SUPPLY CHAIN PERFORMANCE METRICS: AN ETHIOPIAN EXPERIENCE

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Abstract

This research addresses issues related to identifying the proper supply chain performance metrics and models, suggesting the framework to measure and evaluate metrics, benchmarking the financial supply chain performance metrics, linking the metrics with strategies and finally modelling and simulating performance metrics. The research systematically analyses the state of the art metrics from the extensive literature reviews and practices from the apparent top performers of supply chain in the world. This leads to the proper identification of the metrics and models with their pros and cons that in turn leads to the suggestion of the conceptual framework. It is found that metrics such as inventory turnover, revenue growth and total inventory costs are the top priorities for both academicians and companies. It is also found that nine metrics models are available in literature and practice but balanced scorecard and supply chain operations reference models are the widely used models.

Aiming at matching metrics to strategies, the available supply chain strategies from the literature and practices are evaluated and the most viable classifications are selected. Furthermore, the supply chain metrics including operational and financial identified are evaluated in order to find the proper supply chain metrics for each strategies. This premise is the continuation of the theories mentioning ‘different strategy needs different supply chain metrics’ by numerous authors. To claim the theories proposed, different hypotheses are developed. Through rigorous methodologies with different application packages available, hypothesises are claimed and new theory and insights are proposed. Hence, the most significant metrics for each supply chain strategies are identified.

Initially, financial metrics are considered in order to test the respective metrics on practical basis. The most influencing financial metrics from the literature and practices are evaluated in the form of ratios to avoid the biases in the comparison. The five most financial metrics are used as a benchmark for the study in comparative study. The linchpin-key player financial metrics of the top performing supply chain in the world are evaluated and each metrics are set as a best practice for Ethiopian manufacturing companies. To identify the performance gap and compare companies’ performances with each other, 25 large consumer companies are selected. Their financial metrics are analyzed from the raw data collected pertaining to the fast moving consumer goods companies in order to make available clear metrics for benchmarking.

The exigency of benchmarking to the mangers is to identify the performance gaps of the respective supply chain to make a way for improvement. It is found that Ethiopian SCs are performing well under revenue growth metric but poor under revenue per employee metrics.

In relation to the operational metrics, the supply chain metrics and practices are identified from literature. Hypotheses regarding the metrics and practices are developed. To claim the hypotheses, empirical tests are performed on the Ethiopian alcoholic and liquor supply chains using questionnaire. This study also measures supply chain performance using the respondent's perception of performance in relation to major industry competitors. The results indicated that with 5% significance level, firms significantly vary in their new product development, flexibility of production process, the extent of 'made to order' production and production process automation. It was also discovered that five alcohol and liquor companies are significantly differ in all SC performance practices except, the first hypothesis which claims, faster delivery service to customer in comparison with their competitors.

Another research issue is the calibration of supply chain metrics. This issue is covered through finding the possible relationship between the supply chain metrics in dynamic environment. This is done through finding appropriate parameters through mental models, literature, surveys, experiences and conference feedbacks. Different models have been developed using a causal loop diagram. Mathematical models are formulated which will be used as an input to causal loop diagram. After stock and flow diagrams are developed for each scenarios, inputs from the mathematical models are used to analyze the relationship between the supply chain metrics. In this particular case, the internal supply chain is considered. The new model is developed extending from stock management structure developed by Sterman [2000]. Three distinctive strategies with different scenarios are studied. The supply chain metrics in each strategy are evaluated and the possible strategy is proposed. The possible supply chain metrics for internal supply chain is evaluated and compared. Hence, the interdependence of supply chain metrics is studied using system dynamics. The modelled problem is simulated using Vensim software. In addition, the dynamic relationships among the supply chains are studied using supply chain metrics as a platform. Different improvement strategies are tested and proposed using a manufacturing company in Ethiopia.

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List of Acronyms

ABC:	Activity Based Costing
ANOVA:	Analysis of Variances
CFA:	Confirmatory Factor Analysis
CFI:	Comparative Fit Index
CLD:	Causal Loop Diagram
EFA:	Exploratory Factor Analysis
GDP:	Gross Domestic Products
GNP:	Gross National Products
IFI:	Incremental Fit Indices
ISC:	Internal Supply Chain
KPI:	Key Performance Indicator
MRO:	Maintenance, Repair and Operations
NAFTA:	North American Free Trade Agreement
PCA:	Principal Component Analysis
PMD:	Primary Manufacturing Division
RMSEA:	Root Mean Square Error of Approximation
RNI:	Relative Nonconcentrality Index
SGA	Selling, General and Administrative
SCC:	Supply Chain Council
SCOR:	Supply Chain Operations Reference
SCPM:	Supply Chain Performance Metrics
SCS:	Supply Chain Strategy
SCSs:	Supply Chain Strategies
SFD:	Stock and Flow Diagram
SKU:	Stock Keeping Unit
SMD:	Secondary Manufacturing Division
SRMR:	Root Mean Square Residual
TLI:	Tucker-Lewis Index
TOC:	Theory of Constraint
UNIDO:	United Nations Industrial Development Organization
WTO:	World Trade Organizations

Chapter 1

Introduction

Never tell your problems to anyone...
20% don't care and the other 80% are glad you have them

-Lou Holtz

1.1. Supply Chain

A supply chain (SC) consists of all parties involved, directly or indirectly, in fulfilling a customer request. Supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers, and even customers themselves [Chopra et al, 2010]. Some scholars argue that today the real competition is not company against company but rather supply chain against supply chain [Christopher, 1992]. For instance, in its early days, Ford Motor Company was a completely integrated system wherein it owned everything that went into manufacturing of the car and also the logistics. Today, it is a member of its supply chain. However, being the focal company it takes the responsibility of coordinating the entire supply chain efforts.

Traditionally, companies purchase raw materials and components, and convert them into useful products, and make arrangements for distribution of the product so that it reaches the customer. This can be considered as looking from internal supply chain perspective containing purchasing, operations and distribution as shown in Figure 1.1. As entities in upstream and downstream are integrated with internal supply chain, as shown in Figure 1.2, integrated supply chain perspective emerges. As the number of stages and/or members or entities at different stages increases, as shown in Figure 1.3, the complexity in controlling and managing the supply chain will increase. Today's typical supply chains look the same. An interesting feature of most of the supply chains today is the multiple-ownership and multiple-membership. That is, different entities are owned by different persons or organizations, and an entity could be part of more than one supply chain. For example, consumer goods manufacturers such as Colgate-Palmolive, Procter & Gamble and Unilever sell to the same customers and purchase from the same suppliers. This feature results in competing supply chains appear more like interconnected or overlapping networks than a mutually exclusive supply chains.

