A Framework Supporting the Design of a Lean-Agile Supply Chain towards Improving Logistics Performance

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ABSTRACT

In today’s turbulent environment, there is no longer any possibility of manufacturing and marketing acting independently of each other. Organization cannot longer act as an isolated and independent entity in competition with others similarly 'stand-alone' organizations.

Customers are more informed and express more concern on reduced lead time; just-in-time delivery and value-added services. They want greater responsiveness and reliability from their suppliers; whereas logistics managers want low costs so that they remain competitive as well. Logistics, being the process of planning, implementing, and controlling the efficient, cost-effective flow and storage of materials and information is now looked upon as a key corporate point for simultaneously increasing shareholder and customer value.

Logistics performance is described in terms of superior customer value at less cost, and this customers value is derived from tailored services, reliability, and responsiveness whereas a cost advantage comes through capacity utilization, asset turn and synchronous supply.

Instead the need to create value delivery systems that are more responsive to fast changing markets and are much more consistent and reliable in the delivery of that value requires the agility of a supply chain design and collaboration be focused on the achievement this goal.

The underlying philosophy behind the logistics and supply chain concept is that of planning and co-ordination the materials flow from source to user as an integrated system rather than, as a series of independent activities.

The goal of this approach is to link the marketplace, the distribution network, the manufacturing process and the procurement activity in such a way that customers are serviced at high levels and yet at low cost.

The objective of this project has been to develop a framework that supports the design of a lean agile supply chain towards improving logistics performance. At the course of this process, three research questions have been formulated which stems for identifying those efficient metrics that affect logistics performance and the implementation of a lean-agile supply chain design to improve on them. Contributions to these research questions have been through literature studies as well as empirical research from a number of case studies which have ended up answering the entire thesis.

Therefore results and conclusions to this project is a framework which supports the need for a lean agile supply chain design towards improving logistics performance. It has supported the fact that a lean logistics system will provide an efficient flow of material through the supply chain by eliminating waste, minimizing stocks and costs, gives shorter lead times and work toward a JIT process, Whereas agility at the other hand, though argued by many literature studies that its ability to provide high customer service by responding quickly to different or changing circumstances is more of rhetoric with little substance and can probably excel most in a situation of fashionable or bespoke products, has equally proven beyond convincing doubts that it’s manifestation in every industrial landscape is unstoppable through its ability to give flexible manufacturing systems that can switch rapidly to fast changing market demands.
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1. Introduction

Today's marketplace is characterized by higher levels of turbulence and volatility. The wider business, economics and political environments are increasingly subjected to unexpected shocks and discontinuities. Customers are seeking for the best product at the lowest price with immediate availability (Andersson, A. 2007). There is no longer any possibility of manufacturing and marketing acting independently of each other. Organization cannot longer act as an isolated and independent entity in competition with others similarly 'stand-alone' organizations (Christopher, M. 2005).

Supply chain design, which involves the overall strategies for resource utilization, inventory, lead time, and supplier selection (Selldin, E. 2005), must continuously be developed to meet the challenges in the market. Likewise Collaboration has also been related to low cost, shorter lead time, and high quality.

In the design of a supply chain, the customer order decoupling point is of importance as it separates the part of the supply chain where planning is based on forecast (leaness) to where it is based on actual customer orders (agility).

As a result, agile supply chain design has been very intriguing towards achieving logistics performance.

Therefore integrating logistics and supply chain management can provide multitude of ways to increase efficiency and productivity and hence contribute significantly to reduce unit cost (Christopher, M. 2005).

**Improved logistics** means giving the services that customers want at the lowest possible cost, (Donald Waters 2003). Since it is generally accepted that the need to understand and meet customer requirements is a prerequisite for survival.

In many industries, logistics costs represent such a significant proportion of the total costs that it is possible to make major cost reductions through fundamental engineering logistics processes (Christopher, M. 2005).

Therefore logistics is now looked upon as a key corporate point for simultaneously increasing shareholder and customer value.

According to (Christopher, M. 2005).instead the need to create value delivery systems that are more responsive to fast changing markets and are much more consistent and reliable in the delivery of that value requires the agility of a supply chain as a whole be focused on the achievement of these goals.

Manufacturers are striving for competitive advantage by differentiating itself, in the eyes of the customers, from its competition and secondly by operating at a lower cost and hence greater profits.

However, an increasingly powerful route to achieving a cost advantage comes not necessary through volume and the economies of scale but instead through **Logistics** and **Supply Chain Management (SCM)**. In many case, **collaboration** has also been related to low cost, shorter lead time, and high quality.

The underlying philosophy behind the logistics and supply chain concepts is that of planning and coordinating the materials flow from source to user as an integrated system rather than, as was so often the case in the past, managing the goods flow as a series of independent activities (Christopher, M. 2005).
Logistics is essentially a planning orientation and frame work that seeks to create a single plan for the flow of products and information through a business, while supply chain management builds upon this frame work and seeks to achieve linkage and co-ordination between the process of other entities in the pipeline i.e., suppliers, customers, and the organization itself. Thus for example, one goal of SCM might be to reduce or eliminate the buffers of inventory that exist between organizations in a chain through the sharing of information on demand and current stock levels (Christopher 2005).
1.1. Problem statement

In today's just-in-time world, the ability to respond to customers' requirements in ever-shorter time-frames has become critical. Not only do customers want shorter lead times, they are also looking for flexibility and increasingly customized solutions. The key word in this changed environment is **agility**; which implies the ability to move quickly and to meet customers demand sooner.

Organizations are striving to be more **demand-driven** than **forecast driven**. (Håkan Aronsson 2000) stipulated that, companies increasingly cooperates with and rely on other companies to compete on a global market, the concept of supply chain management and logistics is gaining interest, from practitioners as well as researchers.

One possible approach in keeping the **lead time** very close to zero uses the integrated supply chain and collaboration which **synchronized material movement**. This makes information available to all parts of the supply chain at the same time, so that organizations can co-ordinate material movements, rather than wait for messages to move up and down the chain (Donald Waters, 2003).

Therefore collaborative co-operation between firms in non-competing industry offers significant opportunity in this regard (Christopher, M. 1998).

Furthermore supply chain collaboration will be seen as any kind of joint, coordinated effort between two parties in a supply chain to achieve a common goal.

Results show that for an organization to synchronized ordering and production cycle and avoid sub-optimization; there is the need to reach out to supplier's suppliers and customer's customers. This is done through **integration** of all necessary activities along the supply chain, since organization cannot work in isolation, they most co-operate with other organization in the supply chain to achieve their wider objectives.

Figure 1.1 below shows the three levels of integration in logistics

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**Figure 1.1- shows three levels of logistics integration** Source: (Donald Waters 2003)
If organizations only look at its own operations, there are unnecessary boundaries between them, disrupting materials flow and increasing costs. External integration removes these boundaries to improve the whole chain. Christopher advice this moves, saying that most opportunities for cost reduction and/or value enhancement lie at the interface between supply chain partners. Organizations are importantly concern in shifting transaction from "arm-length" to collaboration.

According to (Womack P, et al, 1991), assembling the major components of an automobile into a complete vehicle requires only about 15% of the task of the final assembly plant or the total manufacturing process. The bulk of work lies with the engineering and fabricating more than 10,000 discrete parts and assembling them into perhaps 100 major components- engines, transmissions, steering gears, suspensions, and so forth. Coordinating this process so that everything comes together at the right time with high quality and low cost has been a continuing challenge to the final assembler firm in the auto industry.

In conclusion, logistics and supply chain management can provide multitude of ways to increase efficiency and hence contribute significantly to reduced unit cost.
1.2. Research Objective

As already mentioned earlier about the global effects of the business environment, customers’ awareness and their consistent request for customized products, just-in-time delivery, reduced lead-time and value added and the importance of logistics and supply chain in the achievements of these goals, the essence of this research is to look deeper into ways of designing an agile supply chain and collaboration that will improves performance in logistics.

Having identified imperatively those advantages offered by logistics and supply chain collaboration in achieving shareholder and customer value, the objective of this thesis is to develop a framework that support how agility of the supply chain design and collaboration improves logistics performance by identifying the supply chain that might be appropriate in different circumstance.

1.3 Research questions

To arrive at an answer that suit the objective of this research work, repeatedly how to develop a framework that support how agility of supply chain design and collaboration improves logistics performance necessitate thorough understanding of what lean and agility is all about, the different contexts in which ‘lean’ and ‘agile’ concepts are best applied.

The fact that agility is a concept that doesn’t exist on its own, but build upon a lean platform by seeking to follow the lean principles up to the de-coupling point and agile practices after that point has called for the attention of the following THREE research questions.

Having as objective of this research, to develop a framework that support the agility of supply chain design and collaboration for improving logistics performance requires us to first of all start by identifying those parameters that affects logistics performance, bringing the first research questions.

**Question1.** Which efficient parameters affect the performance of logistics system?

Having identified these parameters that affects logistics performance, we then think of how to use the agile supply chain design to improve upon these parameters, but before doing so, we first of all look into ‘lean’ since agility is a concept that doesn’t exists on its own but build upon a lean platform and seeks to follow the lean principles up to the de-coupling point, then agile concepts follow.

So understanding fully what ‘lean’ and ‘agility’ means and the context in which they are best applied will gives us the roadmap to know exactly the type of supply chain design that might be appropriate to enhancing logistics performance, bringing research question two as follows:

**Question2.** What is ‘lean’ and ‘agility’ and in which context do the concepts best apply?

Having understood what lean and agility is all about and their context of application, we then try to identify the vital futures or characteristics that will support the design of an agile supply chain, bringing the 3rd question.

**Question3.** How may the design of an agile supply chain be supported?
1.4 Project Limitations

This research work focuses on logistics process within industrial, manufacturing and assembly by seeking to translate the need of the marketplace, into the manufacturing system. The research aims to build a ‘one-plan’ mentality that seeks to replace the conventional stand-alone and separate plans of marketing, distribution, production and procurement (Christopher 2005), by designing an agile supply chain and collaboration.

Lean principles have been brought in for reasons that agility is a concept build upon a lean platform and seeks to follow lean principles up to the de-coupling point and agile practices after that point.

The logistics field is a very broad field, but in this research proposal, it is seen as a competitive device; more efficient logistics creates more value and a more efficient production system, connected to the competitive priorities, from (Skinner 1969).

So the mission of logistics in this thesis has been limited under the framework of creating a one-plan business mentality through which the needs of market place are translated into the manufacturing strategy and plan, which in turn link to the strategy and plan of procurement (Christopher 2005).

Agile supply chain design and collaboration has been seen as the only best strategy to meet this mission of logistics.

Within this thesis, logistics and supply chain has been treated as overlapping concepts because the term supply chain management is often used as a substitute or synonym for logistics. Therefore, efficiency parameters in supply chain/logistics performance has been treated as integrated concepts since, according to Christopher, supply chain management is in fact no more than an extension of the logic of logistics.

This research has been carried out solely with companies within the Mälardalen Vicinity of Sweden, reasons not only being for its significant proportion of the Swedish population in this area and it high GDP contribution, but also for its rich-industrial-tradition with worldwide companies like that ABB, Bofors, Volvo Construction Equipments (VCE), Ericsson, Bombardier Transporter etc.

In formulating research question 2 which is about ‘lean’ and ‘agility’, Toyota Production System (TPS) and DELL Computers has been used respectively as case studies, whereas question 3 and literature on collaboration has been more of input-support to question 2.

Semi-structured interviews had been conducted with senior staffs of companies in relevant areas of logistics and supply chain, but it is very unlikely that data obtained through this means is very accurate since companies might not reveal all vital information for confidential reasons.

Therefore results and recommendations of this research work had been limited to findings from case studies and theoretical literature within relevant areas of logistics and supply chain.

Furthermore; time and unavoidable future occurrence had also been detrimental to the success of this study.
2. Research Methodology

This chapter strives to explain in general the understanding of research methodologies, why each methodology might be appropriate and feasible, with a focused on the most viable and preferred research method for this project.

2.1 Research methodology in general

Research methodology here simply explains the different approaches used by the researcher in collecting data (Åsberg 2001). It is always very important to choose the right methodologies in collecting data in order to reach the agreed solution to the research questions.

The Society and culture association outlined and defined the following research methodologies:

1. **Quantitative methodologies**- which are methodologies that involves closed surveys, and structured interviews. This involves a diagrammatic representation of interaction between individuals which enable concrete data to be collected, measured and compared with a standard.

   - **Survey**- A methodology which can use different instruments such as observation, interview or a written list of questions called a questionnaire. Survey is a process of conducting a study from representative samples of specific population e.g. women in work force, children of ages 9 etc.

   - **Observation**-This methodology involves watching and recording behaviors within a clearly defined area. The researcher plays the role of a passive observer and is, therefore, outside the action.

   - **Questionnaire**- Instrument of collecting data beyond the physical reach of the researcher i.e. from a large or diverse sample of people. It is an impersonal instrument for collecting data and must therefore contain clear questions, or simple words that are easily understood since the researcher might not be there to explain their meanings.

2. **Qualitative methodologies** involves a phenomenological perspective where by researchers aim to understand, report and evaluate the meaning of events for people in particular situations, that is how their social world is structured by participants in it. This methodology seeks to know the way in which participant (rather than the researcher) interpret their reality and construct reality. Some examples include an unstructured interview, focus group, open-minded questionnaires and participant observation.

   - **Interview**- an interview may be tightly structured, semi-structured, in-depth or conversational. This methodology involves the researcher and the interviewee in a one-to-one conversation and time consuming. Several people might be interviewed with the same question schedule but at different time intervals.
• **Participant observation** - The researcher is immersed in the action being taken but their role as researcher is not obvious. In this, the researcher still participates in, as well as observes, the action being studies but does so with the knowledge of the other participants.

• **Ethnographic study** - Systematic collection of data derived from direct observation of the everyday life of a particular society, group or subculture. This methodology requires the researcher’s immersion in the culture/subculture under study and is an interactive process.

3. **Statistical analysis** seeks to examine and interpret the meaning of data, make generalizations and extrapolate trends. This data comes in graphical form and expressed in mathematical language which obviously requires mathematical and statistical procedures for their evaluation and interpretations.

