Ranks | 64.00 | 464.00 | | 96.50 | 431.50 | | 91.00 | 437.00 | | 61.50 | 466.50 | | 71.00 | 457.00 | | 44.50 | 483.50 | | 78.00 | 450.00 | | 68.50 | 459.50 | | | 58.00 | 470.00 | |

**Test Statistics[b]**

| | Mann-Whitney U | Wilcoxon W | Z | Asymp. Sig. (2-tailed) | Exact Sig. [2*(1-tailed Sig.)] |
|---|---|---|---|---|---|
| Supply chain Integration | 54.000 | 64.000 | -.119 | .906 | .934[a] |
| Supply Chain Design | 25.500 | 431.500 | -1.783 | .075 | .082[a] |
| Demand Forecasting | 31.000 | 437.000 | -1.457 | .145 | .169[a] |
| Delivery Terms | 51.500 | 61.500 | -.261 | .794 | .805[a] |
| Procurement Volume & prices Fluctuation | 51.000 | 457.000 | -.290 | .771 | .805[a] |
| Inventory Cost | 34.500 | 44.500 | -1.260 | .208 | .230[a] |
| Production cost & time | 44.000 | 450.000 | -.694 | .488 | .527[a] |
| Market Share | 53.500 | 459.500 | -.145 | .884 | .891[a] |
| IT Infrastructure | 48.000 | 58.000 | -.469 | .639 | .680[a] |

**ks**

| | Supply chain Integration Sector | | | Supply Chain Design Sector | | | Demand Forecasting Sector | | | Delivery Terms Sector | | | Procurement Volume & prices Fluctuation Sector | | | Inventory Cost Sector | | | Production cost & time Sector | | | Market Share Sector | | | IT Infrastructure Sector | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total | 1 | 2 | Total |
| N | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 | 4 | 28 | 32 |
| Mean Rank | 16.00 | 16.57 | | 24.12 | 15.41 | | 22.75 | 15.61 | | 15.38 | 16.66 | | 17.75 | 16.32 | | 11.12 | 17.27 | | 19.50 | 16.07 | | 17.12 | 16.41 | | 14.50 | 16.79 | |

a. Not corrected for ties.

b. Grouping Variable: Sector

## Occurrence stages of supply chain deficiency
### Differences between mass production, mass customisation and mixed approach of both

**Ranks**

| | Supply chain Integration Strategy | | | | Supply Chain Design Strategy | | | | Demand Forecasting Strategy | | | | Delivery Terms Strategy | | | | Procurement Volume & prices Fluctuation Strategy | | | | Inventory Cost Strategy | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M P | M C | MP & MC | Total | M P | M C | MP & MC | Total | M P | M C | MP & MC | Total | M P | M C | MP & MC | Total | M P | M C | MP & MC | Total | M P | M C | MP & MC | Total | M P | M C |
| N | 6 | 8 | 18 | 32 | 6 | 8 | 18 | 32 | 6 | 8 | 18 | 32 | 6 | 8 | 18 | 32 | 6 | 8 | 18 | 32 | 6 | 8 | 18 | 32 | 6 | 8 |
| Mean Rank | 13.00 | 18.56 | 16.75 | 18.67 | 15.38 | 16.28 | 19.33 | 15.00 | 16.22 | 11.92 | 17.50 | 17.58 | 14.42 | 16.81 | 17.06 | 10.58 | 18.25 | 17.69 | 14.58 | 19.38 | 15.86 | 15.25 | 16.38 | 16.97 | 18.42 | 21.94 |

**Test Statistics[a,b]**

| | Chi-Square | df | Asymp. Sig. |
|---|---|---|---|
| Supply chain Integration | 1.336 | 2 | **.513** |
| Supply Chain Design | .469 | 2 | **.791** |
| Demand Forecasting | .803 | 2 | **.669** |
| Delivery Terms | 1.820 | 2 | **.403** |
| Procurement Volume & prices Fluctuation | .382 | 2 | **.826** |
| Inventory Cost | 3.130 | 2 | **.209** |
| Production cost & time | 1.117 | 2 | **.572** |
| Market Share | .160 | 2 | **.923** |
| IT Infrastructure | 5.139 | 2 | **.077** |