Supply chain management is an approach whereby the entire network from the supplier to the ultimate customer is analysed and managed in order to achieve the best outcome for the whole system. In a nutshell, concept of supply chain management is evolved around a customer-focused corporate vision, which drives changes throughout a firm's internal and external linkages and then captures the synergy of inter-functional, inter-organizational integration and coordination. Managing a single business entity itself is a complex task, and managing a complex supply chain will be much more complex.

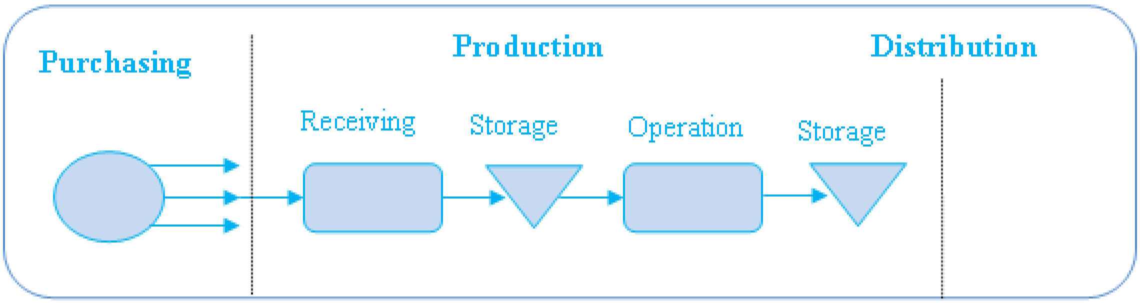

Figure 1. 1: Internal Supply Chain

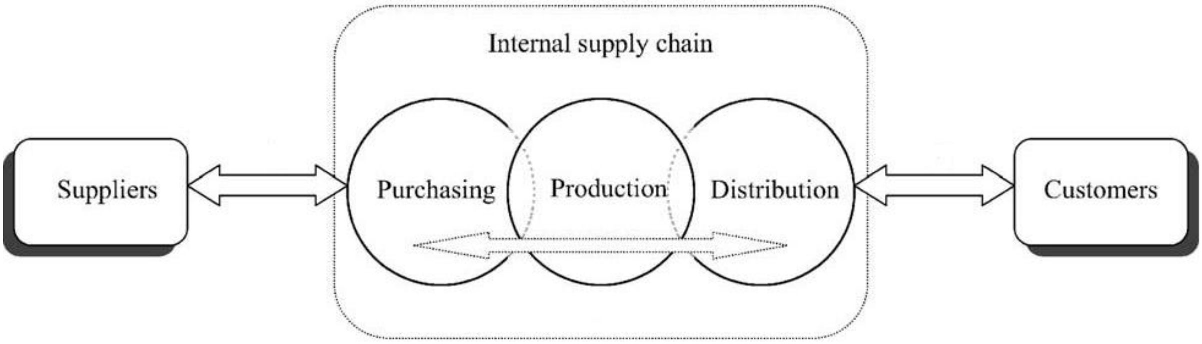

Figure 1. 2: Simple Integrated Supply Chain

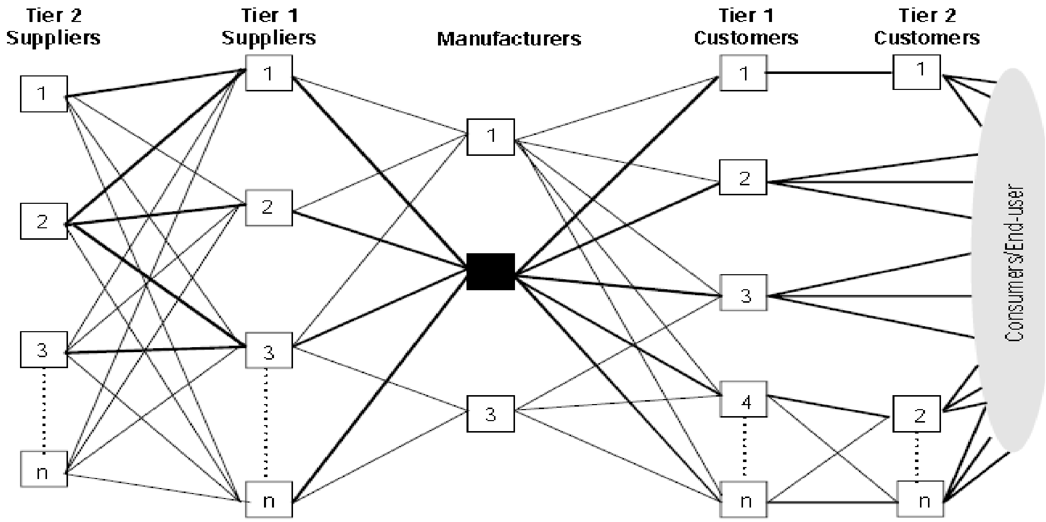

Figure 1. 3: Typical Supply Chain complexity (adapted from Lambert and Pohlen [2001])

1.2. Supply Chain Management

Supply chain management (SCM) is supposed to be heard in the public when Keith Oliver, a consultant at Booz Allen Hamilton, used it in an interview with the financial times in 1982; gained currency in the mid 1990s through publication of articles and books on the subject and rose to prominence in the late 1990s; and made institutionalized discipline after the Council of Logistics Management ended up renaming itself in 2005 as the Council of Supply Chain Management Professionals [Jacoby, 2010]. Lummus and Vokurka [1999] found that SCM is evolved from the series of developments/concepts/theories ranging from quick replenishment, efficient consumer response, continuous replenishment, distributed requirement planning, electronic data interchange, vendor managed inventory and supply chain relationships to the creation of supply chain council. Jacoby [2010] suggests that SCM evolution is first instigated from industrial revolution, mass production, labor and unionisation and ultimately globalisation. Kopczak and Johnson [2003] also identified six shifts in business focus resulting from supply chain management; from cross-functional integration to cross enterprise, from physical efficiency to market mediation, from supply focus to demand focus, from single company product design to collaborative, concurrent, process and supply chain design, from cost reduction to breakthrough business models, and from mass market supply to tailored offerings.

Every business develops its processes and strategies in order to improve its performance. Different approaches/strategies are tested in different regions of the world to improve performance, like Six-Sigma, Just-in Time, Total Quality Management, Business Process Re-engineering, Total Preventive Maintenance, etc. But, it is getting difficult to solve companies' problems by these strategies alone since today customers need variety of quality products and services at lowest cost with highest delivery speed. Since organizational links currently are involving series of companies to meet the supply-demand, SCM stands as the potential remedy. To meet and exceed customer's expectations, it is necessary to properly design firm's internal processes as well as the SC processes, including upstream and downstream partners. Hence, supply chain management is one of the highly recognized business strategies in the profit and non-profit organizations.