4. **Personal reflection** requires the researcher to reflect upon, and evaluate, their own experiences, memories, values and opinions in relations to a specific issue or topic. [http://www.ptc.nsw.edu.au/scansw/method.html](http://www.ptc.nsw.edu.au/scansw/method.html) (Viewed on the 18-11-2007)

Arbnor and Bjerke (1994) outlined three different research methodologies: the analytical approach, the system approach and the actor approach.

1. The **analytical approach** tries to explain the fact that, the state of an object depends solely on the state of the individual part that makes up the object. It is the use of an appropriate process to break down a problem into elements necessary to solve it by identifying the root caused. This means that the performance of individual parts influences the overall performance of the whole.

2. **Action research** - An informal, qualitative, interpretive, reflective and experimental method which requires active participation and collaboration of all researchers involved. It entails a group of people who actually identifies a problem in an environment or organization and jointly device a plan to overcome the problem, by implementing the plan, observing the result, reflect on this result, revise the plan and implement again until the desired outcome is reached.

3. The **System approach** seeks to explain the fact that a whole composed of elements that are related to each other. The cohesion will emerge from the fact that the elements are linked together by their relations. Briefly defined, one might say that a system is a collection of elements in their entirety and the relations between them. Looking at the contemporary organizational perspective of a system, the performance of this organization relies on the interdependency and interaction of the forces surrounding it.

The word “System” is derived from a Greek word “synistanai, which means to bring together or combine. (Whitehead 1925, vonBertalanffy1968) the systems approach emerged as scientists and philosophers identifies common themes in the approach to managing and organizing complex systems. Four different concepts underlie the systems approach.

• **Specialization**: A system is broken down into smaller components allowing more specialized concentration on each component.
• **Grouping**: To avoid generating complexity with specialization, it becomes necessary to group related disciplines or sub-disciplines.

• **Coordination**: As the components and subcomponents of a system are grouped, it is necessary to coordinate the interactions among groups.

• **Emergent properties**: Dividing a system into subsystems requires recognizing and understanding the “emergent properties” of a system.

Within engineering design research and inter-organizational research, the system approach is rather common, due to the art of science and its systems of components and relations between them (Elfving, 2004).

Womack (1990) explains that the reason which allows an interchange of sensitive information in the system (Toyota manufacturing company) is because of the existence of a rational framework in determining costs, price, and profits. This framework drove two parties to work together for mutual benefits, rather than looked upon one another with mutual suspicion. This was just to explain the fact the TPM system works perfectly because of the assumption that all parts act together to achieve a common goal of the company.

In accordance with Lambert et al (1998) who said that the system approach is a critical concept in logistics, since the logistics is a system in itself. It is a network of related activities with the purpose of managing the orderly flow of materials and personnel within the logistics channel.

This is just to support the reason why the system approach is the preferred approach for this project.

According to Yin (1994), five research strategies for carrying out scientific research are possible, namely: experiments, surveys, archival analysis, history and case studies and the chosen strategy depends on the goal of the research, types of research questions and control over behavioral events.

I’m afraid; my focus for this project will limit my explanation of the various research strategies above only to the ‘case study’ because of the way the research questions are being posed ‘how’ and ‘why’ and the fact that the researcher has a negligible control over events and farthest the focus is on a contemporary phenomenon within real-life context. The objective of a case study is to take a small portion of the major context and describe it into reality Ejvegård, (1996). Despite the criticism of insufficient statistical reliability when using a case study, yet the insight and relative deep understanding facilitate analytical generalization so that findings can be generalized to theory (Yin, 1994).

### 2.2 Preferred approach

Within the framework of logistics performance and supply chain design, practical insight about the possibility and problems in this area are needed in qualitative terms. The research questions to this project are of the type ‘how’ or ‘why’ with behavioral events that are beyond the researcher’s control had led to the case study to be the preferred strategy. Moreover, contemporary events are being examined, though lack of statistical reliability and validity as mentioned above are short comings of the case study. Nonetheless, the insight and relatively deep understanding facilitate analytical generalization so that findings can be generalized to theory Yin (1994).

So to overcome this challenge with the case study, semi-structured interviews has been
conducted with different companies within the municipality of Malardalen in Sweden since it is a remarkable industrial region in Sweden with world-wide companies like Volvo, ABB, Ericsson, Bofors, Bombardier transporter, etc and their respective result were treated immediately after each interview.

Three case studies were performed in three of the companies above of which two of the companies were within ABB and one at the Volvo construction equipment (VCE). The empirical data from these case studies have been obtained mainly through semi-structured interviews of at least 60minutes each with top management staffs in areas relevant to this research work (Logistics and supply chain). Continuous evaluation and assessment of the results were made immediately after each interview.

Result from case study II at the ABB Low Voltage Motors was confirmed accurate since after the interview, the report made was later sent to the interviewee for review and certain minor corrections were made but for the rest of the case studies I & III at ABB Cewe Control and Volvo CE respectively the results might not be 100% accurate since the report was based on important jottings and what the researcher’s memory could retained from the interview.

The objective of these case studies was to answer the three research questions. Research question 2 and 3 were later re-formulated into smaller sub-questions with respect to guidelines that make lean production and agile systems successful. See Appendix for a sample of the designed questions (sub-questions). Question 1 also for simplicity reasons was also divided into sets since the staffs of ABB Cewe-Control complained about the broadness of the question.

A summary of the result for the three research questions are presented on chapter IV.
3. Theoretical Background

This chapter strives to review literature on relevant areas of logistics that are important to this research project, by focusing on those parameters that affects performance. Agile supply chain design and collaboration, has been treated as inputs or remedies towards performance with full understanding of lean and agile concepts that are relevant to this research project. Of course, chapter one highlights logistics performance as the core mission of this project by seeking to build a one-plan mentality that translate the needs of the market place into the manufacturing strategy and plan, and in turn into a strategy of plan and procurement. All these necessitate the support of an agile supply chain design and collaborative initiatives.

3.1. Logistics

The very occurrence of our natural environment is portrayed by the uneven distribution of resources. Some areas of the earth are endowed with abundant supply of certain resources while others are not and vice-versa. This has made it difficult for some people to consume exactly what they want, where and when by limiting their choices to just what is available to them in fewer locations. This is explained by the fact that, in some developing countries, it is very likely to find people living in small, self-sufficient villages where most of their needed goods are produced or acquired in the immediate vicinity, thereby limiting production efficiency and a general decreased in standard of living.

Because of this inconveniency in resource availability, knowledge of redistribution and reallocation is been continuously developed to enhance product availability through logistics processes. Therefore, in this type of economy, a well-developed and inexpensive logistics system would encourage an exchange of goods with other producing areas of the country or even the world (Ballou 2004).

The birth of Logistics can be traced back to ancient war times of Greek and Roman empires when military officers titled as 'Logistikas' were assigned the duties of providing services related to supply and distribution of resources. This was done to enable the soldiers to move from their base position to a new forward position efficiently, which could be a crucial factor in determining the outcome of wars. This also involved inflicting damage to the supply locations of the enemy and safeguarding one's own supply locations. Thus, this has lead to the development of a system which can be related to the current day system of logistics management. 2007 www.bestlogisticsguide.com, viewed 10-12-2007.

Improved logistics systems will create a geographical separation of consumption and production, and regions will specialize in those commodities that can be produced most efficiently. Excess production can be shipped economically to other producing areas, and needed goods not produced locally were imported which is explained by the principle of comparative advantage. This same principle, when applied to world markets helps to explain the high level of international trade that takes place today. Efficient logistics systems allow world businesses to take advantage of the fact that lands, and the people who occupy them,
are not equally productive. Logistics is a very essence of trade. It contributes to higher economic standard of living for us all.

Efficient logistics systems (transport) can move product quickly over long distances, so there is no need for a traditional warehouse built close to customers (Waters 2003).

Logistics was introduced during the 1940s among researchers and the US firms with a focus on separate activities and mathematical optimization for transportation solutions. But as time propagates, a new vision of logistics regarding efficiency turns to develop during the 1960s and the 1970s. Logistics has been gradually developing from cost-driven in the past to customers’ service. This significant development can be explained by the impact that logistics has brought to the Japanese car industry during the 1980s from high volume manufacturing based on forecast towards to actual customer order. According to Christopher (2005), it is only in recent years that business organization have recognize the vital impact that logistics management can have in the achievement of competitive advantage.

The rapid evolution of our business environment during the 1990s which is described by importance of information flow, shorter-lead times, flexible processes and increased customer concern has made the logistics system very indispensable to the success of the organization (Andersson 2007). Figure 3.1 below depict the indispensability of logistics management in creating value to both customers and shareholders.
Logistics management has the potential to assist the organization in the achievement of both a cost advantage and value advantage. (Christopher 2005).

Value advantage

Logistics leverage opportunities:
- Tailored services
- Reliability
- Responsiveness

The Goal:
Superior customer value at less cost

Cost advantage

Logistics leverage utilization
- Capacity utilization
- Asset turn
- Synchronous supply

The figure 3.1- represents a number of important ways in which productivity can be enhanced through logistics and supply chain. (Christopher M. 2005).

This diagram above strives to explain the fact that performance in logistics is derived from superior customer value at less cost, and these customers value is derived from tailored services whereas a cost advantage comes through capacity utilization, assets turn and synchronous supply.

3.1.1. Definition and scope of logistics.

Logistics is a very wide discipline that involves several functions. It has been called by names, including physical distribution, materials management, and supply chain. Logistics activities to be managed might include all or part of the following:
- Transportation
- Inventory maintenance
- Order processing
- Facility location
- Warehousing
- Material handling
- Packaging
- Customer service standards,
- Information flow, and
- Product scheduling.

Logistics is the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory (and the related information flows) through the organization and its marketing channels in such a way that current and future profitability are maximized through the cost-effective fulfillment of orders. (Christopher 2005)

A dictionary definition of the logistics is limited into a military context as follows; the branch of military science having to do with procurement, maintaining, transporting materials, personnel and facilities.

A good example of a modern military logistics is the Gulf War from the fact that, in the 1991 Gulf War, the US and allies airlifted half a million people and over half a million tones of materials over 12,000 km and moved additional 2.3 million tones of equipment by sea, in a short time frame. That kind of movement is more than physical handling. That is logistics. Wars have been won and lost through logistics capability or lack of it. Generals have understood the importance of logistics since early days, but the business has learnt it fairly recently. And the logistics capability gives an edge to the business.


The mission of logistics is to get the right good or services to the right place, at the right time, and in the desired condition, while making greater contribution to the firm.

It is essentially a planning orientation and framework that seeks to create a single plan for the flow of product and information through a business.

For reasons that business objectives and activities defers from those of military, the military definition of logistics above does not hold for business logistics management.

A better representation of the definition of logistics that supports the business objectives and activities of which, this researcher equally embraced, was promulgated by the Council of Logistics Management (CLM), a professional organization of logistics managers, educators, and practitioners formed in 1962 for the purposes of continuing education and fostering the interchange of ideas (Ballou, 2004) is as follows;

Logistics is the process of planning, implementing and controlling the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods and related information from point of origin to point of consumption for the purpose of conforming to customer requirements.
The scope of logistics spans the organization, from the management of raw materials through to the delivery of the final product. Figure 3.2- below, illustrating these total systems concept is an adoptions from (Christopher M 2005).

**Figure 3.2 represents a logistics management process.**

It simply explains the fact that, logistics management from this total view point is the means where by the needs of customers are satisfied through the co-ordination of the materials and information flows that extend from the market-place, through the firm and its operations and beyond that to suppliers.

According (Ballou 2004), planning, specifically for logistics management revolves around a primary decision triangle of **Location, Inventory** and **Transportation**, with **Customer Service** being the result of these decisions.

Figure 3.3- below is an adoption from Ballou 2004, representing the Planning Triangle in relation to the Principal Activities of Logistics/Supply Chain Management.
Customers Service Goals: Customer service standard set the level of output and the degree to which logistics systems must respond. Logistics costs increase in proportion to the level of customers’ service provided. Setting very high service requirements can force logistics costs to exceedingly high levels. Low levels of service allow centralized inventories at few locations and the use of less expensive forms of transport.

Customers’ service broadly includes inventory availability, speed of delivery, and order speed and accuracy. The costs associated with these factors increase at a higher rate as customer service level is raised.

Facility Location Strategy: The geographical placement of the stocking points and their sourcing points create an outline for the logistics plan. Fixing the number, location, and size of the facility and assigning market demand to them determines the path through which products are directed to the market place. The proper scope for the facility location problem is to include all product movements and associated costs as they take place from plant, vendor, or port location through the intermediates stocking points and to the customer location.
Inventory Decisions: Inventories are essential to logistics management because it is usually not possible or practical to provide instant or sure delivery times to the customers. They serve as buffers between supply and demand so that the needed product availability may be maintained for customers while providing flexibility for production and logistics to seek more efficient methods for manufacturing and distributing the products.

Inventory decisions refer to the manner in which inventory is managed. Allocating (pushing) inventories to the stocking points versus pulling them into stocking points through inventory replenishment rules represent two strategies. Selective location of various items in the product line in plants, or managing inventory levels by various methods

Transportation Decisions: Transport and inventories are the primary cost-absorbing logistics activities. Experienced has shown that each will represent one-half to two-third of the total logistics costs. Transportation adds place value to the product and services, whereas Inventory adds time value.

Transportation is very necessary because no modern firm can operate without providing for the movement of its raw materials and/or finished products. Therefore transport decisions can involve mode of selection, shipment size, and routine or scheduling. These decisions are influenced by the proximity of warehouses to customers and plants, which in turn, influence warehouse location. Inventory levels also respond to transport decisions through shipment size.

After fully understanding the origin and what logistics is all about, it is very fundamental to look at what logistics performance is by identifying those parameters that affect business performance. According to the definition from the Businessdictionary.com, performance is the accomplishment of a given task measured against preset standard of accuracy, completeness, cost and speed. It is sometimes referred to as ‘efficiency’ according to the Merriam-Webster’s online dictionary (that’s the ability to perform or the manner in which a mechanism performs).

3.1.2. Performance in logistics.

It will be apparent from the previous comments that the logistics management is to plan and co-ordinate all those activities necessary to achieve desired levels of delivered services and quality at lowest possible cost. Logistics performance is about creating value- value for customers and suppliers of firm, and value for the firm’s stakeholders. So one best approach to improving performance in logistics is to define and measure those parameters that affect performance. Logistics performance is described as superior customer value at less cost. These customers’ values are derived from tailored services, responsiveness and reliability while a cost advantage comes through capacity utilization, asset turns and synchronous supply (Christopher M. 2005).