a. Kruskal Wallis Test

b. Grouping Variable: Strategy

**Correlations**

| | | Pre-defined channels for dealing with Suppliers | Integration between departmental information systems or with their supplier's information system. | Reliability of Demand Forecasting | Diversity of procurement & material prices | Supplies Delivery | Inventory volume and holding cost either for raw materials or finished products | Production cost and production delay time | Market share of local and international marketplace | IT infrastructure and IT capability | Information system investment |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-defined channels for dealing with Suppliers | Pearson Correlation | 1 | .495** | .339 | .089 | -.008 | .124 | .012 | .119 | .399* | .148 |
| | Sig. (2-tailed) | | .004 | .058 | .628 | .966 | .498 | .949 | .515 | .024 | .420 |
| | N | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Integration between departmental information systems or with their supplier's information system. | Pearson Correlation | .495** | 1 | .119 | .065 | .054 | .212 | .092 | .123 | .495** | .110 |
| | Sig. (2-tailed) | .004 | | .518 | .724 | .771 | .245 | .616 | .503 | .004 | .547 |
| | N | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Reliability of Demand Forecasting | Pearson Correlation | .339 | .119 | 1 | .191 | .449** | -.262 | -.045 | .042 | .331 | .346 |
| | Sig. (2-tailed) | .058 | .518 | | .295 | .010 | .148 | .807 | .821 | .065 | .053 |
| | N | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Diversity of procurement & material prices | Pearson Correlation | .089 | .065 | .191 | 1 | .057 | .136 | .082 | -.002 | .257 | .109 |
| | Sig. (2-tailed) | .628 | .724 | .295 | | .757 | .457 | .655 | .990 | .156 | .554 |
| | N | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Supplies | Pearson Correlation | -.008 | .054 | .449** | .057 | 1 | -.431* | .059 | -.104 | .110 | -.012 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Delivery | Sig. (2-tailed) | .966 | .771 | **.010** | .757 | | **.014** | .747 | .569 | .550 | .946 |
| | N | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Inventory volume and holding cost either for raw materials or finished products | Pearson Correlation | .124 | .212 | -.262 | .136 | **-.431**$^*$ | 1 | .094 | .063 | .161 | -.029 |
| | Sig. (2-tailed) | .498 | .245 | .148 | .457 | **.014** | | .607 | .730 | .378 | .876 |
| | N | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Production cost and production delay time | Pearson Correlation | .012 | .092 | -.045 | .082 | .059 | .094 | 1 | -.082 | .214 | -.076 |
| | Sig. (2-tailed) | .949 | .616 | .807 | .655 | .747 | .607 | | .657 | .239 | .678 |
| | N | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Market share of local and international marketplace | Pearson Correlation | .119 | .123 | .042 | -.002 | -.104 | .063 | -.082 | 1 | -.028 | -.052 |
| | Sig. (2-tailed) | .515 | .503 | .821 | .990 | .569 | .730 | .657 | | .881 | .776 |
| | N | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| IT infrastructure and IT capability | Pearson Correlation | .399$^*$ | **.495**$^{**}$ | .331 | .257 | .110 | .161 | .214 | -.028 | 1 | |
| | Sig. (2-tailed) | .024 | **.004** | .065 | .156 | .550 | .378 | .239 | .881 | | |
| | N | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |
| Information system investment | Pearson Correlation | .148 | .110 | .346 | .109 | -.012 | -.029 | -.076 | -.052 | **.449**$^{**}$ | 1 |
| | Sig. (2-tailed) | .420 | .547 | .053 | .554 | .946 | .876 | .678 | .776 | **.010** | |
| | N | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 |

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

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

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**Appendix C: Beer Game Simulation**

## Mdx Beer Game 1

This beer game represents the case of fulfilling local markets order under current situation of supply chain deficiencies