Major issue of SCM is the proper design of supply chains to serve customers effectively and efficiently [Poiger, 2010]. This is particularly difficult as companies nowadays face a series of challenges like shrinking product life cycles, the proliferation of product variants, and increasing uncertainty on both the demand and the supply side. Dealing efficiently with uncertainties is one of the most crucial points in supply chain design, and to deal with these uncertainties, different SC strategies emerged [Lee, 2002]. Hence, setting the right SC strategy is mandatory for companies competing in the market [Fisher, 1997; Lee, 2002; Chopra et al, 2010; Jacoby, 2010]. Companies that focus on a specific SC strategy are more likely to build shareholder value than those who do not [Jacoby, 2010]. This idea will make a call for a company in a SC to exercise specific SC strategies.

Supply chain strategies need to be aligned with company's competitive strategy to fulfil corporate goals. A company's competitive strategy defines the set of customer needs that it seeks to satisfy through its products and services. The competitive strategy is defined based on how the customer prioritizes product cost, delivery time, variety, and quality. For example, Wal-Mart aims to provide high availability of a variety of reasonable quality products at low prices. McMaster's, an MRO company, competitive strategy is built around providing the customer with convenience, availability, and responsiveness. With this focus on responsiveness, McMasterdoes not compete based on low price. One can also contrast Dell with its build-to-order model, with a firm like HP, selling PCs through retailers.

A competitive strategy is specified by a bundle of aims and objectives to establish a competitive advantage, which allows the company to outperform others in the same industry or market. Referring to Porter's economic model, there are two basic types of competitive advantage a company may pursue: low cost or differentiation. In cost leadership, a company aims to become the lowest cost producer in its industry. The lowest cost advantage is through pursuing economies of scale, proprietary technology, and preferential access to raw materials, etc. A typical example here is Wal-Mart. With a differentiation strategy, a company seeks to develop products and services that are perceived as unique in its industry, and which create a value advantage for its customers. This emphasizes the importance of focusing on one or more attributes that customers perceive as important, which usually leads to higher cost levels. But customers of these strongly differentiated companies are loyal to its services and products, are less price-sensitive, and reward the effort by paying premium prices. A good example is Apple. A company's supply chain therefore represents an essential strategic resource in the achievement of the strategic goals. For example, customers increasingly recognise the value of supply chain service and quality and are less likely to select products and services only on price. Companies like Apple, Dell, and Procter & Gamble, for example, increasingly outperform others in supply chain excellence.

Both in theory and practice, there are two basic supply chain types, having the potential to assist competitive strategy in the achievement of both cost leadership and differentiation strategy: efficiency-driven supply chains, and responsiveness-driven supply chains. However, best practice companies do not focus on just one fixed supply chain strategy. There is an increasing need to customise supply chains individually, and in consequence need to implement multiple supply chain strategies and solutions; especially where quite heterogeneous customer-product mixes need to be supported within the same global supply chains. The strategic challenge for a supply chain manager is to configure and develop holistically all the multi-layered fields of a supply chain aiming as a whole a strong alignment with the competitive and corporate strategy. The bridge from corporate and competitive strategy to supply chain types is the supply chain strategy. The supply chain strategy determines the goals and the configuration of the supply chain with regard to supply chain partners, structures, processes, and systems.

The supply chain strategy by itself needs to fit with the competitive strategy of any company in order to drive performance. Both competitive and supply chain strategies must be designed in common due to the fact that they will have aligned goals. Achieving this alignment is critical to a company's overall success [Chopra et al, 2010]. For instance, considering Dell's supply chain with personal computer segment is mentioned. Dell uses the direct order model where customers can configure computers and place orders online. Dell gives customers a choice to order customized models as per their requirement, and delivers them at their door steps. This increased the implied demand uncertainty for Dell which needs a responsive supply chain. To provide these services to the customer there will be additional costs involved for carrying huge inventory for all the parts which cannot be charged to the customers because Dell has to be competitive in the market to survive. As a solution to this increased cost Dell closely collaborates with suppliers, which allows Dell to operate with only a few hours of inventory for some parts and a few days of inventory for other common components. This way the supplier will have less demand uncertainty which can be handled through an efficient supply chain. Thus, Dell absorbs most of the uncertainty and provides responsiveness in supply chain and its supplier being efficient absorbs very little uncertainty.

Therefore, a company's success or failure is thus closely linked to the following keys:

1. The competitive strategy and all functional strategies must fit together to form a coordinated overall strategy. Each functional strategy must support other functional strategies and help a firm reach its competitive strategy goal.
2. The different functions in a company must appropriately structure their processes and resources to be able to execute these strategies successfully.
3. The design of the overall supply chain and the role of each stage must be aligned to support the supply chain strategy.

In classifying supply chains into efficient vs. responsiveness, the most widely used approach is matching functional products to efficient and innovative products to responsive supply chains. In efficient vs. responsiveness classification, more flexibility for reactions to changes in a customer demand is one of the criterion for the responsive supply chain where as more cost reduction is said to be the main criterion for efficient supply chains. In reality, supply chains nowadays are trying to combine both supply chains - delivering products and services fast at relatively lower costs. Again, the best example is Dell’s efficiency driven by responsiveness through mass customization and Toyota’s responsiveness through technology capability and just-in-time (JIT) philosophy. Another good example could also be Wal-Mart’s low cost for wide variety of mass consumption goods which dictates that the ideal supply chain will emphasize efficiency but also maintain an adequate level of responsiveness.

Providing the right degree of responsiveness and having an efficient SC at the same time is a goal that is hard to achieve and that typically involves trade-off decisions by management, since increased responsiveness can be perceived to come at the expense of reduced efficiency, and vice-a-versa. Due to these difficulties, many authors see responsiveness and efficiency as distinct strategies that are strongly linked to different types of products. Contrary to this, Minnich

[2007] tried to accommodate efficient and responsive SCs simultaneously through strategies such as revised planning approaches that restructure SC processes to achieve both goals at the same time and enable a SC to be responsive and efficient simultaneously. Chopra et al [2010] also assumed the existence of efficiency and responsiveness in the same SC dictated through a cost-responsiveness efficient frontier.

In SCM perspective, deciding goals of the company and supply chain, aligning supply chain strategy with competitive strategy and ensuring fit in between them needs calibration. This calibration will guide how the supply chain strategy fits well with the overall business strategy and ensures the normal health status of the supply chain. This leads to supply chain performance measurement which is discussed in the next section.