Therefore if the logistics process is going to make a contribution to the company’s overall profitability, then two aspects must be put forward: The first aspect is to decrease the
company’s costs and the other aspect is to increase the company’s receipts through high customer service (Andersson 2007). Consequently, customer service and costs are very essential values to measure to see if the logistics process fulfils the overall mission for the logistics, to create good customer service at low cost (Aronsson, et al, 2004).

According to him, three groups of measurable values exists which includes; tied up capital, Time and Customer services. Each of these groups constitutes the following examples;

**Tide up capital**: average value in stock, work in progress, and product value, **Time**: lead-time, throughput time, and inventory turnover, **Customer service**: Lead-time, information, flexibility, customer adaptations, delivery capacity and delivery dependability.

Measurement of logistics systems will quantify the efficiency and effectiveness of actions leading to performance, so any evaluation of logistics performance needs to reconcile these two aspects of performance measurement (Mentzer and Firman, 1994). Therefore, performance is a function of effectiveness and efficiency since effectiveness will measure the extent to which customer satisfaction is reached through improved logistics processes whereas efficiency will measure the level of cost minimization in delivering these services (Gleason and Barnum, 1986).

Keebler et al (1990) indicated that an excellent measurement system should produce three primary benefits; reduced cost, improved service, and generation of a healthy growth.

The efficiency parameters that define a company’s material flow efficiency and affect the profitability of business can be expressed in terms of customers’ services and costs (Mattsson, 2002a). This customer service according to him constitutes three parts such as; delivery, information, and logistics services, and each part possesses the following efficiency parameters;

**Delivery service**: inventory service level, delivery capacity, delivery dependability, delivery time, and delivery flexibility. **Logistics service**: includes the complementary service of the electronic data interchange (EDI) which place orders, Item coding to track the movement, and Electronic fund transfer (EFT) that arrange payment. **Costs** includes tied up capital, capacity utilization, volume and product mix flexibility.

This implies that customer services and cost are essential values to measure to see if a logistics process fulfills the overall goal for the company (Aronsson, et al 2004).

According to (Ballou 2004), a product or service is of little value if it is not available to customers at the time and place that they wish to consume it. Business generally creates four types of values such as: form, time, place and possession; but logistics creates two out of these four values. Manufacturing creates “form” value as inputs are converted to output (raw materials are transformed into finished goods). Logistics controls the “time” and “place” values in products, mainly through transportation, information flows and inventory. **Possession** value is often considered the responsibility of marketing, engineering, and finance, where the value is created by helping customers acquire the product through such mechanisms
as advertising (information), technical support, and terms of sale (pricing and credit availability).

The component of a typical logistics systems according to Ballou 2004 are: customer service, demand forecast, distribution communications, inventory control, material handling, order processing, parts and service support, plant and warehouse site selection (location analysis), purchasing, packaging, return goods handling, salvage and scrap disposal, traffic and transportation, and warehousing and storage.

Logistics process should be aimed at decreasing the company’s costs and increase the company’s receipts through high customer service in order to achieve the company’s overall profitability, therefore identifying those parameters that affect logistics performance, it is essential to classify these activities according to the measurement of their contributions to the firm.

Ballou separated these activities as key and support activities since he believes that certain activities will generally take place in every logistics channel, whereas others will take place depending on the circumstances, within a particular firm.

The key activities include:

1. Customer service standards cooperate with marketing to:
   - Determine customer needs and wants for logistics customer service
   - Determine customer response to logistics service
   - Set customer service level.

2. Transportation:
   - Mode and transport service selection
   - Freight consolidation
   - Carrier routing
   - Vehicle scheduling
   - Equipment selection
   - Claims processing
   - Rate auditing.

3. Inventory management:
   - Raw materials and finished goods stocking policies
   - Short-term sells forecasting
   - Product mix at stocking points
   - Number, size and location of stocking points
   - Just-in-time, push and pull strategies.

4. Information flows and order processing
   - Sales order-inventory interface procedures
   - Order information transmittal methods
   - Ordering rules.
Support activities might include:

1. Warehousing.
   - Space determination
   - Stock layout and dock design
   - Warehouse configuration
   - Stock placement

2. Material handling
   - Equipment selection
   - Equipment replacement policies
   - Order-picking procedure
   - Stock storage and retrieval

3. Purchasing
   - Supply source selection
   - Purchase timing
   - Purchase quantities.

4. Protective packaging designed for:
   - Handling
   - Storage
   - Protection from loss and damage.

5. Information maintenance.
   - Information collection, storage, and manipulation
   - Data analysis
   - Control procedures

The key activities are deemed to contribute most to the total cost of logistics or they are essential to the effective coordination and completion of logistics task, though some support activities may be as critical, as the key activities in any particular circumstance, they are considered here as contributing to the logistics mission (Ballou2004).

A logistics process is said to be performance /efficient if the result is translated in terms of superior customer value at less cost, and this customer values comes from tailored services, responsiveness and reliability.

According to (Christopher 2005), customer value might include; **quality, service, costs and time**. Therefore customer service and cost are very fundamental to measure the performance of a logistics process. Factors affecting customer services may include; delivery frequency and reliability, stock level and order cycle time (Christopher 2005).
The table 3.1 below is an adoption and modification from Ballou (2004), Seldin (2005), describing briefly some key and supportive activities to logistics.

<table>
<thead>
<tr>
<th>Key activities</th>
<th>Description</th>
<th>Contributions to logistics.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer service standard</td>
<td>It set the level of output and degree of readiness to which logistics systems must respond.</td>
<td>Logistics cost increase in proportion to the level of customer service provided. Setting very high service standard can force logistics costs to exceedingly high level.</td>
</tr>
<tr>
<td>Transportation</td>
<td>Transportation ensures the movement of raw materials and finished products. It is very indispensable to every modern firm.</td>
<td>Transport is one of the primary cost-absorbing logistics activity. From experienced, it represents about one-half of the total logistics costs. It adds place value to a product and services.</td>
</tr>
<tr>
<td>Inventory</td>
<td>Inventory strategy determines where inventories are located and the size of the inventories. Inventories are essential to logistics management because it is usually not possible or practical to provide instant production or ensure delivery times to customers.</td>
<td>They represent another primary cost-absorbing activity, with about two-thirds of logistics total costs. Inventory maintenance adds time value. They serves as buffers between supply and demand so that needed product availability may be maintained for customers while providing flexibility for production and logistics in seeking efficient methods for manufacturing and distribution of product. Therefore, low inventory levels are cost efficient while buffer inventories can improve flexibility.</td>
</tr>
<tr>
<td>Order processing</td>
<td>It is the activity triggering product movement and service delivery. It is associated with the lead-time.</td>
<td>It is the total time that it takes for customer to receive goods or service. Its costs are minor compared to transportation or inventory. Shorter lead-times are generally better than longer.</td>
</tr>
<tr>
<td>Supportive activities.</td>
<td>Description</td>
<td>Contributions.</td>
</tr>
<tr>
<td>Protective packaging.</td>
<td>It is a supportive activity of transport and inventory maintenance as well as of warehousing and materials handling.</td>
<td>It contributes to the efficiency with which those activities are carried out (inventory and transport).</td>
</tr>
<tr>
<td>Purchasing and product scheduling</td>
<td>They may be considered more of production than of logistics.</td>
<td>However, they also affect the overall logistics effort, and specifically they affect the efficiency of transportation and inventory management.</td>
</tr>
<tr>
<td>Information maintenance</td>
<td></td>
<td>Support all other logistics activities in that it provides the needed information for planning and control.</td>
</tr>
</tbody>
</table>
3.1.3. Other significant trends of logistics performance

Logistics automation which is the application of computer software and/or automated machinery to improve the efficiency of logistics operations is another remarkable way of achieving performance in logistics within warehouse or distribution centers.


1. Fixed machinery
   - Automated cranes (also called automated storage and retrieval systems): provide the ability to input and store a container of good for later retrieval. Typically cranes serve a rack of locations, allowing many levels of stock to be stacked vertically, and allowing far high storage densities and better space utilization than alternatives.
   - Conveyors: Automated conveyors allow the input of containers in one area of the warehouse, and either through hard coded rules or data input allows destination selection. The container will later appear at the selection destination.
   - Sorting systems: similar to conveyors but typically have higher capacity and can divert containers more quickly. Typically used to distribute high volumes of small cartons to a large set of locations.
   - Industrial robots: Four to six industrial robots, e.g. palletizing robots are used for palletizing, depalletizing, packaging, commissioning and order picking.
   - Typically all these will automatically identify and track containers based upon barcodes, or increasingly, RFID (radio frequency identification device) tags.
   - Mobile technology: These are hand held or truck mounted terminals which connect wireless to logistics automation software and provide instructions to operators moving throughout the warehouse. Many also have in-built barcode scanners to allow identification of containers.

2. Software
   - Integration software: This provides overall control of the automation machinery and for instance allows cranes to be connected up to conveyors for seamless stock movements.
   - Operational control software: Provides low-level decision making, such as where to store incoming containers, and where to retrieve them when requested.
   - Business Control software: Provides higher level functionality, such as identification of incoming deliveries / stock and scheduling order fulfillment, assignment of stock to outgoing retailers.
According to Waters D. (2003), ERP systems such as the **Electronic Data Interchange** (EDI), is amongst the latest technological achievements in the light of communication in the 1990s. The EDI allows data exchange between remote computers without any intermediaries.

**ITEM CODING**, and **Electronic Fund Transfer (EFT)**, was associated technologies developed to complement/support the EDI.

Item Coding will give every package of material moved an identification tag, which is usually a barcode or a magnetic strip that can be read automatically as the package moves through the journey. This enables the logistics systems to track the exact location of every package at any time and automated materials handling can move, sort, consolidate, pack and deliver materials.

**EFT** automatically debits the customer’s account and credit the supplier’s when the delivery of material is acknowledged. This make the entire loop completes with the EDI to place orders, Item coding to track the movement, and EFT to arrange for payment. E.g. The secret behind the success of Wal-Mart, the largest grocery retailer in US, lies on “everyday low prices” on a huge variety of products made possible by an inventory replenishment system that combines information technology and unique logistics processes (Fawcett et al. 2007).

### 3.1.4. Summary of logistics theory.

The background and evolution of logistics has been mentioned, which stems from military operations of ancient war time of Greek and Roman empires to business focus due to its important contribution to the organization. Chosen definition of logistics to this research has been adopted from the Council of Logistics Management (CLM). Within this area, the importance of logistics has been highlighted regarding its contribution to both customers and shareholders. A list of some of the logistics activities mentioned, and the scope which span the organization from management of raw materials to the delivery of the final product (Christopher 2005).

Planning in logistics management according to (Ballou 2004) has been seen to revolve around a primary decision triangle of Location, Transportation, and Inventory with customer service being the result of the decision and **VALUE** in the form of **time and place** being the respective associates of Inventory and Transportation.

Logistics performance has been described in terms of superior customer value at less cost, and this customer values are derived from tailored services, responsiveness and reliability while less costs comes from capacity utilization, asset turn and synchronous supply (Martin 2005).

Therefore customer service and costs have been viewed as essential values to measure inorder to determine if the logistics processes fulfill its overall mission which is ofcourse seen in terms of profit contribution to the company.

Performance measurement systems in logistics has been seen as the process of quantifying the efficiency and effectiveness of actions leading to performance since effectiveness will
measure the extent to which customer satisfaction is fulfilled through improved logistics processes whereas efficiency will measure the level of cost minimization while delivering this service to achieve the overall profitability of business.

Therefore a chosen approach to identify those efficient parameters that affect logistics performance has been according to (Aronsson et al 2004 and Mattsson 2002) to measure customer services and costs since they have a significant impact on the overall profitability of the firm.

Significant trends of logistics automation have been reviewed as an enhancement tool to logistics performance as well.

If logistics management is to exert a large influence on strategy, a structured or formal approach to making this contribution is necessary. This structured approach is available via the concept of the supply chain (Gattorna et al 1996). Therefore it becomes very ideal to look into theory about supply chain management.

### 3.2. Supply Chain Management

Today’s marketplace, (as mentioned in chapter one) is more fiercely competitive and turbulent than ever before. Globalization, technological innovations and customized demands are on the rise. Succeeding in this exciting but challenging world entails managers to pursue Peters Drucker’s (1999) management’s new paradigms; this concept of business relationships extends beyond traditional enterprise boundaries and seeks to organize the entire business processes throughout a value chain of multiple companies. Managers will then work to build strong relationships with supply chain partners who possess essential complementary capabilities. A supply chain is the network of activities that are involved in transforming raw materials and resources to useful product for the final customer. In the light of this research, a supply chain design is viewed as an enhancement strategy for performance. A typical supply chain is made up of several production units and storage points, connected by transportation of goods and by exchange of information (Seldin 2005).

#### 3.2.1. Definition and scope of supply chain management.

Companies are tried to design effective business models that could meet the needs of customers better than competitors since success depends on building processes that can design, make and deliver the innovative, high quality, low-cost products and services that customers demand.

But the challenge of this to managers has been the lack of those needed resources by their companies. They therefore decided to look more proactively beyond their own companies’ four walls to consider how the resources of suppliers and customers can be used to create value. According to Fawcett et al (2007), the effort to align goals, share resources and
collaborate across company boundaries are the essence of supply chain management (SCM). E.g. the classical economist Adam Smith (1776) and the wealth of the nation foresaw the essence of industrialization by determining that division of labor; specialization and exchange represent a qualitative increase in productivity. Through specialization, wealth is increased and the result is a high standard of living. Similarly, SCM is collaborative specialization since it allows a company to do a few things very well for which it has unique skills and outsourced other activities to suppliers or customers that possess the needed skills.

The definition of supply chain management propagated in this thesis is adopted from Christopher (2005) is:

_The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole._

Since this process involves multiple suppliers likewise customers, the word ‘chain’ was better replaced by ‘network’ by developing a more accurate definition of supply chain as “a network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users”.