| Number | Equations |
|---|---|
| 1 | A = 0.25 |
| 2 | B = 0.33 |
| 3 | Production Capacity 3= 300 Tin/Spin |
| 4 | Production Capacity 2= 6000 Towel Unit |
| 5 | safety level= 0.2 |
| 6 | SMOOTHTIME= 1 |
| 7 | Time to Adjust Production= 0.25 week |
| 8 | Order Processing Time= 7 week |
| | Distribution Time= 3 week |
| 9 | Production Time= (Prod in 2/Production Capacity 2 )+(Prod in 3/Production Capacity 3) |
| 10 | Procurement Time= RANDOM UNIFORM(1,2,0.05) |
| 11 | time increase= Order Processing Time+2*Procurement Time +Distribution Time+ Production Time |
| 12 | Lead Time= INTEG (time increase, 0) |
| 13 | SpinRaw Inventory= INTEG (supplies 3-Prod in 3,10) |
| 14 | Spin Finished Inventory= INTEG ( in 3-supplies 2,10) |
| 15 | Textile Raw Inventory= INTEG (supplies 2-Prod in 2,60) |
| 16 | Textile Finished Inventory= INTEG (in 2-sold 2,10000) |
| 17 | Inventory 1= INTEG (in 1-sold 1,200) |
| 18 | Inventory 0= INTEG (in 0-sold 0,200) |
| 19 | Inventory= INTEG (in-sold,200) |
| 20 | Production Loss 2= Prod in 2* 0.12 |
| 21 | Production Loss 3= Prod in 3 * 0.12 |
| 22 | Procurement Delay= IF THEN ELSE( (Procurement Time>1),(Procurement Time-1), 0) |
| 24 | Cost Increase= 1*(Backlog+Backlog 0+Backlog 1+TextileBacklog+SpinBacklog)+ 0.5* (Inventory+Inventory 0 +Inventory 1+Textile Finished Inventory + Spin Finished Inventory+Textile Raw Inventory +SpinRaw Inventory)+1*(Production Loss 2+Production Loss 3)+1*(Procurement Delay*2) |
| 25 | Total Costs= INTEG (Cost Increase,0) |
| 26 | Eff Inv 3= Spin Finished Inventory-SpinBacklog |
| 27 | Eff Inv 2= Textile Finished Inventory-TextileBacklog |
| 28 | Eff Inv 1= Inventory 1-Backlog 1 |
| 29 | Eff Inv 0= Inventory 0-Backlog 0 |
| 30 | Eff Env= Inventory-Backlog |
| 31 | supplies 2= DELAY MATERIAL (ordered 2,Procurment Time,10,0) |
| 32 | supplies 3= DELAY MATERIAL (ordered 3, Procurement Time,10,0) |

| 33 | sFlow 3= placed 3-in 3 |
|---|---|
| 34 | sFlow 2= placed 2 –in 2 |
| 35 | sFlow 1= placed 1-in 1 |
| 36 | sFlow 0 = placed 0-in 0 |
| 37 | sFlow = placed-in |
| 40 | SupplyL 3= INTEG (sFlow 3,10) |
| 41 | SupplyL 2= INTEG (sFlow 2, 0) |
| 42 | SupplyL 0 = INTEG(sFlow 0,100) |
| 43 | SupplyL 1 = INTEG(sFlow 1,100) |
| 44 | SupplyL = INTEG(sFlow,100) |
| 45 | ORDer=RANDOM NORMAL(1095,23824,12905,6291, 0) |
| 46 | ordered= DELAY FIXED (placed,1,200) |
| 47 | ordered 0= DELAY FIXED (placed 0,1,200) |
| 48 | ordered 1= DELAY FIXED (placed 1,1,200) |
| 49 | ordered 2= DELAY FIXED ((placed 2+(placed 2*safety level))*0.001,2,30) |
| 50 | ordered 3= DELAY FIXED ((placed 3+(placed 3*safety level)),2,10) |
| 51 | placed=  MAX(0,SMOOTH(ORDer,SMOOTHTIME)  +A*(200-(Inventory-Backlog)-B*SupplyL)) |
| 52 | Placed 0=MAX(0,SMOOTH(ordered,SMOOTHTIME)+A*(200-(Inventory 0-Backlog 0)-B*SupplyL 0)) |
| 53 | placed 1= MAX(0,SMOOTH(ordered 0,SMOOTHTIME)+A*(200-(Inventory 1-Backlog 1)-B*SupplyL 1)) |
| 54 | placed 2=MAX(0,SMOOTH(ordered 1,SMOOTHTIME)+A*(10000-(Textile Finished Inventory-TextileBacklog)-B*SupplyL 2)) |
| 55 | placed 3=  MAX(0,SMOOTH(ordered  2,SMOOTHTIME)+A*(10-(Spin Finished Inventory-SpinBacklog)-B*SupplyL3)) |
| 56 | Production size2= (Prod in 2- Production Loss 2)/0.001 |
| 57 | Production size3= (Prod in 3- Production Loss 3) |
| 58 | Prod in 2= IF THEN ELSE (Textile Finished Inventory < (ordered 1+TextileBacklog+     (ordered     1*safety     level)),((ordered 1+TextileBacklog+(ordered 1*safety level))-Textile Finished Inventory)\ *0.001,0) |
| 59 | Prod in 3= IF THEN ELSE (Spin Finished Inventory < (ordered 2+SpinBacklog+(ordered 2*safety level)),((ordered 2+SpinBacklog+(ordered 2*safety level))-Spin Finished Inventory,0) |
| 60 | SpinBacklog= INTEG (SpinbFlow, 0) |
| 61 | TextileBacklog= INTEG (TextilebFlow, 0) |
| 62 | Backlog 1 = INTEG(bFlow 1,0) |
| 63 | Backlog 0 = INTEG(bFlow 0,0) |
| 64 | Backlog = INTEG(bFlow,0) |
| 65 | SpinbFlow=ordered 2-supplies 2 |
| 66 | TextilebFlow= ordered 1-sold 2 |
| 67 | bFlow 1= ordered 0-sold 1 |
| 68 | bFlow 0 = ordered-sold 0 |
| 69 | bFlow = ORDer-sold |
| 70 | in= DELAY FIXED (sold 0,1,200) |
| 71 | in 0= DELAY FIXED (sold 1,1,200) |
| 72 | in 1= DELAY FIXED (sold 2,1,200) |
| 73 | in  2=  DELAY  FIXED  (SMOOTH(Production  size2,Time  to  Adjust |