1.3. Supply Chain Performance Measurement: An Overview

Generally, performance measurement systems are described as the overall set of metrics used to quantify both the effectiveness and efficiency of action [Shepherd and Gunter, 2006]. A metric is a standard of measurement. It means that by using metrics comparisons can be made. Measure is an amount or degree of something. Measures and attributes are used synonymously. Metric is a derivative of measure. Hence in some places they are also used interchangeably. However, more specifically, while performance measures/attributes could be both qualitative and quantitative, performance metrics are restricted to quantitative measures. Companies use metrics as performance measurements to set standards or incentives for describing and achieving superior performance [Shapiro, 2007]. Thus, performance metrics are barometers of management effectiveness. Further, Performance metrics are the communication protocol of the company's health status to the outside world.

Traditionally, the focus of performance measurement has been on process operations within the organizational boundaries of a firm. In the context of SCM, performance measurement involves not only the internal processes, but also requires an understanding of the performance expectation of other member firms in the supply chain, backward from the suppliers and forward to the customers [Gunasekaran et al, 2001]. To meet objectives, the output of the processes enabled by the supply chain must be measured and compared with a set of standards. In order to be controlled, the process parameter values need to be kept within a set limit and remain relatively constant. This will allow comparison of planned and actual parameter values, and once done, the parameter values can be influenced through certain reactive measures in order to improve the performance or re-align the monitored value to the defined value. It is generally believed that a well-crafted system of supply chain metrics can increase the chances for success by aligning processes across multiple firms, targeting the most profitable market segments, and obtaining a competitive advantage through differentiated services and lower costs. Most of the companies realize that supply chain needs to be assessed for its performance in order to evolvean efficient and effective supply chain [Gunasekaran et al., 2001]. Hence the study of supply chain performance metrics is an important area of research.

There is no dearth of measures/metrics considered over the years, and one can find many metrics being suggested in literature. The metrics can be broadly classified into two categories: operational and financial. Operational metrics of performance relate to the efficiency and effectiveness of the internal manufacturing and logistics processes within the firm. These categories of performance metrics reflect competencies in specific areas of manufacturing and logistics, including cost, delivery speed and reliability, quality, and flexibility. These four categories reflect the two arguably most important dimensions of performance; efficiency or the ability to provide a service at a lowest possible cost, and responsiveness or the ability to accommodate customers' special request. Operational performance metrics provide a relatively direct indication of the effects of the relationship between SC structure and logistics. Financial performance metrics are more likely to reflect the overall assessment of a firm, and include conventional indicators of business performance, such as market share, return on asset, and sales growth, cost of goods sold (COGS), profit, etc. While these measures are less under the direct control of manufacturing and logistics functions within a firm, it is important to consider whether they are affected by the relationships between supply chain structure and logistics implied by the framework.

Literature on supply chain performance metrics (SCPM) can be categorized into works/articles dealing with identification of SCPM, suggesting the SCPM frameworks and models, benchmarking the SCPM, linking SCPM to strategies and modelling and simulation of SCPM. For example, identification of the SCPM has been done by Beamon [1999], Lapide [1999], Lambert and Pohlen [2001], Gunasekaran et al [2001], Klenjinen and Smiths [2003], Gunasekaran and Kobu [2007] to name a few. The authors identified several metrics in existence in the literature and personal experiences. In other dimension of SCPM, authors like Kaplan and Norton [1992], De Toni and Tonchia [2001], Gunasekaran et al [2004], Neely et al [2005], Bhagwat and Sharma [2007a], Sarode et al [2008], Lin and Li [2010] and Najmi et al [2013] developed SCPM frameworks/models in order to evaluate the performance of the SC. Some of the models are generic in nature and are used by researchers for further study; for example, BSC developed by Kaplan and Norton [1992]. Regarding the benchmarking the SCPM, the works of Maskell [1992] and Shah and Singh [2001] can be mentioned. Some of the SCPM are identified and benchmarked. Pertaining to linking the SCPM to strategies, authors such as Selldin and Olhager [2007], Narasimhan et al [2008], Qi et al [2009], Wagner et al [2012] and Wright [2013] can be considered as reference though the strategies and SCPM in consideration are small enough to conclude the work. Regarding the modelling and simulation of the SCPM authors like Borlani et al [2008], Campuzano and Mula [2011], Asgari and Hogue [2013], Cedillo-Campos and Sánchez-Ramírez [2013], attempted to model and simulate the SCPM using system dynamics (SD) approach.

The main problems observed in SC performance measurement are incompleteness and inconsistencies, failing to represent a set of financial and non-financial metrics in a balanced framework, failing to connect the strategy and the measurement, having a biased focus on financial metrics and being too much inward looking [Gunasekaran et al., 2004; Gunasekaranand Kobu, 2007, Gomm, 2010]. Lin & Li [2010] observed following problems in SC performance measurement research: (i) the majority of research is focused on the study of intra-organizational performance, (ii) the previous research did not consider the variation of measured values, (iii) no common metrics existed for evaluating different processes on the same scale and (iv) the process teams not having motivation, capacity, and authority to improve processes and their results. There are difficulties in measuring performance within organizations and even more difficulties arise in inter-organizational performance measurement [Hervani et al., 2005; Cai et al, 2009]. The reasons for lack of systems to measure performance across organizations are multidimensional, including non-standardized data, poor technological integration, geographical and cultural differences, differences in organizational policy, lack of agreed upon metrics, or poor understanding of the need for inter-organizational performance measurement.

In the manufacturing SC, because of the emerging economic nations, the competition in between the SCs is becoming fierce. Manufacturing in developing nations like China, Mexico, Brazil, India, South Africa, Ethiopia, etc are increasing in volume and quantity so that they need further market places in other regions of the world. Besides, the cost of labour and capital in these developing nations is lower than those in developed nations. As more number of manufacturing companies (multinational companies) migrated, especially, to developing countries, due to the supply and demand balances, the complexity of the SCs increases. Besides, due to import or export of raw materials, semi-finished products, and final goods from and to their manufacturing firms, the control over their overall SC performance is complex. This complexity inhibits the managers from assessing the performance improvements of their own SCs from their competitors. This is because the complexity of the relation between metrics is making it difficult for the managers to visualise and improve performance.

Most of the case studies on supply chain performance measures are based on case studies of companies in western or highly developed countries (e.g., the United States, Canada, Europe, or Japan) and are highly descriptive. Very few studies have examined supply chain performance measures in emerging economies and cultural settings other than North America and Europe. However, the supply chains of BRICS (Brazil, Russia, India, China and South Africa) countries gained some momentum from literature even though it is on an infant stage. Little attention has been given to other African nations including Ethiopia. In this regard there is neither journal article nor dissertation revealing the practice of SCM and the SC metrics in the Ethiopian manufacturing and service industries up to date. Ethiopia, one of the developing nations in East Africa, is now receiving attention from multinational corporations who are global supply chain leaders. Currently, Ethiopia has attracted foreign direct investments from European countries, China, India, USA and Egypt. Hence, it is imperative to study the SCM in general and SC metrics in particular for the proper functioning and performing of individual companies toward common goal of satisfying customers with minimum cost.