The scope of Supply chain management is often discussed as managing the flow of information and materials from the “suppliers’ supplier to the customers’ customer” Fawcett (2007). Supply chain management involves a significant change from traditional arm’s-length, even adversarial, relationships that so often typified buyer/supplier relationships in the past. As a matter of fact, the focus of supply chain management is on co-operation and trust and the recognition that, properly managed, the ‘whole can be greater than the sum of the parts’ (Christopher 2005).

Supply chain management describes the management of the entire chain of activities from raw material supply to final consumer in order to minimize the time taken to perform each activity, eliminating waste and offer optimal response by maximizing value. It is not merely concern with logistics, but information provision, materials, relationships, strategies and culture are all crucial elements (Bob Lawson et al 1999).

The job of supply chain managers is to find opportunities to work with customers and suppliers to reduce costs while improving services. The goal is to use is to use technology and teamwork to build efficient and effective processes that creates value for the end customers (Fawcett 2007).
Figure 3.4 below is an illustration of a typical supply chain with several production units and storage points, connected by transportation of goods and by exchange of information (Selldin 2005).

Fig. 3.4 is an illustration of a supply chain with several supply chain nodes, transportation, and information flow drawn from (Selldin 2005).

Products are transformed through the supply chain, from the raw materials to useful product for the final customer. The raw material is said to be located upstream of the supply chain as shown on (fig.3.4) and flows through the direction of the customer downstream as transformation takes place to the final product. Some important characteristics for products in a supply chain perspective according to Selldin which will be discussed in detail later in this research are the production volume, number of variants, uncertainty in demand, product life cycle length, and accepted lead-time. These product characteristics are mainly determined by market and can be labeled demand characteristics.
The material flow in a supply chain consists of the product between the different chains nodes, which can be production units or storage points. At the production units, manufacturing processes transform the products by various sorts of mechanical and chemical processing as well as by assembling. The manufacturing processes are characterized by the set-up time, flexibility, organizational structure, and investments in machinery. Inventories are used to decouple the different manufacturing processes from each other (Selldin2005).

Information in a supply chain can consist of a combination of point-of-sales data, customer orders, inventory levels, capacity availability, production plans, and demand forecasts (Selldin2005).

### 3.2.2. Integration in supply chain.

As mentioned earlier in the beginning of chapter one about the impossibility of manufacturing and marketing acting independently of each other due to the turbulent nature of the business environment, organizations have realized the existence of unnecessary boundaries between them that disrupt the flow of materials and increase costs if they are to operate in isolation. They can’t longer act as an isolated and independent entity in competition with others similarly 'stand-alone' organizations.

External integration removes these boundaries to improve the whole chain since most opportunities for cost reduction and/or value enhancement lie at the interface between supply chain partners.

Results indicate that for an organization to synchronize ordering and production cycles and avoid sub-optimization, there is the need to reach out to suppliers and customers and even go beyond that to establish business relationship with the supplier’s suppliers and customer’s customers. This can be done through coordination and collaboration while ensuring that there is an effective alliance/partnership along the supply chain system. There is also the need to ensure that there is adequate flow of information and other related “integrating activities”. This would ensure that the full potential of the upstream and downstream integration process with suppliers and customers is attained.

A supply chain integration system is typically composed of a sequence of organizational and/or independent companies. Since organizations cannot work in isolation, there is the need to corporate with other organizations’ in the supply chain to achieve their overall objective. This is because the set of approaches that is utilized to effectively and efficiently integrate suppliers, manufacturers, warehouses, distribution centers, retailers and ultimately customers so that merchandise is produced and distributed at the right quantities to the right locations and at the right times, in order to minimize the total system cost whiles satisfying the service level requirement. Integrating supply chain within and without an organization would ensure that from the initial stage of separate supply chain functions to integrating all activities along the supply chain, the full potential of achieving customer order point will be attained. **Fig 1.1** in chapter one is a clear example that explains various stages involved in integrating the various levels of logistics activities within an organization.
3.2.3. Benefits of integration

The following are some of the benefits of integration drawn from (Waters 2003):

- Genuine co-operation between all parts of the supply chain, with shared information and resources
- Low costs- due to balanced operations, lower stock, less expediting, economies of scale, elimination of non value added activities.
- Improved performance-due to more accurate forecast, better planning, higher productivity of resources, rational priorities, and etc.
- Improved material flow, with co-ordination giving faster and more reliable movements.
- Better customer service, with shorter lead times, faster deliveries and more customization.
- More flexibility, with organizations reacting faster to changing conditions
- Standardized procedures, becoming routine and well-practiced with less duplication of effort, information, planning, and etc.
- Reliable quality and fewer inspections, with integrated quality management programs.

3.2.4. Information in supply chain

The challenges for manufacturing firms are shifting from internal efficiency to supply chain efficiency. The outward-shifting focus to the supply chain calls for information technology support systems that can handle information exchange between supply chain partners Seldin E (2005). According to Fawcett E et al. (2007), Technology drives global change. He explains that as machine technology once transformed an agricultural economy into an industrial one, modern information technology (IT) is shifting our economy to not just knowledge economy but also to a collaboration economy. Modern information technology makes integration possible, therefore information can be integrated through ordinary means of communications such as telephone, fax and email; it can also be integrated through dedicated supply chain-planning software. Ballou. H (2004) recognizes the fact more efficient logistics operations are possible from the benefits that timely comprehensive information can provide within the firm, as well as from the benefit of sharing appropriate information among other channel members. This has led companies to think of information for logistics purposes as a logistics information system. Naim et al. (2002) concludes that an integrated and co-ordinated supply chain is possible due to modern information and communication technology. A strategy for implementing such systems is the linkages between successive partners in a supply chain; not only for tactical planning and control, but also with respect to strategic intent; as suggested by case studies (see e.g. Arntzen et al.1995, Camm et al. 1997, Hahn et al. 2000, Naim et al. 2002).
3.2.5. Benefits of Information Technology to SCM

According to Fawcett et al. (2007), the following are some of the breakthroughs of information technology.

- Advances in information technology have facilitated the globalization of business and are enabling many of the changes taking place in SCM. Many managers credit the new IT that have emerged in the past 20 years for propelling the SCM to the forefront of strategic discussions. By effectively harnessing and managing the information now available, organizations can design and operate their supply chains much more effectively and efficient than ever before. As an example, for hundred years ago, businesses have relied on paper-based systems when exchanging goods and services, but today, leading companies no longer depends on paper purchase requisitions, purchase orders, invoices, receiving forms, or a manual accounts payable “matching process”. All needed information can be transmitted electronically with minimal human intervention.

- Changes in information technology provide new areas where firms can differentiate themselves from competitors and cultivate genuine competitive advantages. Some have even stated that, given the current competitive climate, “little doubt remains about the importance of information and information technology to the ultimate success, and perhaps even the survival, of any supply chain management initiative”

- There are four reasons why timely and accurate information has become more critical for effective SCM than ever before. First to provide outstanding customer satisfaction, managers need information about order status, inventory availability, delivery schedules, shipment tracking, and invoices. Second, information substitutes for inventory and other resources when dealing with uncertainty. Information takes costs out of the supply chain when used effectively. Third, information increases flexibility with regard to when, where, and how resources are utilized to gain a competitive advantage. Fourth, web-based information sharing is changing relationships between buyers and sellers and redefining SC relationships.

- Clearly, information technology will play a critical role in determining the success of an organization’s SC collaboration efforts. It is because it helps managers do things—some of which have never been possible before.
3.2.6. Efficiency in supply chain

According to Christopher (1998), actually, the biggest challenge of companies is the need to answer to increasing level of uncertainty from customers. Reduced product technology and competitive pressure are forcing continuous changes in products in an even more frequent way, along with customers demanding as much innovation as possible. The supply chain is an important element in logistics development for all industries. It has been a major component of competitive strategy to enhance organization’s productivity and profitability. Therefore measuring the performance of a supply chain is a powerful tool to answer availability in global markets. The performance of the supply chain is considered in terms of efficiency and responsiveness. Efficiency is considered as cost efficiency while responsiveness is considered in terms of speed and flexibility (Selldin 2005) likewise logistics performance.

So rather than limiting our understanding on the performance of a supply chain as a separate entity from logistics, it has been critical to treat them as integrative concepts since supply chain is no more than an extension of the logic of logistics. Logistics management is primarily concerned with optimizing flows within the organization, while supply chain management recognizes that internal integration by itself is not sufficient. Therefore it has been very critical to talk about parameters that affect logistics performance as integrative concepts with supply chain.

These concepts seeks to support logistics and supply chain according to (Christopher 2005) as a planning and co-ordination of materials flow from source to users as integrated system rather than, as was so often the case in the past, managing the flow of goods as a series of independent activities. The main objective of this approach is to link the market place, the distribution network, the manufacturing process and the procurement activities in such a way that customers are serviced at high level and yet at lower costs.

Performance measurement according to Cohen, (2004) is about the use of the right metrics/parameters in the right place in order to know the vitality of the supply chain. The metrics should form a multi-dimension set, measuring all relevant performance areas, structured to give a general view of the success of the organization, aligned with business goals.

As a result, a summary of the set of metrics that measures performance in logistics-Supply chain has been described on the tables below according to the balanced scorecard-measures that drive performance, Kaplan, R., Norton, and P.D., (1992, 1996 & 2000)

The set of measures in these studies have been defined according to the balance scorecard perspectives; financial, customer, internal processes and innovation and learning. The balance scorecard is a phenomenon from Dr. Robert Kaplan (Harvard business school) and David Norton as a performance measurement framework that added strategic non-financial performance measures to traditional financial metrics to give managers and executives a more balance view of organization.
1. **Customer perspective**: In this set of metrics we look for the interface with customer, evaluating; sales/customer support and logistics since these are the activities that directly interact with customer in the sale and delivery processes.

*The activities of sale and customer support will be measured by product quality and market share. Quality is associated with good condition and manufacturing which is the ultimate goal of the customer, whereas market share refers to the position the product occupies in the market along with its competition.*

*Logistics is associated to product delivery, strongly connected with lead time, service level. Actually beyond cost, service level and quality are the cornerstones of customer satisfaction.*

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Primary &amp; support Activities</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Perspective</td>
<td>Sales/customer support</td>
<td>• Quality-% non conformity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Forecast accuracy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Market share</td>
</tr>
<tr>
<td>Logistics</td>
<td></td>
<td>• On time delivery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Number of products/distribution channel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Damaged shipments</td>
</tr>
</tbody>
</table>

2. **Financial Perspective**: The financial perspective was developed to evaluate cost and profits of organizations and the performance measures needs to be realized throughout the organization.

Activities to measure includes: suppliers; manufacturing/operations; storing; logistics and accounting processes.

*Regarding supply, it is very crucial to measure costs of acquisition in order to evaluate fluctuations, deviations from suppliers. Production and quality costs are associated to manufacturing and operations. Logistics and inventory costs represents such a significant part of the final product cost, so monitoring and follow up can represent such a competitive advantage. Finally measuring accounting processes allows a rigorous tracking of the financial evolution of the company.*
### Table 3.3 Financial perspective

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Primary &amp; Support activities</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial perspective</td>
<td>Sourcing</td>
<td>Material acquisition costs</td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
<td>• Non-quality costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Warehousing costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Manufacturing unit costs.</td>
</tr>
<tr>
<td>Warehousing</td>
<td></td>
<td>• Inventory carrying costs</td>
</tr>
<tr>
<td>Logistics</td>
<td></td>
<td>• Logistics costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Transport costs</td>
</tr>
<tr>
<td>Accounting processes</td>
<td></td>
<td>• Cash flow</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Income</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Economic value added</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Operating ratio</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Return on investment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Revenue per employee</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Return on asset</td>
</tr>
</tbody>
</table>

3. **Internal Business Process Perspective**: Internal business process perspective relies on primary activities of value chain, like: sourcing, planning, operation and delivery. **Sourcing activity must evaluate suppliers’ quality and responsiveness, the metrics related to planning should quantify the downstream and upstream operations of productive process.**

**Process operations are quantified in metrics of produced quantities, production ratios, cycle times and usage. Warehousing uses space and storing capacities associated with time and product rotation.**

**Metrics associated with manufacturing process has a strong relation with quality and time. Quality has a high impact on customer satisfaction; time is a measure of efficiency and effectiveness of resources.**
Table 3.4 Internal Business Process

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Primary &amp; support Activities</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal Business Process</td>
<td>Sourcing</td>
<td>• Supplier on-time delivery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Material inventories</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Material quality</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Supplier cycle time</td>
</tr>
<tr>
<td>Planning</td>
<td></td>
<td>• % of orders delivered according to plan</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Schedule changes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• BOM accuracy</td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
<td>• Adherent to schedule</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• % of defect products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Number of finished products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Manufacturing cycle time</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Setups/changeovers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Plan utilization</td>
</tr>
<tr>
<td>Delivery/storing</td>
<td></td>
<td>• Finished goods inventory turn</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Stock keeping units</td>
</tr>
</tbody>
</table>

4. Innovation and Learning Perspective: This reflects the human site of organization and shows the integration of organizations in society. 

Organizations should measure the health of the organizational culture installed. Kotter (1992), exposed that culture represent a set of interdependent values of behavior of a community that tend to perpetuate for long periods of time. This continuity is a product of a large variety of social forces, frequently invisible, a group of rules and values that people learn, being reward when follow it and ostracized when reject it. 

To measure innovation and learning perspective, we will define metric to evaluate innovation, social responsibility and human resources. Innovation and social responsibility are related with interactions between organizations and society. Human resources metric are introduced to identify the employee satisfaction in their working environment. 

Human capital is actually a sustainable competitive advantage, once that it affects performance, so organizational culture must be aligned with business goals.
Table 3.5 Innovation and learning perspective

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Primary &amp; support activities</th>
<th>Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation and learning</td>
<td>Innovation</td>
<td>% of new product development</td>
</tr>
<tr>
<td>perspective</td>
<td>Social Responsibility</td>
<td>Social programs investments</td>
</tr>
<tr>
<td>HR</td>
<td>% Absenteeism</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% Employee training</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Employee productivity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motivation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Employee turnover</td>
<td></td>
</tr>
</tbody>
</table>

Since the framework intends to measure performance in a supply chain environment, metrics must evaluate supply chain behavior in terms of efficiency and effectiveness.

Supply chain measures, were divided into two categories, internal and external. Internal vision of the SC enhances cost and management efficiency whereas externally reliability, responsiveness and flexibility.