| | |
|---|---|
| | Production),(Prod in 2/Production Capacity 2),SMOOTH(Production size2,Time to Adjust Production)) |
| **74** | in 3= DELAY FIXED (SMOOTH(Production size 3,Time to Adjust Production),(Prod in 3/Production Capacity 3),SMOOTH(Production size 3,Time to Adjust Production)) |
| **75** | Sold= MIN(Inventory+in,ORDer+Backlog) |
| **76** | Sold 0= MIN(Inventory 0+in 0,ordered+Backlog 0) |
| **77** | Sold 1= MIN(Inventory 1+in 1,ordered 0+Backlog 1) |
| **78** | Sold 2= MIN(Textile Finished Inventory+in 2,ordered 1+TextileBacklog) |
| **79** | SAVEPER = TIME STEP |
| **80** | INITIAL TIME = 0 week |
| **81** | TIME STEP = 0.25 week |
| **82** | FINAL TIME = 36 week |

# Mdx Beer Game 2

This beer game represents the case of fulfilling international markets order under current situation of supply chain deficiencies

| Number | Equation |
|--------|----------|
| 1 | A = 0.25 |
| 2 | B = 0.33 |
| 3 | safety level=0.2 |
| 4 | SMOOTHTIME= 1 |
| 5 | Production Capacity 3=300 Ton/ Spin |
| 6 | Production Capacity 2=6000 Towel Unit |
| | Time to Adjust Production=0.25 week |
| 7 | Retailer ORDer= RANDOM NORMAL(5718,272878,100017,75667,0) |
| 8 | placed 2= MAX(0,SMOOTH(Retailer ORDer,SMOOTHTIME)+A*(10000-(Textile Finished Inventory-TextileBacklog)-B*SupplyL 2)) |
| 9 | ordered 2= DELAY FIXED ((placed 2+(placed 2*safety level))*0.001,5,30) |
| 10 | placed 3= MAX(0,SMOOTH(ordered 2,SMOOTHTIME)+A*(10-(Spin Finished Inventory-SpinBacklog)-B*SupplyL3)) |
| 11 | ordered 3= DELAY FIXED ((placed 3+(placed 3*safety level)),1,10) |
| 12 | Procurement Time= RANDOM UNIFORM(1,8,2) |
| 13 | supplies 3= DELAY MATERIAL (ordered 3, Procurement Time, ordered 3,0) |
| 14 | Production Loss 3= Prod in 3 * 0.12 |
| 15 | Prod in 3= IF THEN ELSE (Spin Finished Inventory<(ordered 2+SpinBacklog+(ordered 2*safety level)),((ordered 2+SpinBacklog+(ordered 2*safety level))-Spin Finished Inventory),0) |
| 16 | Production size3=(Prod in 3- Production Loss 3) |
| 17 | in 3= DELAY FIXED (SMOOTH(Production size3,Time to Adjust Production),(Prod in 3/Production Capacity 3),SMOOTH(Production size3,Time to Adjust Production)) |
| 18 | Procurement time 2= RANDOM UNIFORM(1,2,0.5) |
| 19 | supplies 2= DELAY MATERIAL (ordered 2,Procurement time 2,10,0) |
| 20 | Production Loss 2= Prod in 2* 0.12 |
| 21 | Prod in 2=IF THEN ELSE (Textile Finished Inventory<(Retailer ORDer+TextileBacklog+(Retailer ORDer*safety level)),((Retailer ORDer+TextileBacklog+(Retailer ORDer*safety level))-Textile Finished Inventory)*0.001,0) |
| 22 | Production size2=(Prod in 2- Production Loss 2)/0.001 |
| 23 | in 2= DELAY FIXED (SMOOTH(Production size2,Time to Adjust Production),(Prod in 2/Production Capacity 2) ,SMOOTH(Production size2,Time to Adjust Production)) |
| 24 | Delivery Time= RANDOM UNIFORM(1,4,2) |
| 25 | sold= DELAY MATERIAL (Retailer ORDer, Delivery Time,500,0) |
| 26 | Textile Finished Inventory= INTEG (in 2-sold, 10000) |
| 27 | SpinRaw Inventory= INTEG (supplies 3-Prod in 3, 30) |
| 28 | Procurement Delay1= IF THEN ELSE( (Procurement time >4),(Procurement time -4), 0) |
| 29 | Procurement Delay2= IF THEN ELSE( (Procurement Time |

| | |
|---|---|
| | 2>1),(Procurement Time 2-1), 0) |
| 30 | time increase= Order Processing Time+Procurement Time+Procurement time 2+Delivery Time+Production Time |
| 31 | Lead Time= INTEG (time increase,0) |
| 32 | Cost Increase=1*(TextileBacklog+SpinBacklog)+0.5*(Textile Finished Inventory+Spin Finisied Inventory+Textile Raw Inventory+SpinRaw Inventory)+1*(Production Loss 2+Production Loss 3)+1*(Procurement Delay1+Procurement Delay2) |
| 33 | Total Costs= INTEG (Cost Increase, 0) |
| 34 | Eff Inv Rate= Eff Inv 2+Eff Inv 3 |
| 35 | Effective Inventory= INTEG (Eff Inv Rate, 0) |
| 36 | Eff Inv 2= Textile Finished Inventory-TextileBacklog |
| 37 | Eff Inv 3= Spin Finisied Inventory-SpinBacklog |
| 38 | Spin Finished Inventory= INTEG (in 3-supplies 2, 10) |
| 39 | Textile Raw Inventory= INTEG (supplies 2-Prod in 2, 60) |
| 40 | SupplyL 2= INTEG (sFlow2,200) |
| 41 | SupplyL3= INTEG (sFlow3,10) |
| 42 | sFlow3= placed 3 -in 3 |
| 43 | sFlow 2= placed 2 -in 2 |
| 44 | SpinBacklog= INTEG (SpinbFlow, 0) |
| 45 | SpinbFlow= ordered 2-supplies 2 |
| 46 | TextileBacklog= INTEG (TextilebFlow, 0) |
| 47 | TextilebFlow= Retailer ORDer-sold |
| 48 | FINAL TIME  = 36 week |
| 49 | INITIAL TIME  = 0 week |
| 50 | SAVEPER  = TIME STEP |
| 51 | TIME STEP  = 0.25 week |

## Mdx Beer Game 9

This beer game represents the case of fulfilling local markets order under scenario of information visibility.