1.4. Objectives of the Thesis

Based on the discussion in the previous sections, major problems with regard to SC performance measurement are identified, which subsequently helped in the formulation of the thesis objectives. The major problems identified are as follows: biased focus on financial metrics, lack of common set of metrics that are shared among supply chain partners, the metrics are not tested practically, having a large number of metrics which makes it difficult to identify the critical few among trivial many, failing to connect the strategy and the measurement, and lack dealing with the dynamicity, interdependence and interrelationships among the metrics. The author is an Ethiopian and this fact motivated the author to look into Ethiopian contexts. Accordingly, the following thesis objectives are set with the goal of deepening knowledge in supply chain performance measurement in manufacturing companies in Ethiopia:

1. To identify the common supply chain performance metrics and models from the literature and best performing companies of the world.
2. To identify the supply chain strategies that are being adopted by the manufacturing companies in Ethiopia and to map metrics for each strategy.
3. To find the benchmarks with respect to financial metrics for manufacturing supply chains in Ethiopia and to identify their performance gaps.
4. To test supply chain operational practices and operational metrics on manufacturing supply chains in Ethiopia.
5. To evaluate the dynamic behaviour of key operational metrics under different SC strategies.

Consequently, these objectives are dealt in subsequent chapters. That is, the first objective is covered in Chapter 2, the second objective is covered in Chapter 3, the third objective is covered in Chapter 4, the fourth objective is covered in Chapter 5 and the fifth objective is covered in Chapter 6.

1.5. Organization of the Thesis

The thesis is organized into seven chapters as - introduction, supply chain performance measurement: metrics, models and framework, linking SC measures with SC strategies of manufacturers in Ethiopia, financial prformance metrics: a comparitive study, operational metrics: an empirical study, performance modelling and simulation using SD approach, and conclusions and scope for future work.

Chapter 1 deals with introduction to the thesis. In this chapter, brief introduction about supply chain, supply chain management, supply chain performance measures were covered. Finally, the problems in performance measurement were identified, based on which the thesis objectives have been formulated.

Chapter 2 deals with extensive review of literature and critical analysis of the same, based on which a SCPM framework is proposed. In this chapter, the popular common metrics from the literature and industry were identified and compared. The chapter also covered the supply chain performance metrics models with their pros and cons.

Chapter 3 covers linking of SC strategies and SC metrics through empirical investigation. In this chapter, the theoretical background related to supply chain strategies and measures was covered, and also items that reflect measures and strategies were identified. Finally, the mapping of strategies and measures using statistical analysis was done.

Chapter 4 covers a comparative study of financial metrics of SC. The performance of world class SCs with respect to key financial metrics has been studied and benchmarks were identified. The performance of Ethiopian consumer goods manufacturing companies is compared with the benchmarks.

Chapter 5 deals with empirical investigation of SC operational practices and metrics. The operational practices and metrics are identified from the literature and are tested with Ethiopian Alcohol and Liquor Companies.

Chapter 6 covers the SC performance modelling and simulation using system dynamics approach. The three production strategies, namely, pure-push, push-pull and pure-pull are evaluated using a case study of Ethiopian Tobacco SC. In this chapter, the model scenarios and equations were developed. Chapter 7 concludes the research work with insightful to the future works.

Chapter 2

Supply Chain Performance Measurement: Metrics, Models and Framework

"*All this will not be finished in the first 100 days. Nor will it be finished in the first 1000 days, nor in the life of this Administration, nor even perhaps in our lifetime on this planet. But let us begin.*"

– J.F. Kennedy

2.1. Introduction

The importance of performance measurement in general and in the context of SC in particular is brought out in Section 1.3. Generally, performance measurement systems are described as the overall set of metrics used to quantify both the effectiveness and efficiency of action [Shepherd and Gunter, 2006]. SC performance measurement system is, hence, a system that provides a formal definition of SC performance model based on mutually agreed upon goals, measures, measurement methods that specify procedures, responsibilities and accountability of SC participants and the regulation of the measurement system by SC participants [Holmberg, 2000].

A metric is a standard of measurement. It means that by using metrics comparisons canbe made. Measure is an amount or degree of something. Measures and attributes are used synonymously. Metric is a derivative of measure. Hence in some places they are also used interchangeably. However, more specifically, while performance measures/attributes could be both qualitative and quantitative, performance metrics are restricted to quantitative measures. A model in the context of performance measurement can be looked as broad categories of measures/attributes that reflect overall performance and sets of metrics that are linked to the measures/attributes. In the same way, a framework in the context of performance measurement can be considered as conceptual structure depicting various components and linkages.

In the present work, literature on SC performance measurement is critically looked in three perspectives; metrics/measures, models and framework. There are excellent review articles. For instance Gunasekaran and Kobu [2007], Ramaa et al [2009] and Aykuz and Erkan [2010] covered the literature from 1999-2009. Extensive search has been made through cross-referencing and keyword-searching. Numerous articles were found from science-cited journals, conference proceedings, books, white papers, magazines and dissertation works. 68 articles, out of which 53 are from journals, dealt with performance metrics were identified. Similarly, 59 articles, out of which 47 are from journals, dealt with performance models were also identified. For the sake of information, the names of journals and number of relevant articles found are given in Table 2.1.

Instead of giving simple description of each author's works, literature is looked into critically. More specifically, the amount of conformity between the metrics/measures that are studied by researchers and that are used by companies is analyzed. Pros and cons of various performance models are brought out. Finally, an attempt has been made to suggest a SC performance measurement framework. These are discussed in the following sections.