Table 3.6 Supply chain-Internal Vision, Customer/External Vision

<table>
<thead>
<tr>
<th>Supply chain-Internal Vision</th>
<th>Supply chain costs</th>
<th>The supply chain management costs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply chain Asset Management Efficiency</td>
<td>• Cash-to-cash cycle time</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Asset turns</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Supply chain- Customer/External Vision</th>
<th>Supply chain delivery reliability</th>
<th>Fill Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply chain responsiveness</td>
<td></td>
<td>Delivery Performance</td>
</tr>
<tr>
<td>Supply chain flexibility</td>
<td></td>
<td>Supply chain response time.</td>
</tr>
</tbody>
</table>

Above has been a tabulation and detailed explanation of some of those parameters that affects logistics performance. Managing these parameters to yield a satisfactory result have been the necessity to focus on the agility of a supply chain, therefore it becomes very imperative to review literature about agility.
Supply chain management is moving from traditional vertical hierarchy based organization to structured processes units. In this process, the vertical integration has been replaced by horizontal integration, involving inter-firm integration and extensive outsourcing to achieve efficiency (Van Hoek et al, 2001).

Moreover, firms move towards mass customization which stresses on efficiency with short time responses and product variety from mass market, and it combined ‘the standardization and customization with one supply chain’ (van Hoek et al., 2001); hence leanness is important at this stage to achieve high quality with waste limitation (Aitkin et al., 2002). Further movement will be to have a fast market response and high product and service variety through applying these capabilities.

Therefore, under such operating environments, agility is important as it is about ‘customer responsiveness and mastering market turbulence’ (Van Hoek et al., 2001).

As a result, managing those parameters towards a satisfactory result has been vital to look into literature about lean and agility.

### 3.2.7. An agile supply chain

The need to respond to ever increasing levels of volatility in demand is one of the greatest challenges facing organization today. For a variety of reasons product and technology life cycles are shortening, competitive pressures force more product changes and consumers demand greater variety than ever before.

Relevant literature has showed that business success can only be achieved through effective co-ordination of all the participants companies across the supply chain (Van Hoek et al, 2001) to shorten product life cycle and reduce product cost (Levary, 2000) as supply fluctuate more rapidly than ever before.

Breaking through this challenge has been the need of the organization to focus its effort upon achieving greater agility such that it can respond in shorter time frames both in terms of volume change and variety change (Christopher, 2005). That is, it needs to be able quickly to adjust output to match market demand and to switch rapidly from one variant to another. Volatility of demand is not a problem to a truly agile business; its process and organizational structure as well as its supply chain relationships enable it to cope with whatever demands are placed upon it. Agility is considered as a vital factor for business success in complex industrial landscapes as it enables rival firms to efficiently perform under time-to-market pressures.

Agility, which is the ability to match supply with demand, is not synonymous with ‘leanness’, but built upon a lean platform and seek to follow the lean principles up to the de-coupling point and agile practices after that point.

The origin of agility is a business concept that lies in flexible manufacturing systems (FMS) (Aitken et al., 2002). Initially, manufacturing flexibility was realized through automation to
enable rapid changes and as a consequence, a greater responsiveness to changes in product volume and variety and later this concept was spread into the wider business context (Christopher and Towill, 2000).

On the other hand, leanness, with reference to automotive industry, to the Toyota Production System (TPS), is often used in connection with lean manufacturing to minimize inventory, of components and work-in-progress and move towards a ‘just-in-time’ environment wherever possible (Womack et al., 1990). According to Christopher (2005), it’s pre-occupation with the reduction or elimination of waste (muda). Lean manufacturing is characterized be ‘level scheduling’; a forward to ensure resource optimization.

The origin of lean to the Japanese automobile industry of the 1970s was an industrial context typified by high volume manufacture of relatively standard products (i.e. low levels variety) and a focus on achieving efficiencies in the use of resources in maximizing economies of scale. Lean practice has proven from experience to work well, in a situation of standard products and relatively predictable demand (Christopher 2005).

However in market environments where demand is uncertain, the level of variety are high and consequently low volume per stock keeping unit, a different response is needed. Though efficiency is always acceptable in the context of unpredictable demand, effectiveness becomes more of a priority in the supply chain management. Effectiveness in this context is meant the ability to respond rapidly to meet the precise needs of an often fragmented market place. That is to say, rather than the emphasis being on producing standard products for mass markets ahead of demand, the requirement becomes one of producing multiple product variants (often customized) for much smaller market segments in response to known demand (Christopher, 2005). Figure 3.5 depict the different contexts of which lean and agile paradigm might work best.

Goldman et al. (1995) identify four basic dimensions of agility: enriching customers, cooperating to enhance competitiveness, organizing to master change and uncertainty, leveraging the impact of people and information. The definition provides a basic conceptual view with the relevant elements of agility, stressing the responses to changes and capturing changes as opportunities (Sharifi and Zhang, 1999).

In the context of supply chain, agility lies in the same theoretical premises as agile manufacturing (Ismail and Sharifi, 2006). More specifically, Aitkn et al. (2002) propose a three-level model with key principles to agile enterprise from rapid replenishment, lean production, and organizational agility to individual action.
Figure 3.5 is obtained from Martin (2005), reflecting the different contexts in which lean and agile paradigm might work best.

From figure 3.5 above, ‘Lean’ works best in a high volume, low variety and predictable environments, whereas ‘Agility’ is needed in a less predictable environment where the demand for variety is high.

In some situation, they may exists the need for both lean and agile supply chain solution since some products will have predictable demand whilst for others, the demand will be far more volatile Christopher (2005). Identifying the types of supply chain strategies according to him that might be appropriate in different circumstances is to position the product in an organization’s portfolio according to their supply and demand characteristics.

Supply characteristics is meant the lead time of replenishment and it is clear that different supply chain strategy will be employed when lead times are shorter than when they are longer.

Demand conditions might be characterized by predictability of demand.
Figure 3.6 is an adoption from Martin (2005), suggesting four broad generic supply chains strategies dependent upon the combination of Supply/Demand conditions for each product.

![Figure 3.6 Generic Supply Chain Strategies](image)

- **Long lead times** (Supply characteristics)
  - **Demand characteristics**
  - **Predictable**
    - **Lean** Plan and optimize
  - **Unpredictable**
    - **Hybrid** De-couple through postponement

- **Short lead times**
  - **Predictable**
    - **Kanban** Continuous replenishment
  - **Unpredictable**
    - **Agile** Quick response

**Fig. 3.6 Generic Supply Chain Strategies**

From figure 3.6 above, when demand is predictable and the replenishment lead times are short, then a just-in-time philosophy is applied which is mediated by a **kanban**.

When lead times are long with predictable demands as shown on the top left hand box, a ‘**lean**’ approach is used of which material components can be ordered ahead of demand and manufacturing and transportation facilities can be optimized in terms of cost and asset utilization. Conversely in a situation where demand is unpredictable and lead times are short as depicted on the bottom left hand corner, **agility** prevails enabling ‘quick response’ type solutions – the extreme case being make-to-order.

With longer lead times and unpredictable demands as shown on the top right hand corner, the first concern should be to reduce the lead time suitable for agile solutions to be applied since the variability of demand is certainly beyond the organizational control. But, when lead times cannot be reduced, then the next option would be to create a lean/agile solution (hybrid). This hybrid solution requires the supply chain to hold strategic inventory in some generic or unfinished form at the de-coupling point with final configuration made rapidly once real demand is known.

The goal of this hybrid is to build an agile response upon a lean platform by seeking to follow lean principles up to the de-coupling point and agile practices after that point as depicted on figure 3.7 below. A **good example of a de-coupling point enabling a lean/agile hybrid strategy according to Christopher** is provided by paint manufacturer such as **ICI** where consumers can afford customized solutions in terms of the color of paint mixing machines located in retail outlets. **The retailers only need to stock a relatively small number of base colors to provide an almost infinite number of final colors. Thus ICI can utilize lean processes in producing base colors in volume but can provide an agile and timely response to end users.**
Fig 3.7 is an adoption and modification from Christopher (2005), illustration of the customer of the customer order de-coupling point (CODP) showing the division between forecast-driven- activities/operations to Customer-order driven activities.

Fig 3.7 is a hybrid supply chain showing the CODP (Christopher 2005)

3.2.8. Lean strategy

The aims of a LEAN STRATEGY are to do every operation using less of each resources-people, space, stock, equipment, time, and so on. It organizes the efficient flow of materials to eliminate waste, give the shortest lead time, minimum stocks and minimum total cost. Waters D (2003) summarized the approach of Lean manufacturing into five main principles:

- *Value* - designing a product that has value from a customer’s perspective
- *Value stream* - designing the best process to make the product by setting effectively the requirements.
- *Value flow* - making the flow of materials through the supply chain by ensuring an efficient flow of materials, eliminating waste, interruptions, waiting and detours.
- *Pull* - Only making products when there is a customer demand by using the JIT principles.
- *Aim of perfection* - Looking for continuous improvements to get closer to the aim of perfect operations by continuously trying to identify areas of waste and eliminating them.

Townsend R (1970) says that all organizations are at least 50% waste- waste people, waste effort, waste space and waste time. During their development work, Toyota identified the following areas of the supply chain where this waste is most likely to occur:

- *Quality* - That is too poor to satisfy customers (either external or internal)
- *Wrong production level or capacity* - making products or having capacity that is not currently needed.
- *Poor process* - having unnecessary, too complicated or time-consuming operations.
• Waiting - for operations to start or finish, for materials to arrive, for equipment to be repaired, and so on.
• Movement - with products making unnecessary, long, or inconvenient movements during operations
• Stock - holding too much stock, increasing complexity and raising costs.

A lean strategy looks for ways of eliminating this waste. The typical approach does a detailed analysis of current operations, and then removes operations that add no value, eliminates delays, simplifies movements, reduces complexities, uses higher technology to increase efficiency, looks for economies of scale, locate near to customers to save travel, and removes unnecessary links from the supply chain Perry M. (1996).

3.2.9. Agile strategy

The aim of the an AGILE STRATEGY as mentioned previously in this chapter is to give high customer service by responding quickly to different or changing circumstances. Waters explains emphasized that there are two aspects of agility. First there is the speed of reaction; agile organizations keep a close check on customer demand and react quickly to changes, and secondly, it is the ability to tailored logistics to demands from individual customers. This justification comes from the obvious importance of customers. Of course, without, customers, organization has no sales, no income, no profit, no business- and soon no organization.

Perry M. (1996) says ‘to sustain competitive advantage, requires a total commitment to your customer’. Organization with a customer focus will typically:

• Aim for complete customer satisfaction
• Allow customers easy access to their organization
• Find exactly what they want
• Design logistics to meet, exceed, these demands.
• Be flexible and respond quickly to changing customer demands
• Get a reputation for outstanding quality and value
• Do after-sales checks to make sure that the customer remains satisfied
• Look outward so that they are always in touch with customers, potential customers, competitors, and so on.

3.2.10. Lean versus agile

At first sight the aim of lean and agile operations seem contradictory. One looks to minimize costs, and see customer service as a constraint; the other looks to maximized customer service, and sees costs as a constraint. For these reasons, Water tries to bring out some important differences as in table 3.7 below:
Table 3.7- Lean versus Agile (Water 2003)

<table>
<thead>
<tr>
<th>Factors</th>
<th>Lean logistics</th>
<th>Agile logistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Efficient operations</td>
<td>Flexible to meet demands</td>
</tr>
<tr>
<td>Method</td>
<td>Remove all waste</td>
<td>Customer satisfaction</td>
</tr>
<tr>
<td>Constraint</td>
<td>Customer service</td>
<td>Cost</td>
</tr>
<tr>
<td>Rate of change</td>
<td>Long-term stability</td>
<td>Fast reaction to changing circumstances</td>
</tr>
<tr>
<td>Measure of performance</td>
<td>Productivity, utilization</td>
<td>Lead times, service level</td>
</tr>
<tr>
<td>Work</td>
<td>Uniform, standardized</td>
<td>Variable, more local control</td>
</tr>
<tr>
<td>Control</td>
<td>Formal planning cycles</td>
<td>Less structured by empowered staff.</td>
</tr>
</tbody>
</table>

3.2.11. Characteristics of a truly agile supply chain.

Yusuf et al. (2004) treat supply chain agility as a measurement of how well the relationships across supply chains involve in the process of manufacturing, design, delivery and customer service. Christopher (2000) defines supply chain agility ‘as a business-wide capability that embraces organizational structures, information systems, logistics process and in particular, mindset’. In the research of van Hoek et al. (2001), four dimensions of agile supply chain have been identified, which are customer sensitivity for a customer oriented supply chain; virtual integration to leverage information across supply chains; process integration to master changes focusing on core competencies; and network integration to coordinate with partners (Christopher, 2000; van Hoek et al., 2001).

Supply chain management is moving away from traditional processes to agile capability to realize operation on actual demand, where information is instantly available through information sharing and exchange and organizations are designed for maximum efficiency during integration processes (Yusuf et al., 2004). Therefore IT plays a key role on realizing by adopting the ‘information enrichment’ supply chain (Gunasekaran and Ngai, 2004) and synchronizing suppliers in the network by proving real time information (Christopher, 2005).

According to Christopher, a supply chain must possess the following distinguished characteristics inorder to be truly agile, as Figure 3.8 suggests below.
Fig. 3.8 The agile supply chain

Firstly, the agile supply chain is *market sensitive*. By market sensitive is meant that the supply chain is capable of reading and responding to real demand. Most organizations are forecast-driven rather than demand-driven simply because they lack direct feedback from the marketplace by way of data on actual customer requirements. They therefore rely on forecasts based upon past sales or shipments and convert these forecasts into inventory. The breakthrough of the information technology in the last decade has made it possible for data to be read direct from point-of-sale or point-of-use which in turn facilitate the organization’s ability to hear the voice of the market and respond directly to it.

The use of IT to communicate between upstream and downstream partners has created a *virtual* supply chain. Virtual supply chains are information based rather than inventory. Electronic Data Interchange (EDI) and the internet have made it possible for partners in the supply chain to share the same data, rather than waiting for that extended chain to transmit data from one step to another.