| No | Equation |
|----|----------|
| 1 | Eff Inv=Inventory-Backlog |
| 2 | Eff Inv 0=Inventory 0-Backlog 0 |
| 3 | Eff Inv 1= Inventory 1-Backlog 1 |
| 4 | Eff Inv 2=Textile Finished Inventory-TextileBacklog |
| 5 | Eff Inv 3= Spin Finished Inventory-SpinBacklog |
| 6 | Eff Inv Rate=Eff Inv+Eff Inv 0+Eff Inv 1+Eff Inv 2+Eff Inv 3 |
| 7 | Total Effective Inv= INTEG (Eff Inv Rate,0) |
| 8 | Procurement Delay=IF THEN ELSE( (Procurement Time>1) , (Procurement Time-1), 0) |
|  | Cost Increase= 1*(Backlog+Backlog 0+Backlog 1+ TextileBacklog +SpinBacklog) +0.5*(Inventory+Inventory 0+Inventory 1+Textile Finished Inventory+Spin Finished Inventory+Textile RawInventory +SpinRaw Inventory)+1*(Production Loss 2+Production Loss 3)+1*(Procurement Delay*2) |
| 9 | Total Costs= INTEG (Cost Increase,0) |
| 10 | Production Capacity 2=300 |
| 11 | Production Capacity 3=6000 |
| 12 | Total Production time=(Prod in 2/Production Capacity 2)+(Prod in 3/Production Capacity 3) |
| 13 | Distribution time=3 week |
| 14 | Procurement Time=RANDOM UNIFORM(1,2,0.5) |
| 15 | Order Processing Time=0 |
| 16 | time increase= Order Processing Time+(2*Procurement Time)+Total Production time+ Distribution time |
| 17 | Lead Time= INTEG (time increase,0) |
| 18 | SL=200 |
| 19 | S= 1095 |
| 20 | SMOOTHTIME=1 |
| 21 | ORDer= RANDOM NORMAL(1095,23824,12905,6291, 0) |
| 22 | ROrder= MAX(0,SMOOTH(ORDer,SMOOTHTIME) +S-Inventory+Backlog+SL-SupplyL) |
| 24 | WOrder=MAX(0,SMOOTH(ORDer,SMOOTHTIME)+S-Inventory 0+Backlog 0+SL-SupplyL 0) |
| 25 | DOrder= MAX(0,SMOOTH(ORDer,SMOOTHTIME)+S-Inventory 1+Backlog 1+SL-SupplyL 1) |
| 26 | TOrder= MAX(0,SMOOTH(ORDer,SMOOTHTIME)+S-Textile Finished Inventory+TextileBacklog+SL-SupplyL 2) |
| 27 | SpinOrder=MAX(0,SMOOTH(ORDer,SMOOTHTIME)+S-Spin Finished Inventory+SpinBacklog+SL-SupplyL3) |
| 28 | safety level=0.2 |
| 29 | supplies 2= DELAY MATERIAL (TOrder+(TOrder*safety level))*0.001,Procurment Time,MISL,0) |
| 30 | supplies 3= DELAY MATERIAL ((SpinOrder+(SpinOrder*safety |