Table 2. 1: List of Journals

Journal Name	No. of Articles found for	
	Performance Metrics	**Performance Models**
Benchmarking: An International Journal	1	2
Brazilian Journal of Operations & Production Management		1
Computers & Industrial Engineering	2	2
Decision Support Systems	1	1
European Journal of Operations Research	1	1
Harvard Business Review	1	2
Integrated Manufacturing Systems	1	1
International Journal of Advanced Manufacturing Technology		1
International Journal of Applied Management & Technology	1	
International Journal of Applied Management Science	1	
International Journal of Business Research & Management		1
International Journal of Engineering Science & Technology	1	1
International Journal of Logistics Management	6	2
International Journal of Operations & Production Management	8	9
International Journal of Physical Distribution & Logistics Management	3	1
International Journal of Production Economics	3	3
International Journal of production Research	5	2
Journal of Advanced Manufacturing Technology		1
Journal of Management Accounting Research		1
Journal of Business Logistics		1
Journal of Operations & SC management	1	2
Journal of Operations Management	4	
Journal of SC Management	1	
Journal of the Operational Research Society	1	1
Journal of Transportation Management		1
Logistics Information Management	1	1
Logistics Research	1	
Long Range Planning		1
Omega	1	
Production Planning & Control	2	1
Resources, Conservation & Recycling	1	
SC Management Review		1
SC Management: An International Journal	2	2
Scientific Research & Essays	1	1
Software Quality Journal	1	1
Total Quality Management		1
Transportation Research	1	1
Total	53	47

2.2. Supply Chain Performance Metrics

There are several metrics in existence; however, the majority of the works are not tested in the actual scenario. Hence, the pressing need is not for the development of novel performance metrics, there is a need for a method with which to evaluate existing metrics [Caplice and Sheffi, 1994]. One important issue in performance measurement systems, especially in a SC, is to minimize the number of measures in order to be effective, easy to use and simple to analyze [Behrouzi and Wong, 2011]. Keebler et al [1999] also affirmed that while there are hundreds of measures, research has shown that less than two dozen measures are only critical for evaluating and improving the performance of the SC. Maskell and Baggaley [2004] emphasized that in designing a performance measurement system, the goal is to reduce the number of measures to a minimum.

In the context of above, a point of curiosity is the amount of conformity between metrics used by companies and metrics focussed by researchers. Hence a study is conducted by referring to metrics studied in 68 research articles and to metrics used by top 25 companies in the Gartner's 2013 rankings. While the metrics studied in research articles are mentioned in the articles itself, the metrics used by companies are identified by carefully going through the company literature/reports. The details are presented in the following sub-sections.

2.2.1. Literature

After carefully studying the literature, metrics considered by researchers are identified along with the number of occurrences in the articles. Some general metrics are also applied in this exercise. For example, in the flexibility measures, the capacity flexibility incorporates volume flexibility, process flexibility and customization flexibility. In the quality measures, accuracies may represent order entry accuracy, status coomunication accuracy, forecast accuracy, inventory accuracy, picking accuracy, shipping accuracy, etc [Frazelle, 2002]. Total SC cost includes direct purchasing operating cost, manufacturing operating cost, transportation cost, warehouse/distribution center operating cost, inventory holding cost and customer service operating cost. However, total inventory costs and total transportation costs are included in the metrics to measure performances of intermediate levels in the organization. The metrics found from literature are tabulated in Table 2.2 in descending order of number of occurrences.

Table 2. 2: Performance Metrics: Literature

Metrics	**Code**	**Frequency of Occurrence in Literature**	**Attribute**
Return on Assets	L1	61	Financial
Inventory turnover	L2	58	Financial
Market share	L3	57	Financial
Revenue growth	L4	55	Financial
Cash to cash cycle time	L5	54	Time
Order fill rate	L6	50	Time
COGS	L7	49	Financial
Perfect order fulfilment	L8	47	Time
Total inventory costs	L9	46	Financial
On time delivery	L10	45	Time
Product and process innovation	L11	45	Flexibility
Product performance	L12	39	Quality
New products time to market	L13	37	Time
Accuracies (forecast, etc)	L14	36	Quality
New product introduction flexibility	L15	35	Flexibility
No. of customers' complaints	L16	28	Quality
Customer order processing time	L17	28	Time
Responsiveness	L18	26	Time
Product cycle time	L19	24	Time
Number of defects	L20	23	Quality
Total SCM cost	L21	21	Financial
Product development cycle time	L22	21	Time
Design modification	L23	20	Flexibility
Information sharing across SC	L24	18	Flexibility
Productivity	L25	17	Financial
Capacity utilization	L26	14	Financial
Frequency of delivery	L27	13	Quality
Total transportation cost	L28	12	Financial
Product mix	L29	12	Flexibility
After sales service	L30	9	Quality
Training to managers and workers	L31	7	Quality
Capacity flexibility	L32	6	Flexibility
Production cost	L33	5	Financial
Conformance to design specs	L34	5	Quality
Flexible work force	L35	5	Quality
Time to serve customer complaints	L36	2	Time
Vendor development initiatives	L37	1	Quality
Present value of the firm	L38	1	Financial
Net income	L39	1	Financial

Considering frequency of occurance as synonmyous to popularity, these metrics can be treated as the common SC metrics found in the literature. However, there are exceptions. For instance, inventory turnover ratio, which ranked second, in the order of frequency from the literature, some authors was disregarded by some authors as a SC metric. For example Lambert and Pohlen [2001] argued that a single inventory turn metric for the SC cannot capture the differences that an improvement in turns will have at each level or for the total SC. Hence, performance measured by total inventory carrying costs, would be a better measure since it considers both the cash value of the inventory at various positions in the SC as well as varying opportunity costs for inventory investments for various SC members [Stock and Lambert, 2001].

2.2.2. Industry

Top 25 Companies in SC excellence in the Gartner's 2013 ranking are considered as a sample for the present study. These companies are the major global companies which have experienced and enjoyed the benefits of the implementation of SCM practices. The companies in the Gartner ranking are manufacturers of different types of items like electronics, food, consumer goods, machineries, healthcare utilities, chemicals, communications, textiles, basic metals, etc and thus can be considered as a representative sample for product varieties manufactured. In addition to Gartner ranking, the selected companies are also in the Fortune 500 list for the year 2013. For example, 12 companies are on top 60 based on revenue ranking and 16 companies are on top 60 based on profit ranking. Both rankings (Gartner and Fortune 500) thus reveal that the companies considered are performing in a robust way, and as a result their SC metrics can safely be used as benchmarks.

The metrics used by the companies are identified by looking at their annual reports and websites, any case studies referred by researchers. Since the companies are large in size in which multiple stage operations are performed, it is difficult for them to address specific operational metrics in detail in their reports and presentations. However, it is believed that the fundamental metrics are included in these findings. The identified metrics are categorized under financial and operational with the operational metrics further categorized into cost, quality, flexibility and time metrics in tune with companies' competitive priorities. The complete list, along with number of companies that used the metrics, is given in Table 2.3.