Information sharing will only benefit supply chain partners through *process alignment*, i.e. collaborative working between buyers and suppliers, joint product development, common systems and shared information.
Results indicate that for an organization to synchronize ordering and production cycles and avoid sub-optimization, there is the need to reach out to suppliers and customers and even go beyond that to establish business relationship with the supplier’s suppliers and customer’s customers. This can be done through coordination and collaboration while ensuring that there is an effective alliance/partnership along the supply chain system.

There is also the need to ensure that there is adequate flow of information and other related “integrating activities” to form a network since there is that growing recognition that individual businesses no longer compete as stand-alone entities but rather as supply chains. Managing network will seek to replace the conventional stand-alone and separate plans of marketing, distribution, production and procurement.

A good example of an agile supply chain system was exhibited by Michael Dell to compete with the manufacturing and marketing of personal computer (PC) Christopher (2005).

*Dell is one of those PC manufacturers who maintained a cost advantage over rivals by assembling and configuring PC according to order. The arrival of the internet makes it possible for Dell to process an order within 36 hours after the order is placed via the internet.*

More than 80% of his orders were actually built, customized, and shipped within 8 hours compared to the time spent testing the machines and loading software. For most direct-to-customer sales, he could expect to see payment within 24 hours of order placement, whereas Compaq (global market leader at that time) had to wait for about 25 days for payments through dealers. His ambition was to constantly re-examine to eliminate possible moment of non-value-adding time out of procurement and assembly processes. As a result, he finally reduce the number of interventions or ‘touches’ involved in manufacturing of his PC to 60, against an industrial average of around 130.

Another fundamental reason for his responsiveness and reliability with customized orders was because of the relationship he built with his suppliers. He didn’t only reduce the number of suppliers companies from 204 in 1992 to 47 by 1997, but established long-term relationships with them. By 2003, around 30 suppliers provided 75% of Dell’s direct material purchase. Most of his suppliers companies were located not more than a distance of 15 minutes away from his factories, and could maintain 8-10 days of inventory in vendor warehouse. He was source from suppliers close to its plant. Production lines in his factories were schedule every two hours thanks to the IT links with the key suppliers.

*His ability to pull material into the factories based on actual order prohibited the need for inventory and a warehouse. The fact that he could communicate directly with customers make it possible for him to shape demand by steering customers towards configurations using steadily available components.*

As a summary, Dell’s ability to see or read and respond directly to the needs of the market place makes his supply chain market sensitive. This was further supported by the breakthrough of IT which makes the supply chain virtual as information could be shared between upstream and downstream partners thereby forming a process alignment through collaboration that is linked together as a network.
This would ensure that the full potential of the upstream and downstream integration process with suppliers and customers is attained. Therefore, higher level of collaboration and synchronization is required if the network is to be truly agile.

### 3.2.12. Summary of supply chain

Relevant theory to this research project within the area of supply chain management is mentioned in this theoretical chapter and a chosen definition of supply chain management according to Christopher (2005) is stated.

Integration in supply chain has been treated as enhancement strategy since unnecessary boundaries that disrupt the flow of vital information exists if organizations have to operate in isolation.

Efficiency in supply chain and logistics performance has been jointly treated as integrative concepts to identify those parameters that affect logistics performance. Reasons for these complementarities are that supply chain is no more than an extension of the logic of logistics. During this process, a set of metrics has been mentioned according to Kaplan (1996) as key performance indicators.

The different contexts of lean and agile supply chain solutions are brought up and the identification of the context in which both might be needed as solution.

Four distinguished characteristics of an agile supply chain are treated according to Christopher (2005), which forms a network of integration to coordinate with partners.

Supply chain collaboration in supply chain management literature is commonly considered a one-best-way recipe to improve performance. With the basic assumption that “the more collaboration- the better the management of the supply network”, it therefore becomes very fundamental for us to supplement the understanding and success of supply chain agility by reviewing theory on collaboration.
3.3. Collaboration

The success of project work depends on the collaboration and participation of the staff. Teamwork is a kind of collaboration and is characterized by a group of people who are responsible for the execution of their tasks, allocation of tasks to the team members, etc. (Anders A. 2007). Collaboration and communication are significant performance factors (Bullinger and Warschat, 1995). Heide and John (1990) defined collaboration as joint action in buyer-supplier relationships and focus on collaborative product and process development processes. In many literatures, collaboration has also been related to low cost, short lead-time and high quality.

3.3.1. Collaboration in Integrated Supply Chain.

From “arms-length” to collaboration

The strategy of managing the supply chain relationship in manufacturing environment has shifted from arms-length transaction based on price to collaboration based on trust and reliable information exchange in the last two decades. Arms-length relationship appeared in the 1980s to visualize the relationship between suppliers and buyers under the famous transaction cost theory (Williamson, 1979; Jones et al., 1997), which was defined as a traditional contractual relation between parties, where partners activities were restricted to those stipulated in the contract with no intention to share resources at all (Eddie W.L., Peter E.D., 2006).

According to a supply chain management (SCM) perspective, organizations do not seek to achieve cost reductions or improvements in profit at the expense of their supply network partners but, rather, seek to make the supply network more competitive as a whole (Romano, 2003). Managing collaboration among supply chain network partner is a strategic task that can contribute to competitiveness and profitability of both individual firms and the entire networks.

The advantages of networking rather than arms-length, relationships rely on the joint use of different knowledge inputs and the combination of trust with market incentives. Hence a networked industrial policy can gain its rationale from these principles (Dietrich, 1994). The relationships mentioned in the above paragraph are, obviously, one of the new relationships in integrated supply chain-collaboration. It runs to every part of the value chain, relies on high level of trust, cooperates with advanced E-business, and brings win-win to all the partners in supply chain.

According to (Womack et al 1990), the brain behind the success of the lean Toyota production system over mass production was because of the rational framework in place to determine costs, price, and profits, which motivated two parties to work together for mutual benefit, rather than look upon one another with mutual suspicion. The interchange of sensitive information was supported by the ground rules laid on the contract between the assembler and
suppliers for a long-term commitment to work together. The basis for this contract was on cooperative relationship, one that is fundamentally different from the relatively adversarial relationships between the assembler and supplier in the west.

*The next level of intensity is collaboration whereby both specified workflow and information are exchange in a manner that permits JIT systems, EDI, and other mechanisms that attempt to make seamless many of the traditional linkages between and among trading parties (Robert E, John W, Niklas, 1998).*

The pivotal importance of SC collaboration in SCM literature has also been reinforced by the impressive results achieved by successful programs in supply networks coordinated by large, high performing focal firms, such as Wal-Mart, Procter & Gamble, and Henkel (Seifert, 2003).

### 3.3.2. Role of trust in collaboration

In collaboration, Trust implies that one believes the partner will stand by its word, not take unexpected actions with a negative impact on the firm (Anderson and Narus, 1990). Trust builds the openness and transparency among buyer and suppliers (Hamel, 1991) so that constructs the long-term collaborative relationship. Therefore the trust should be mutual and high-level reliable.

*……each little step along the development path of a collaborative research project into a contractual arrangement would cause enormous delays and hence endanger its very success. The level of trust needed here is the one labeled “goodwill trust”. (Sako, 1992, Andreas, 2004)*

Recently, the role of trust in collaboration has become more and more popular research subject. Many papers discussed on how to build the trust-foundational collaboration in business. Control comes to the table when adequate trust is not present (Sitkin and Roth, 1993).

*Thus, trust and control are seen not as mutually exclusive but interdependent. ……control, is a key factor influencing the degree of implementing of remote collaboration technologies (Ian, Richard, Thekla, Ellen, 1999).*

Trust doesn’t mean totally emerge to your partner. Enterprises should learn how to combine trust and control to avoid risks and assure their own security of collaborative relationship.
3.3.3. Collaborative Innovation Initiatives across the Supply Chain

The need for constant innovation goes beyond the four walls of the company. The entire supply chain must be involved. As the competitive battleground shift from companies versus company to supply chain versus supply chain, avoiding obsolescence means promoting learning everywhere across the chain. Modern companies must therefore play more active role in the learning that takes place up and down the chain (Fawcett, et al 2007). He explains some of the advantages offered by collaborative innovation across the supply chain as follows.

Collaborative innovation across the supply chain brings together creative talented people found in companies along the chain. Harnessing their experience and better thinking makes sense. A study by PricewaterhouseCoopers revealed that 50% of money-making ideas come from customers, suppliers or competitors.

Secondly, supply chain innovative practices are too costly for a single member of the chain to undertake. For example, fast-cycle product development relies on collaboration. In a manufacturing system where 8 of the 10 engineers in the R&D facility are suppliers personnel, (just like the first-tier suppliers to a lean development program at Toyota who assigns staff members-called resident design engineers – to the development team in the assembler company shortly after the planning process starts and two to three years prior to production) the result is better coordination which has let to shorter development cycles and higher-quality, lower-cost products. The manufacturing and its suppliers have shared in the market share gains. Therefore by working together, sharing resources, companies can improve their own as well as their entire chain competitiveness.

Another profound example is experienced by DaimlerChrysler who loaned key suppliers one or more process engineers for a year or longer. The engineer helps the suppliers reengineer their own processes to improve efficiency and quality. Supplier personnel learn process improvement skills that they can share across the company as well as with their own suppliers.

Some of the collaborative innovative initiatives include:

**Collaborative Improvement Suggestion Programs:** Sometimes, all that is needed is to get suppliers or a customer to share ideas is to ask them and suggestion programs do this. Example, John Deere had great success with its cost reduction opportunities (JDCROP), encouraging suppliers to submit cost-reduction suggestions to Deere for evaluation by Deere engineers. Viable suggestions are approved. A joint supplier-Deere team then work to make the suggestion a reality. First years savings are shared 50/50, giving both partners in the improvement effort a tangible reason to be creative and strive for excellence.

**Collaborative training:** Every member of the supply chain must operate efficient process capable of producing high-quality outputs in order to deliver outstanding value to end customers. Unfortunately, many companies often lack such processes. They often lack managerial skills and capital to build them. The only viable way to improve their processes is to get help from SC members who possess needed expertise and experience. SC leaders therefore make it practice to provide training to valued channel partners.
**Collaborative problem solving:** Large and small problems arise in the course of managing the supply chain relationships. When a problem is discovered, a problem-solving team comprised of buyer and supplier personnel is formed. The team then search out the root cause, brainstorm a solution, and takes action. Joint problem-solving is used to improve the products, processes, and relationship. Collaborative problem solving can also mitigate the impact of an unexpected disaster.

**Collaborative Process Improvements:** Process improvements are often the most resource-intensive form of collaborative innovation. They incorporate and extend the other four collaborative ventures to help SC partners dramatically improve their own capabilities. Companies like DaimlerChrysler and Rockwell Collins have dedicated a large portion of their process engineering to staffs to assist key suppliers in process redesign effort.

**Collaborative pilot project:** Great SC companies improve their odds of pioneering innovative practices by establishing an efficient approach to help them validate groundbreaking ideas and test new programs. Collaborative pilot projects are often used.

### 3.3.4. Summary of collaboration.

Theoretical literature in the area of collaboration has depicted its prime importance in supporting the agility of a supply chain in the sense that it forms a linkage between supply chain partners where significant information and communications are interchanged, built on the basis of trust, thereby replacing the traditional arms-length mentality of business operations.

Collaboration has been viewed from a supply chain management perspective as a means where organizations seek to achieve cost reductions or improvements in profit not at the expense or detriment of their supply chain network partners but rather strives to make the supply network more competitive as a whole (Romano, 2003).

A list of some collaborative innovation initiatives has been explained as strategies for business organization to bring together talented people from different background and cumulate their ideas towards achieving performance.

### 3.4. Grand Summary of the theory introduced.

The introduced theory is this chapter has summarized relevant literature about Logistics, SCM, and Collaboration.

Logistics is a very broad field and ofcourse the prime core of this research work, but a chosen definition of logistics has been limited to the one propagated by the Council of Logistics Managers (CLM). This was a professional organization of logistics managers, educators and practitioners formed in 1962 (Ballou 1994), which seemed to convey the idea that product flows are to be managed from point of where they exist as raw materials to where they are finally discarded.

"Logistics has been defined as that part of the supply chain process which plans, implements, and control the efficient, cost-effective flow and storage of raw materials, in-process inventory, finished goods and service, and related information from point of origin to point of..."
consumption for the purpose of conforming to customer requirements”

Performance in logistics has been explained in terms of value creation for customers and suppliers, and value for the firm’s stakeholders. It has been vital to determine the performance of a logistics system through measurement since performance measurement is one critical step in the design and evaluation of a system.

Therefore measuring performance in logistics has been very essential to expressed in terms of customers service and cost (Aronsson, et al, 2004). Supply chain at the other hand has been seen as an important element in logistics development because of its competitive strategy to enhance organization’s productivity and profitability. Since this process involves multiple suppliers likewise customers, the word ‘chain’ was better replaced by ‘network’ by developing a more accurate definition of supply chain as “a network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users” (Christopher 2005).

For such cumulative opportunities offered by logistics and supply chain, efficiency in supply chain and logistics performance has been treated jointly as integrative concepts to identify those parameters that affect logistics performance since supply chain is no more than an extension of the logic of logistics.

A summary of these efficient parameters affect logistics performance has been described according to the balance scorecard (Kaplan, 1996).

The different contexts of lean and agile supply chain solutions are brought up and the identification of the context in which both might be needed as solution.

Four distinguished characteristics of an agile supply chain are treated according to Martin (2005), which forms a network of integration to coordinate with partners.

Supply chain collaboration in supply chain management literature is commonly considered a one-best-way recipe to improve performance.

A simple definition of collaboration according to Heide and John (1990) was propagated as “joint action in buyer-supplier relationships and focus on collaborative product and process development processes”.

In many literatures, collaboration has also been related to low cost, short lead-time and high quality. With the basic assumption that “the more collaboration- the better the management of the supply network”. Therefore, literature on collaboration has been reviewed as supplement to the success of the supply chain agility.
4. Summary and contribution of Papers

This chapter presents the empirical results obtained from the research project. It also gives the introduction to how and why the case study was carried out; contributions of the papers published from the different companies and a brief summary that encompasses the case study. The thesis provides answers to the three sets of research questions that are related to Logistics/supply chain, lean and agility. Therefore contributions from the papers are published here.