| | |
|---|---|
| | level))*0.001, Procurment Time,MISL,0) |
| 31 | Time to Adjust Production=0.25 week |
| 32 | Production Loss 2=Prod in 2* 0.12 |
| 33 | Production Loss 3=Prod in 3 * 0.12 |
| 34 | Production size3=(Prod in 3- Production Loss 3) |
| 35 | Production size2=(Prod in 2- Production Loss 2)/0.001 |
| 36 | Production Time=(Prod in 2/Production Capacity 2)+(Prod in 3/Production Capacity 3) |
| 37 | Prod in 2= IF THEN ELSE (Textile Finished Inventory< DOrder+TextileBacklog+ DOrder*safety level )), (DOrder+TextileBacklog (DOrder*safety level))-Textile Finished Inventory)*0.001,0) |
| 40 | Prod in 3=IF THEN ELSE (Spin Finished Inventory<(TOrder+SpinBacklog+ (TOrder*safety level)), (TOrder+SpinBacklog+ (TOrder*safety level))- Spin Finished Inventory)*0.001,0) |
| 41 | In= DELAY FIXED (sold 0,1,S) |
| 42 | In 0= DELAY FIXED (sold 1,1,S) |
| 43 | In 1= DELAY FIXED (sold 2,1,S) |
| 44 | In 2= DELAY FIXED (SMOOTH(Production size2,Time to Adjust Production),(Prod in 2/Production Capacity 2),SMOOTH(Production size2,Time to Adjust Production)) |
| 45 | In 3= DELAY FIXED (SMOOTH(Production size3,Time to Adjust Production),(Prod in 3/Production Capacity 3),SMOOTH(Production size3,Time to Adjust Production)) |
| 46 | TextileRaw Inventory= INTEG (supplies 2-Prod in 2,MISL) |
| 47 | SpinRaw Inventory= INTEG (supplies 3-Prod in 3, MS) |
| 48 | Textile Finished Inventory= INTEG (in 2-sold 2,S) |
| 49 | Spin Finished Inventory= INTEG (in 3-supplies 2,MISL) |
| 50 | Inventory 1= INTEG (in 1-sold 1,S) |
| 51 | Inventory 0= INTEG (in 0-sold 0,S) |
| 52 | Inventory= INTEG (in-sold,S) |
| 53 | sFlow = ROrder-in |
| 54 | SupplyL = INTEG(sFlow,ISL) |
| 55 | sFlow 0 = WOrder-in 0 |
| 56 | SupplyL 0 = INTEG(sFlow 0, ISL) |
| 57 | sFlow 1=DOrder-in 1 |
| 58 | SupplyL 1 = INTEG(sFlow 1, ISL) |
| 59 | sFlow 2=TOrder -in 2 |
| 60 | SupplyL 2= INTEG (sFlow 2- supplies 2, ISL) |
| 61 | sFlow 3=SpinOrder-in 3 |
| 62 | SupplyL3= INTEG (sFlow 3, MISL) |
| 63 | bFlow = ORDer-sold |
| 64 | Backlog = INTEG(bFlow,0) |
| 65 | bFlow 0=ROrder-sold 0 |
| 66 | Backlog 0 = INTEG(bFlow 0,0) |
| 67 | bFlow 1=WOrder-sold 1 |
| 68 | Backlog 1 = INTEG(bFlow 1,0) |
| 69 | TextilebFlow=DOrder-sold 2 |
| 70 | TextileBacklog= INTEG (TextilebFlow,0) |
| 71 | SpinbFlow=ordered 2-Prod in 3 |

| | |
|---|---|
| **72** | SpinBacklog= INTEG (SpinbFlow,0) |
| **73** | sold = MIN(Inventory+in,ORDer+Backlog) |
| **74** | sold 0= MIN(Inventory 0+in 0,ROrder+Backlog 0) |