Table 2. 3: Performance Metrics: Industry

Metrics	**Code**	**No. of Companies used**	**Attribute**
Customer satisfaction	M1(L16)	25	Quality
Inventory turnover ratio	M2(L2)	24	Financial
Revenue growth	M3(L4)	24	Financial
On time delivery	M4(L10)	24	Time
Gross Profit Margin	M5	23	Financial
Lost sales	M6	23	Financial
Average annual value of inventory	M7(L9)	23	Financial
Service levels	M8(L6)	23	Quality
Market share	M9(L3)	22	Financial
Forecast accuracy	M10(L14)	22	Quality
Operating cycle time	M11(L19)	22	Time
ROA	M12(L1)	21	Financial
Volume growth	M13	21	Financial
Product introduction rate	M14(L13)	21	Flexibility
Cash to cash cycle time	M15(L5)	21	Time
Transportation efficiency	M16(L28)	20	Financial
Capacity utilization	M17(L26)	20	Financial
Delivery punctuality	M18(L18)	20	Quality
Order fulfilment	M19(L27)	20	Time
COGS	M20(L7)	19	Financial
Product availability	M21	18	Flexibility
Cycle time	M22(L19)	18	Time
Inventory days of supply	M23	18	Time
Perfect order fill rate	M24(L8)	16	Time
Manufacturer order fulfilment	M25	15	Time
Productivity	M26(L25)	14	Financial
Earnings per share	M27	13	Financial
Inventory days of receivables	M28	13	Time
Inventory days of payable	M29	13	Time
Return on Equity	M30	12	Financial
Cost per piece	M31	11	Financial
Serviceability	M32	8	Quality
Return on sales	M33	7	Financial
Scrap rates	M34	7	Quality
Asset as a % of sales	M35	4	Financial
Shipment variability by SKU	M36(L29)	4	Flexibility
Average sales per unit facility	M37	3	Financial
Price/cash flow	M38	2	Financial
SGA expenses	M39	2	Financial
Operations profit	M40(L39)	2	Financial
Price/Earnings ratio	M41	1	Financial
Product incidents	M42(L20)	1	Quality
% increase in inventory	M43	1	Flexibility

Considering the metrics that are used by half of the companies, it can be seen that inventory turnover ratio, revenue growth, gross profit margin, ROA, earnings per share, and return on equity are the metrics used for financial measure in order of significance. Similarly, lost sales, average value of inventory, transportation efficiency, capacity utilization and COGS are the metrics used for the cost measure. Customer satisfaction, service levels, forecast accuracy, delivery punctuality and productivity are the metrics used for the quality measure. In the same manner, volume growth, product introduction rate and product availability are the common metrics used for the flexibility measure. Finally, on time delivery, operating cycle time, cash to cash cycle time, order fulfilment, cycle time and inventory days of supply are the common metrics for the time (speed) metrics.

As can be seen from Table 2.3, most of the companies are using financial metrics for their exposure, the fact supported by researchers. Some measures such as innovation measures and sustainability measures are not found even though innovation is a key factor for survival in competition. Innovation is a dynamic measure in which the product life cycle for most of the products is short and there is a frequent introduction of innovative products. One reason could be the secrecy maintained by the companies because of which companies may not expose all of their performance metrics. The effects of globalization, technology and the growing need for environmental responsibility and sustainability is forcing organizations and individuals to make changes in the way they live, work and play [Bititci et al, 2008]. In the literature, however, sustainability metrics are mentioned as essential metrics. For example, Fabbe-Costes et al [2011] discussed sustainability of SCs with the help of a scanning framework; it includes six levels such as, societal, network, chain, firm, function, SC managers and people level. To complement the claim and for further improvement, Zhang et al [2011] found that SC co-ordination, technology application, risk management, and reliability assurance are important performance measures. With the advent of environmental concerns organizations have been redefining their SC measurement process by selecting green measures. For example, Olugu et al [2011] explained green SC key performance indicators in the automobile company for both forward and backward chains.

2.2.3. Comparison

Comparing both the metrics identified from the literature (Table 2.2) and the metrics evaluated from the Gartner's top 25 companies in the SC excellence (Table 2.3), the majority of the metrics are similar in type and nature. Hence, based on the type of product and nature of an organization one can use those metrics to assess and maintain the health of the businesses. The metrics that are common to both the lists are shown in the Figure 2.1. The code used for metrics in literature only is used in Figure 2.1 to avoid confusion. Since better rank means the metric is more frequently used, metrics such as customer satisfaction, inventory turnover, revenue growth, on time delivery, inventory cost, service levels, market share, forecast accuracy, product cycle time, ROA, product introduction rate, cash to cash cycle time, transportation cost, capacity utilization, responsiveness, order fulfilment, COGS, perfect order fulfilment, productivity, net income and no. of defects are commonly applied for both researchers and practitioners.