4.1. Introduction

Case Study:
This research was conducted at three selected companies within the vicinity of Mälardalen in Sweden. This area of the country is known for its rich industrial-tradition with worldwide companies like Volvo, ABB, Bombardier, Bofors, Ericsson etc, and harbors a significant proportion of the country’s population and as well as its enormous contributions of GDP to the economy. These selected companies were all manufacturing companies with different products as shown respectively below:

Company A= ABB Cewe Control With products like Soft starters, Push buttons, and Contactors
Company B= ABB Low Voltage Motors and
Company C= Volvo Construction Equipment (VCE)

The reason for choosing this particular companies (manufacturing) was based on the theoretical framework for which the project is built upon and to match this theoretical framework to real industrial life. This research project relies on the strategy of Toyota lean manufacturing and Dell’s customized computers in organizes and managed the supply chain which placed them at the forefront over competitors, therefore success in manufacturing lies on the organization and management of the upstream and downstream partners of the chain.

Furthermore, nearness of the institution (Mälardalen University), where this researcher studies to the companies has been of great advantage.

In the case study performed, the same set of research questions were used for the three companies and a total of 5 people were interviewed which varies from 2 at ABB Cewe-control, 2 at ABB Low Voltage Motors through 1 at Volvo CE and these people were all selected officials ranging from production, logistics through supply managers/planners with a good knowledge and experience in the field. This interview was structured for at least 60 minutes each and on three different occasions (days).

This research questions were further reformulated and detailed into sets of bulleted list with the third question being more of input-support to the second question (see appendix for...
The objective of this case study was to answer the three research questions of which the results is presented on the following papers:

4.2. Paper I: Which efficient parameters affect the performance of logistics systems?

- How do they affect these logistics systems?
- How are they managed to achieve performance?

This question has been broken down into three sets which involves the Logistics activities in various areas: Customer perspective; financial perspective and internal business process (Turn to appendix).

The report presented in this paper is a summary of the result obtained from the three companies (ABC) interviewed since the same research question was used for all the companies and the response were almost similar. Particular emphasizes is made in relation to the company where necessary.

In this case study, it was found that all this companies share similar views at the level of continuously improving the **order lead-time**, which is the total order cycle time or order delivery time that refers to the time elapsed in between the receipt of customer order until the delivery of finished goods to the customers. A reduction in the order cycle time will leads to a reduction in the supply chain response time and as such is an important performance measure and source of competitive advantage (Christopher, 1992). It directly interacts with the customer services in determining competitiveness.

**On-time delivery** or **delivery capability** is equally a concern. This is the ability to delivery on time or when needed. The major issue here especially with company ‘B’ is that they keep **buffer inventories** of partly finished and finished products likewise raw materials in order to improve flexibility while allowing manufacturing to plan production during period of unstable demands and failures from the supply side also. They aren’t satisfied with the performance of delivery from their supplier of which has led them (manufacturing) to ensure customer satisfaction by detrimentally accumulating inventory which is a liability.

‘Company A’ equally keeps **buffer inventory** of finished products since they produce on high volume of standard products. Therefore keeps inventories to care take for periods of unstable demand which of course is costs consuming.

So far company ‘C’ deals with the production of heavy/bulky equipments. Because of the nature of these products (bulky/heavy), they don’t keep inventory of finished goods which sometimes affect the lead times. I found out that their major focus was on improving the **lead time, on-time delivery** since it is usually very longer, **make order more visible** and **order fulfillment rate**. Reasons being that there are engaged in the manufacturing of bulky and heavy equipments which will be much space-consuming with a very high inventory carrying costs if they have to keep inventory of finished products in order to take care of unexpected
longer lead times and on-time deliveries which might be caused by high market demand or failure from the supply side.

It is rather a dealer who is like their customer might keeps a few inventory of the finished goods, but when it comes to dealing directly with the commands of individual customers, they usually specifies how long it might takes them to get things done and it therefore becomes discretionary for the customer to choose to accept or not.

Nevertheless, this company still keeps a defined amount of raw materials inventories especially in a situation where the supplier is located far away. They used barcodes and RFID systems to track movement of materials. An unsatisfactory percentage of their orders are not delivered to schedule sometimes due to quality problem for the suppliers.

Another significant trend for company ‘C’ is to improve a safety and healthy environment through developing sustainable transport systems. Their top priority is to reduce the greenhouse effect of carbon emitting substances (CO2) by urging their suppliers to focus on the manufacturing of high quality products that will help maintain a safety and a healthy environmental standard of transport regulations binding the European transport system as well as international safety norms developed after the September 11 terrorist attack.

This inventory and transportation costs are the primary cost-absorbing logistics activities and therefore much of a liability to the company.

**Total distribution cost:** Sometimes the most important research concerning logistics is going on the area of design of efficient and cost effective distribution systems. Therefore, an understanding of the total distribution cost is essential, so that proper trade-offs can be applied as basis for planning and reassessment of distribution systems. The urgency of transportation costs was highlighted by Thomas and Griffin (1996), who argued that since transportation cost account for more than half of the total logistics cost, more active research is needed in the area. To deal with distribution costs, measuring individual cost element together with their impact on customer services encourages trade-offs that leads to a more effective and efficient distribution system.

**Capacity utilization:** The role played by capacity in determining the level of activities in the supply chain is quite important. According to Slack et al (1995), of the many aspects of production performance, capacity utilization directly affects the speed of response to customer demand through its impact on flexibility, lead-time and deliverability.

Company ‘B’ faces problem at the level of synchronizing production with their internal suppliers (in-house supply). This makes it difficult for manufacturing to adhere to the schedule of production and as a result wastage is sometimes realized due to excess capacity.

**Effectiveness of scheduling techniques:** Scheduling refers to the time or date on or by which activities are to be undertaken. Such fixing determines the manner in which resources will flow in an operating system. The effectiveness of which has an important impact on production and thus supply chain performance. For example scheduling techniques such as JIT, MRP and ERP have implications on purchasing, throughput time and batch size.
In the case of supply chain since scheduling depends heavily on customer demands and supplier performance, the scheduling tools should be viewed in that context (Little et al., 1995).

**Evaluation of suppliers:** The evaluation of suppliers in the context of the supply chain (efficiency, flow, integration, responsiveness and customer satisfaction) involves measures important at the strategic, operational and tactical level.

**Measuring customer service level and satisfaction:** A happy customer is of outmost important. Lee and Billington (1992) and Van Hoek et al (2001) emphasize that to assess supply chain performance, supply chain metrics must be centre on customer satisfaction.

**Flexibility:** This can be rightly regarded as a critical factor in a situation of competitive supply chain. This means having the capability to provide products/services that meet individual customers’ demands. Flexibility measures includes (i) Product development cycle tome, (ii) machine/tools set up time, (iii) economies of scope (Christopher, 1992)- refers to the production of small quantities of wider range (e.g. JIT lot size) and (iv) number of inventory turns.

So far the presentation of these parameters has been based on the result obtained from the three companies. Nevertheless, these also include a presentation of some responses that popped up which were deemed relevant at the course of the interview but not originally presented in the research questions. Having gotten an extensive view of these efficient parameters that affects logistics performance from different manufacturing environments, and with the intension of seeking to ameliorate on them, by using the lean-agile supply chain it becomes very imperative to look at how these companies are working through this solution as shown on paper II below.

4.3. **Paper II: Lean and agility of a supply chain**

This paper combines research question 2 which is about ‘lean’ and ‘agility’ with question 3 which was to explain ‘how the design of an agile supply chain be supported’. Collaboration also in the supply chain was viewed as more of input support to these questions.

These research questions were designed and further detailed down into sub-questions based on the theoretical framework of the Lean Toyota production systems and DELL customized computer production of organizing and managing the supply chain (See appendix).

The results in this paper have been presented separately according to the responses from the individual companies because of some minor discrepancy in the level of application, but so far an insight and deep understanding of this results was acknowledged from ‘Company B & C’
4.3.1. Lean and agility at ‘Company B’

For reasons of time constraints, the designed questions to question 2 and 3 were answered discretely.

Having posed related questions that support lean and agile concept as explained above, ABB Low Voltage Motors was seen to be getting ‘leanness’ and ‘agile’ though still at the infantry level.

They have an annual production of about **110,000** motors of 8 different sizes of which **approx. 70%** is produced on high volume of standard sizes based on forecast of past sales and shipment which is converted into inventory supporting the ‘lean’ principle and 30% is demand-driven or actual customer order supporting the ‘agile’ concept.

They deal with **approx. 100 suppliers**, of which **approx. 30%** are located here in Sweden and some of these suppliers even keep stocks right inside the assembly factories and established a long term relationship with them under the framework of trust and mutual benefit on profit sharing.

They select these suppliers based on bids, proven record of performance as well as long term evaluation of total cost.

Their suppliers collaborate with assemblers at the design phase of product development which allows them share ideas on innovative and quality improvement at a reduce costs.

Their suppliers are allowed to carry on activities with other companies which help them make external profits and learn innovative techniques of production that might offer a cost advantage.

They organize the suppliers in tiers for some components of which the first supplier is given a specification and allowed to collaborate with order suppliers in the manufacturing.

As explained in question 1, they keep inventory of semi-finished products with final configuration made once real demand is known which explains the concept of decoupling point on an agile supply chain for products with longer lead-time with unknown demand.

With this approach still getting introduced, their average industrial time is much closer to that of competitors of similar products.

They are implementing some of the lean tools such as the **kaizen** for continuous incremental improvement process, the famous **JIT** (Pull) concept which is mediated by a **kanban** that signal the cycle or replenishment, the **5S**, the Single Minute Exchange of Die (SMED) and so forth. With their top priority geared towards **Quality, Safety and OTD**.

The use of EDI and the internet has made it possible for easy communication and information sharing between parties such that the manufacturing systems is much flexible to meet up with the rapid changing market demand.
4.3.2. Lean and agility at ‘Company C’

The organization of ‘Volvo AB’ is divided into groups of which each is responsible for a particular brand of products such as: Volvo trucks, Renault trucks, Mack trucks, Volvo Buses, Construction Equipment, Volvo Penta, Volvo Aero, and Financial Services. All these groups are being managed by an organizational structure of which Volvo logistics is a department under it and it is responsible for developing and managing the solutions for automotive and aerospace industries worldwide.

The responses from this company regarding ‘lean’ and ‘agility’ were almost similar to that of ‘Company B’ as a result the author has decided not to repeat some of the responses but instead tried to focused on the areas where they exists some discrepancy.

Volvo AB actually practices a manufacturing strategy know as the Volvo Production System (VPS) which of course is synonymous with the lean philosophy because the mode of application and techniques are almost the same.

Volvo CE keeps a defined amount of material inventory and not of finished or semi-finished products since they deal with heavy and bulky products as earlier mentioned. They actually plan a percentage of their manufacturing based on forecast, as well as real customer order.

They operate with the suppliers on similar manner as the Lean producer does, from integration of the supplier in the design face of product development, information sharing, and fewer suppliers with long and short term relationship to sharing of personnel.

Added to the lean techniques, they implements techniques such as visibility, performance indicators, human and environmental safety rules/care etc. They used barcodes and RFID systems to track movement of materials. They implements some of these principles through education, group thinking, and management level and so forth with significant improvements realized in terms of performance, productivity, safety and environment.

For individual customer orders, the lead time might take about 4-6 months period before delivery. So far, more than 50% of their products are produced on actual customer orders whereas the rest is based on forecast from past data which makes them to carry projections for changes in future markets.
4.3.3. Lean and agility at ‘Company A’

‘Company A’ didn’t have much to say about ‘lean’ and ‘agility’ though their manufacturing strategy was much forecast-driven based on documented information on past sales, there was still some sort of process alignment between chain members through information sharing.

Their produce is on high volume and keeps inventory of both raw material and finished stocks to ensure continuous customer supply during period unstable demand.

Much collaboration was seen at the level of manufacturing and the supply side. Suppliers were given access to the manufacturer’s documents and could read orders directly once the customer places them. They deal with many as about 250 suppliers of which about 40 of them are key suppliers.

Relationships with them are on long-term basis. They also carry on in-house production but all their external suppliers are independent supply companies and located all round the world, from within Sweden, to France, China, USA etc.

Despite the insufficiency of information from ‘Company A’ regarding lean and agility, signs of embracing these concepts wasn’t far from the truth because of the preceding explanations.
4.3.4. Summary of the papers

This section of the thesis presents a brief summary of the papers which stemmed to answer the three research questions that are very important to this project. The first part of these papers had been a focus to present some of those efficient metrics that affect logistics performance (See table 4.1 below) whereas the proceeding paper had been to provide solutions to these efficient metrics through a lean-agile supply chain design.

Table 4.1 is a summary of the efficient metrics affecting logistics performance from the case study

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Short description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order-lead-time</td>
<td>Elapsed time between order receipts until delivery of final product.</td>
</tr>
<tr>
<td>On-time-delivery</td>
<td>Measure of the customer service level. i.e. reflects whether perfect delivery has taken place</td>
</tr>
<tr>
<td>Order Visibility</td>
<td>Used of Electronic Data Interchange (EDI) systems to read and respond quickly to orders.</td>
</tr>
<tr>
<td>Order-fulfillment rate</td>
<td>Combination of delivery reliability and order completeness.</td>
</tr>
<tr>
<td>Inventory cost</td>
<td>Cost of keeping raw materials, semi-finished and finished goods</td>
</tr>
<tr>
<td>Quality</td>
<td>Mostly at the level of raw material supplies because of limited information circulation between the supplier and the assembler</td>
</tr>
<tr>
<td>Difficulty of adhering to schedule of production</td>
<td>Inability to synchronize production according to schedule due to quality problem from the suppliers as the case of Volvo CE. For ABB Low VM, it arises because of cycle time, working with batches (long production batches and fewer set-ups)</td>
</tr>
<tr>
<td>Total distribution costs</td>
<td>Costs of transporting raw materials and finished goods.</td>
</tr>
<tr>
<td>Capacity Utilization</td>
<td>Excess capacity and wastage is seen with ABB Low VM due to scheduling problem</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Ability to respond quickly to fast changing market demand.</td>
</tr>
</tbody>
</table>

Having gone through these efficient metrics, it was found that lean and agility has a profound importance to ameliorate on these metrics. As you can see with the level of performance achieved by ‘Company B’, while embracing these concepts though still at the infantry stage, well as ‘Company C’ is beyond reasonable doubt to suggest that lean and agility can contribute significantly to enhancing a more efficient flow of materials through the supply chain as well as providing customized services and respond quickly to changing demands respectively.
5. CONCLUSIONS, RECOMMENDATIONS AND FUTURE WORK

5.1. CONCLUSIONS

Our today’s environment has never been turbulent than this before. Manufacturers are faced with high level of competition, shorter product life cycles, and well as pressure from customers who are in continuous requests for reduced costs, shorter lead times, JIT deliveries, customized demands and value added services.