| **75** | sold 1=MIN(Inventory 1+in 1,WOrder +Backlog 1) |
| **76** | sold 2=MIN(Textile Finished Inventory+in 2,DOrder+TextileBacklog) |
| **77** | INITIAL TIME  = 0 |
| **78** | SAVEPER  = TIME STEP |
| **79** | TIME STEP  = 0.25 week |
| **80** | FINAL TIME  = 36 week |

## Mdx Beer Game 10

This beer game represents the case of fulfilling international markets order under scenario of information visibility.

| No | Equation |
|---|---|
| 1 | SMOOTHTIME=1 week |
| 2 | SL=500 Towel Unit |
| 3 | S=5718 Towel Unit |
| 4 | MS= 20 Ton/Spin |
| 5 | MISL= 40 Ton/Spin |
| 6 | MSL=20 Ton/Spin |
| 7 | ISL=200 Towel Unit |
| 8 | Production Capacity 3=300 |
| 9 | Production Capacity 2=6000 Towel Unit |
| 10 | Time to Adjust Production=0.25 week |
| 11 | safety level=0.2 |
| 12 | Retailer ORDer= RANDOM NORMAL(5718,272878,100017,75667,0) |
| 13 | TOrder= MAX(0,SMOOTH(Retailer ORDer,SMOOTHTIME)+S-Textile Finished Inventory+TextileBacklog+SL-SupplyL 2) |
| 14 | SpinOrder= MAX(0,SMOOTH(Retailer ORDer,SMOOTHTIME)+(MS-Spin Finished Inventory+SpinBacklog+MSL- SupplyL3)/0.001) |
| 15 | Procurement delay2= IF THEN ELSE( (Procurement time2>4),(Procurement time2-4), 0) |
| 16 | Procurement Delay= IF THEN ELSE( (Procurment Time>1),(Procurment Time-1), 0) |
| 17 | Cost Increase=1*(TextileBacklog+SpinBacklog)+0.5*(Textile Finished Inventory+Spin Finished Inventory+Textile Raw Inventory+SpinRaw Inventory)+1*(Production Loss 2+Production Loss 3)+1*(Procurement Delay+Procurement delay2) |
| 18 | Cost= INTEG (Cost Increase, 0) |
| 19 | Total Costs= INTEG (Cost Increase, 0) |
| 20 | Delivery Time= RANDOM UNIFORM(1,3,2) |
| 21 | Procurement time2= RANDOM UNIFORM(1,8,2) |
| 22 | Eff Inv 2= Textile Finished Inventory-TextileBacklog |
| 23 | Eff Inv Rate= Eff Inv 2+Eff Inv 3 |
| 24 | Prod in 2= IF THEN ELSE (Textile Finished Inventory< (TOrder+TextileBacklog+(TOrder*safety level)), ((TOrder+TextileBacklog+(TOrder*safety level))-Textile Finished Inventory)*0.001,0) |
| 25 | Textile Finished Inventory= INTEG (in 2-sold, S) |
| 26 | sold= DELAY MATERIAL (Retailer ORDer, Delivery Time,500,0) |
| 27 | TextilebFlow= Retailer ORDer-sold |
| 28 | time increase= Order Processing Time+Procurement time2+Procurment Time+Total Production time+Delivery Time |
| 29 | supplies 3= DELAY MATERIAL ((SpinOrder+(SpinOrder*safety level))*0.001, Procurement time2,MISL,0) |
| 30 | Production time2= IF THEN ELSE(Prod in 2 >0, (Prod in 2/Production Capacity 2 )+0.25*(Prod in 2/Production Capacity 2),0) |