As a result, the objective of this research project has been to develop a framework that supports a lean-agile supply chain design toward improving logistics performance. At the course of this process, numerous literatures have been reviewed in relevant areas of logistics and supply chain that are important to this project and three sets of research questions have been formulated which stems from identifying those efficient metrics that affect logistics performance through the implementation of a lean and agile supply chain design for their enhancement.

These research questions have partly been answered by literature studies as well as contributions from the case studies of which their respective results are presented on chapter three and four of this project. A summary of the conclusion of the results from the case studies and literature review is presented as follows:

Research question 1 - which was to identify those efficient metrics that affect logistics performance and how from the case studies is summarized as follows:

It appears from the previous comments (Literature studies) that the logistics management is to plan and co-ordinate all those activities necessary to achieve desired levels of delivered services and quality at lowest possible cost. Therefore performance in logistics is described in terms of superior customer value at less cost Christopher (2005). This further implies that, if a logistics system is going to make contributions to a firm, then the overall effect should be translated in terms of costs reduction and better customer services. Recalling that logistics and supply chain throughout this project has been treated as integrated concepts, therefore integrating these two concepts together will provide multitudes of ways to increase efficiency and productivity and hence contribute significantly reduce unit cost.

So far, indications from literature studies and case studies regarding efficient metrics that affect logistics performance have been seen to exhibit some sort of opposing or antagonistic behaviors amongst themselves. The surge to improve on one might turn to impact the behavior of the other negatively. For example, lead time which is the time-lapsed between order request and fulfillment, while trying to improve on this lead time (customer service level) might entails keeping inventory of both raw materials (to safe guard against failure from the supplier), semi-finished and finished goods. Ironically, the cost of keeping these inventories turns to affect the company’s profit as well. So at this point, it becomes very imperative to look at the entire logistics systems in a company and calibrate those metrics that impact performance most as top priorities. A summary of the efficient metrics that affect
performance in logistics/supply chain from both the literature studies and case studies is shown on table 5.1 below.

**Table 5.1- A summary of efficient metrics that affect logistics performance/supply chain from both literature review and case studies.**

<table>
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<td>Ability to respond quickly to fast changing market demand.</td>
</tr>
<tr>
<td>Transport safety</td>
<td>Transport Losses, damages and shortages incurred during movements.</td>
</tr>
<tr>
<td>Forecast accuracy</td>
<td>Though never perfect but are valuable for the better preparedness of actual demand. Accurate and timely demands are vital components for an effective supply chain.</td>
</tr>
<tr>
<td>Sourcing cost</td>
<td>Cost of raw material acquisition.</td>
</tr>
<tr>
<td>Manufacturing/operations cost</td>
<td>Manufacturing unit cost, Cost of non-quality, cost of warehousing</td>
</tr>
<tr>
<td>Sourcing</td>
<td>Suppliers’ on-time delivery, material inventory, material quality, Supplier cycle time.</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>Adherent to schedule of manufacturing, % of defects products, Manufacturing cycle time, set ups/changes, Plan utilization.</td>
</tr>
<tr>
<td>Planning</td>
<td>% of order delivered according to plan. BOM</td>
</tr>
<tr>
<td>Effectiveness of scheduling techniques</td>
<td>Scheduling refers to the amount of time or date on or by which activities are to be undertaken.</td>
</tr>
<tr>
<td>Environmental safety</td>
<td>At Volvo, one of their top priorities for a safer environment is to reduce the effect of carbon emitting substance by investing in the production of renewable energy-cars as well as urging their suppliers to embarked mostly in the production of quality</td>
</tr>
</tbody>
</table>
**Question 2.** *What is ‘lean’ and ‘agility’ and in which context do the concepts best apply?*

It is very obvious that the need to respond to ever increasing levels of volatility in demand is one of the greatest challenges facing organization today. For a variety of reasons product and technology life cycles are shortening, competitive pressures force more product changes and consumers demand greater variety than ever before.

Breaking through this challenge has been the need of the organization to focus its effort upon achieving greater agility such that it can respond in shorter time frames both in terms of volume change and variety change (Christopher, 2005).

Therefore having identified those efficient metrics that affect logistics performance from both the literature study and empirical research as presented on table 5 above, a **lean logistics** system will organize the efficient flow of materials to eliminate waste, give the shortest lead time, minimum stocks and minimum total cost whereas an **agile logistics** system will ensure flexibility and responsiveness of the SC to give customized services or respond quickly to fast changing demands (unpredictable demand).

A lean concept is much favorable in a situation of high volume manufacturing of standard product under predictable demand whereas agile concept is acceptable where varieties are high with unknown demand.

Evidence from the case studies presented in chapter five (especially from Company B and C) has equally shown the significant gains made in some of these efficient parameters while embracing the lean and agile strategies.

**Question 3.** *How may the design of an agile supply chain be supported?*

Relevant literature has showed that business success can only be achieved through effective co-ordination of all the participants companies across the supply chain (Van Hoek et al, 2001) to shorten product life cycle and reduce product cost (Levary, 2000) as supply fluctuate more rapidly than ever before.

Therefore fig. 3.8 in chapter four has explained the fact that an agile supply chain must be market sensitive such that it can read and respond directly to the needs of the market. Market sensitivity can only be facilitated if there exists IT solutions to communicate between upstream and downstream partners to make that supply chain virtual. Once supply chain partners are able to exploit the available IT solutions to communicate between each other, a process alignment is created through which buyers and suppliers can collaborate actively in joint product development well as information sharing. This information sharing and other related integrative activities eventually form a network.

Having all these as supportive characteristics for an agile supply chain design, results from the case studies have revealed also that collaboration in supply chain management is commonly considered a one-best-way recipe to improve performance. It set up the ground rules for selecting and establishing a mutual and long term relationship with suppliers based on trust, when to integrate them in the manufacturing process well as sharing of personnel (as the case of Company C) and vital information.
The objective of this project has been to develop a framework that supports the design of a lean agile supply chain towards improving logistics performance. At the course of this process, three research questions have been formulated which stems for identifying those efficient metrics that affect logistics performance and the implementation of a lean-agile supply chain design to improve on them. Contributions to these research questions have been through literature studies as well as empirical research from a number of case studies which have ended up answering the entire thesis.

The empirical result shown in chapter five is a framework which supports the need for a lean agile supply chain design towards improving logistics performance. It has supported the fact that a lean logistics system will provide an efficient flow of material through the supply chain by eliminating waste, minimizing stocks and costs, gives shorter lead times and working toward a JIT process. Whereas agility at the other hand, though argued by many literature studies that its ability to provide high customer service by responding quickly to different or changing circumstances is more of rhetoric with little substance and can probably excel most in a situation of fashionable or bespoke products, has equally proven beyond convincing doubts that is manifestation in every industrial landscape is unstoppable through its ability to give flexible manufacturing systems that can switch rapidly to fast changing market demands.

5.2. RECOMMENDATION

The following recommendations when implemented will seek to enhance logistics performance in manufacturing industries.

- In a situation where companies are faced with longer lead times as the research project indicates and demand is predictable, a lean type approach is necessary. Material components or products can be ordered ahead of demand and manufacturing and transportation facilities can be optimized in terms of cost and asset utilization.
- If the replenishment lead times are short and demand predictable, a kanban type solution is necessary. This is a philosophy of continuous replenishment where, at its extreme, as each product is sold or used, it is replaced.
- When lead times are short and demand is unpredictable, then agile or quick response systems are needed. Such as make-to-order (but in a very short-time).
- In a situation of longer lead times and unpredictable demand, the first priority should be to seek to reduce the lead time since variability of demand is certainly beyond organizations control.
  
  If lead times cannot be reduced, then a hybrid lean/agile solution is needed. This hybrid solution requires the supply chain to be ‘de-coupled’ through holding strategic inventory of some generic or unfinished form, with final configuration being made rapidly once real demand is known.
Added to the above recommendation, the following points need to be considered when selecting suppliers. Quite often, organizations use price and quality as the sole determining factor when choosing supplier. While price and quality are important determining factors, other dimensions such as lead time and payment terms must not be overlooked. The following important considerations below are necessary when selecting supplier.

- **Lead time** - This is the time between placing an order and delivery of the product. The longer the lead, the higher the cycle inventory, and safe stock must be to meet demand. These high inventories are translated to higher costs to maintain these inventories and must be taken into account when evaluating the ‘price’ from each supplier.

- **Delivery reliability** - This is the ratio of the number of deliveries made without errors (regarding, time, place, and Quality/quantity) to the total number of deliveries in a period. It is much better to have a reliable delivery at the expense of longer lead times as other operational activities may be planned in advance to reduce cost.

- **Flexibility** - Since you can’t always rely on the accuracy of forecast, a flexible supplier should be able to quickly respond to changing market needs. E.g. what mechanisms exists for rush delivery? What costs are incurred? Will the lead time be the same as for a regular delivery or will it be shorter?

- **Transportation costs** - The transportation costs of delivering the product to your location is part of the total purchasing costs. In some cases, these costs is buried in the product’s unit cost, while in other cases, it is shown as a separate line. For local suppliers, it may be possible to arrange a pick-up using your own trucks, reducing the transportation costs further.

- **Pricing terms** - Suppliers often offer quantity discount for larger batch sizes, however extra holding costs for inventory should be factored in if the batch sizes are significantly larger than what your requirements are.

- **Technological capability** - the ability of your supplier to provide you with accurate, timely information will help with planning and increase customer service in the event of stock-out situations. Web-enabled suppliers that track your orders enable you to make adjustments as well as to inform your customers to changes to their orders.
5.3. **FUTURE WORK**

Though it is often argued that no one ‘right’ way to develop and implement strategy exists, the key to successful planning is to get the best fit between chosen tools and techniques, the organization’s current culture capability and business environment and the desired outcome (Gooderham G 1998).

Though many literatures has been written about the enormous advantages of lean and agility, and its achievements in real industrial life, it might be clear to advocate that integrating this two concepts together in a particular business will yield a lot more than expected, but the shortcomings here is that there haven’t been enough possibility to cement this two concepts together so that they can work corporately to achieve the overall goal of the company in both predictable and uncertain market situations with varied lead times. Even Toyota which is the foundation for the lean manufacturing is not very agile as such, coupled with the fact that some argued that agility is much of a rhetoric and can only do better in a situation of bespoke (tailored services).

Therefore much emphasizes is needed to cement this two concepts together such that a hybrid or generic solution is formed which can overcome most of the uncertainty in manufacturing and marketing by developing more realistic models that can support both systems.
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APPENDIX- RESEARCH QUESTIONS

The questions have been developed in sets stemming from the major three research questions outlined in the project.

Research Question 1. Which parameters affect the performance of logistics systems?

• How do they affect these logistics systems?
• How are they managed to achieve performance?

This question has been broken down into three sets which involves the Logistics activities in various areas: Customer perspective; financial perspective and internal business process.

1. Customer perspectives: Looking for how logistics activities associated with customer perspectives are such as , lead time, service level, on-time delivery, delivery capability, order visibility, order fulfillment rate, and transport safety (losses, damages and shortages),

2. Financial perspectives was to measure those activities related to costs such as the costs of material acquisition, costs of non-quality, logistics/transport costs, warehousing (inventory carrying costs), Cash flow, return on investment and revenue per employee.
3. Internal business processes: Logistics activities that relies on primary activities of value chain such as;
   - Sourcing- On-time delivery of raw material, Raw material inventories, quality confirmation, and supplier cycle time.
   - Planning- % of order delivered according to plan, schedule changes, BOM
   - Manufacturing- Adherent to schedule, % of defect products.

**Research question 2.** Based on lean and agility of supply chain.

Lean is a philosophy from the Toyota Production System which is characterized by high volume manufactured of standard products under predictable demand. Lean logistics looks for a more efficient flow of materials through the SC thereby ensuring faster deliveries, reduce stock level and reduce handling or give lower costs, whereas agility is associated with flexibility and responsiveness of the SC to give customized services or respond quickly to fast changing demands (unpredictable demand).

   - Do you apply the lean principles in your manufacturing process?
   - If yes, in what circumstances?
   - How do you apply them?
   - What is the level of achievement upon applying it?
   - Do you apply the agile solutions in your supply chain to meet up customized orders? (Agility of the supply chain here is seen as the degree of responsiveness or flexibility of the supply chain to meet up with specific customers order or customized products)
   - If yes, in what circumstances?
   - How do you apply them?
   - What is the level of achievement?
   - Is there situation where both lean and agile supply chain solutions are needed?
   - If so, when?
   - And how is the situation managed?

**Research question 3.** What are those distinguished characteristics that support the supply chain agile?

   - How do they really influence the supply chain agile?

Collaboration in supply chain management is commonly considered a one-best-way recipe to improve performance.

   - Do you collaborate with your partners?
   - If yes, how? (information sharing via EDI, internet etc)
• Under which framework do you collaborate with your partners? (trust, mutual benefits on profit sharing)
• What relationship does exist between you and your suppliers? (Long term or….)
• Do you deal with fewer or many suppliers?
• Are they independent, in-house or quasi
• Are they located close to your manufacturing plant or far away?
• Do they offer supplies to other companies or only to your firm?
• Do you select them on the basis of bids or past relationship and proven record of performance?
• Do you engage the supply department at the design phase of the product development or it is merely the sole responsibility of the central engineering staffs in the design of the product?
• Do you share personnel with your suppliers?
• Do you give order for supplies before an order is placed by your customer or after?
• Do you realize performance in the average industrial time to build the same product over your competitors?
• Do your suppliers have access to your blueprint? (techniques of manufacturing)
• Do you keep inventory of finished goods? If yes, how long?
• Do you plan production based on forecast or real demand?
• Do you organize suppliers in tiers?