| | |
|---|---|
| 31 | Production time1= IF THEN ELSE (Prod in 3>0, (Prod in 3/Production Capacity 3)+0.25*(Prod in 3/Production Capacity 3),0) |
| 32 | Total Production time= Production time1+Production time2 |
| 33 | supplies 2= DELAY MATERIAL ((TOrder+(TOrder*safety level))*0.001,Procurment Time,MISL,0) |
| 34 | Effective Inventory= INTEG (Eff Inv Rate,0) |
| 35 | Lead Time= INTEG (time increase, 0) |
| 36 | Order Processing Time=0 week |
| 37 | Production size2=(Prod in 2- Production Loss 2)/0.001 |
| 38 | in 3= DELAY FIXED (SMOOTH(Production size3,Time to Adjust Production),(Prod in 3/Production Capacity 3),SMOOTH(Production size3,Time to Adjust Production)) |
| 39 | SpinRaw Inventory= INTEG (supplies 3-Prod in 3, MS) |
| 40 | Production size3=(Prod in 3- Production Loss 3) |
| 41 | Spin Finished Inventory= INTEG (in 3-supplies 2, MISL) |
| 42 | Prod in 3= IF THEN ELSE (Spin Finished Inventory<(SpinOrder+SpinBacklog+(SpinOrder*safety level)),((SpinOrder+SpinBacklog+(SpinOrder*safety level))-Spin Finished Inventory)*0.001,0) |
| 43 | Textile Raw Inventory= INTEG (supplies 2-Prod in 2, MISL) |
| 44 | Production Time=(Prod in 2/Production Capacity 2)+(Prod in 3/Production Capacity 3) |
| 45 | Eff Inv 3= Spin Finished Inventory-SpinBacklog |
| 46 | sFlow 2= TOrder -in 2 |
| 47 | SupplyL 2= INTEG (sFlow 2, ISL) |
| 48 | Production Loss 2= Prod in 2* 0.12 |
| 49 | sFlow 3= SpinOrder*0.001-in 3 |
| 50 | SpinBacklog= INTEG (SpinbFlow, 0) |
| 51 | SupplyL3= INTEG (sFlow 3, MISL) |
| 52 | SpinbFlow= TOrder*0.001-supplies 2 |
| 53 | Production Loss 3= Prod in 3 * 0.12 |
| 54 | Procurment Time= RANDOM UNIFORM(1,2,0.5) |
| 55 | TextileBacklog= INTEG (TextilebFlow, 0) |
| 56 | FINAL TIME  = 36 week |
| 57 | in 2= DELAY FIXED (SMOOTH(Production size2,Time to Adjust Production),(Prod in 2/Production Capacity 2) ,SMOOTH(Production size2,Time to Adjust Production)) |
| 58 | INITIAL TIME  = 0 |
| 59 | SAVEPER  = TIME STEP week |
| 60 | TIME STEP  = 0.25 |