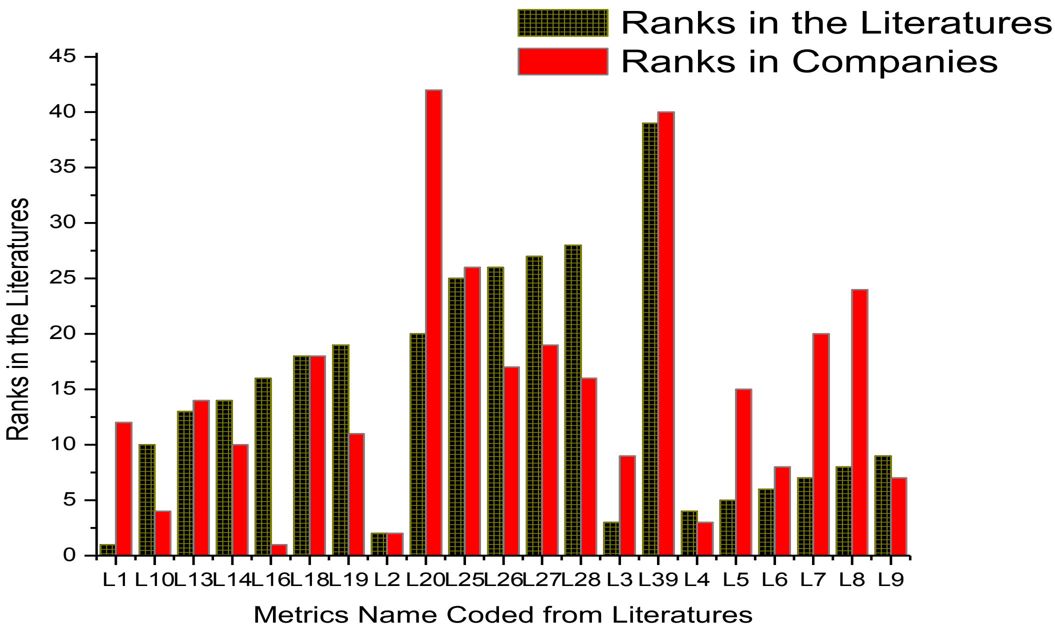

Figure 2. 1: Rank Comparison of Metrics from Literature and Companies

It is clearly seen that metrics such as inventory turnover (L2) and revenue growth (L4) and total inventory cost (L9) are the top common priorities for both ranks; new product time to market (L13) and responsiveness (L18) are the common medium prioritized by both parties; productivity (L25) and net margin (L39) are the common low prioritized metrics for the literature and companies. Hence metrics L2, L4, L9, L13, L18, L25 and L39 can be considered as aligned in literature and practice, and can be considered as the best fit metrics, and can be considered for all Company verticals. However, metrics such as ROA (L1) and customer satisfaction (L16) showed a clear gap in priority of application for both parties. ROA is identified as the top ranked metrics from the literature but companies preferred COGS and total inventory turnover ratio. Traditionally, companies prefer COGS over ROA to determine their efficiency. The other reason why companies prefer COGS measure is due to its standardized measurement and represented in a balance sheet clearly. The reason behind companies not preferring ROA as a primary metric is that it lacks a clear vision or the ability and commitment to execute a long-term strategy. However, unlike COGS and customer satisfaction, the long-term trajectory of ROA reveals how effective a company is, over time, at harnessing business opportunities in a highly uncertain environment. It captures the fundamentals of business performance in a holistic way, looking at both income statement performance and the assets required to run a business. In the same manner, customer satisfaction is used as a broader measurement in the companies' metrics but researchers preferred customer service into components. Hence, this common metrics can be used to evaluate the SC performance without violating the hierarchical and relationship nature of the metrics.

2.3. Supply Chain Performance Metrics Models

A model in the context of performance measurement can be looked as broad categories of measures/attributes that are used to reflect overall performance and sets of metrics that are linked to the measures/attributes. With the development of SCM, the emergence of different types ofSC performance metrics models is inevitable. The most widely used models are Supply Chain Operations Reference (SCOR) which is proposed by SCC and the balanced scorecard (BSC) developed by Kaplan and Norton [1992]. There are also other performance models suggested by different authors. For example, the resource-output-flexibility attribute (usually represented by dimension based measurement system) is proposed by Beamon [1999], decisional level is suggested by Gunasekaran et al [2001], etc. Salient features of performance models suggested by different researchers are tabulated in Table 2.4.

Table 2.4: Salient Features of Performance Models proposed in Selected Articles

Authors	Performance Attributes	Salient Features
Kaplan and Norton [1992] Kleijnen and Smits [2003] Bhagwat and Sharma [2007a]	• Financial • Internal business • Learning & growth • Customer satisfaction	The balanced scorecard, a new performance measurement system that gives top managers a fast but comprehensive view of the business is developed. Irrespective of its costly and time-consuming process, it is difficult to convert operations to financial measures.
Maskell [1992]	• Delivery performance • Customer service • Process time • Production flexibility • Quality • Financial	Established performance targets and generated new performance measures. New performance measures being used by world class manufacturers vary considerably which makes difficult to generalize them.
Lapide [1999]	• Financial • Process, cross functional • Extended enterprise • Purchasing related • Manufacturing related • Logistics related • Marketing related	Identified the proper SC performance models and suggested performance targets or internal or external benchmarks. The framework is not supported by real case SCs.
Beamon [1999] Beamon and Chen [2001]	• Resource • Output • Flexibility	Identified three types of performance measures and propose flexibility quantitative measurement approach for SCs. Lack of system thinking of measuring SC widely across the whole chain.
Neely et al [2000] De Toni and Tonchia [2001] Lambert and Pohlen [2001]	• Financial • Non-financial	Identifying distinct performance measures for the intangible factors and avoided confusion on both measures. Hierarchical structures of metrics are ignored while integrating both measures for aligning to the goals.
Shah and Singh [2001]	• Total length of the stages • ISC inefficiency ratio • Working capital • Productivity	Suggested and proposed performance benchmarks for ISC. It is difficult to replicate it to the SC.
Gunasekaran et al [2001, 2004] Bhagwat and Sharma [2007b]	• Strategic • Tactical • Operational	Combine decision making levels with financial and non-financial criteria and consider SC processes with respect to decision making levels. Too many number of metrics and measures
Lai et al [2002]	• Service effectiveness for shippers • Operations efficiency for transport logistics service providers • Service effectiveness for consignees.	Measurement instrument for evaluating SC performance in transport logistics are developed and evaluated. Relationship between SCP in transport logistics and other constructs, such as competitive advantage.
Chan and Qi [2003]	• Supplying • Inbound logistics • Core manufacturing • Outbound logistics	Identify five core processes as holistic complex SC measurement and introduce fuzzy set theory for judgment and evaluation processes. Overlook on the decision making ability.
Giménez and Ventura [2003]	• Absolute • Relative	It validates that internal and external integration improves SC performance by empirically investigating grocery SCs. Most of the performance measures considered is firm level measures.
Otto and Kotza [2003]	• System Dynamics • Operations Research	Design six unique sets of SC metrics to measure the effectiveness of SC management.

Authors	Performance Attributes	Salient Features
	• Logistics • Marketing • Organization • Strategy	All the metrics are not used in business practice to measure SC performance.
Chen and Paulraj [2004]	• Supplier performance • Buyer performance	It creates an interactive role in interaction between different initiatives and factors to develop key SCM constructs that leads a systematic development of SCM instruments. The SC considered is one of a simple model to conclude a construct as an accepted theory.
Lockamy and McCormack [2004] Shepherd and Gunter [2006]	• Plan • Source • Make • Deliver	Investigate the relationship between SCM planning practices and SC performance. The return process is not investigated
Hervani et al [2005]	• Environmental Performance Indicators	It integrates works in SCM, environmental management, and performance management into one framework. The core indicators are not identified and tested on the real scenario.
Li et al [2005]	• Delivery Dependability • Time-to-Market	Test and validate the instruments for SC practices to drive performance. The performance measures considered are too small in number to claim the theory proposed.
Holmberg [2000] Frazelle [2002] Neely et al [2005] Chibba [2007] Behrouzi and Wong [2011] Miguel and Brito [2011] Sarode et al [2008]	• Cost • Quality • Time • Flexibility • Service	The operational metrics are clearly set to extend to SC performance measurement issues. Financial measures are not treated well in the study.
Li et al [2006]	• Market Share • Return on Investment • Market share growth • Return on Investment growth • Profit margin on sales • Overall competitive position	Tests the relationships between SC practices, competitive advantage and organizational performance. The output due to operational metrics is not shown.
Jammernegg and Reiner [2007]	• Costs • [Intraorganizational • Service level • [Interorganizational]	Deal with performance measurement and improvement of SC processes by coordinated application of inventory management and capacity management. Lack to view the whole SC process as concentrate only costs and service level.
Shapiro [2007]	• Utilization • Productivity • Effectiveness	Process based evaluation of individual metrics for logistics is clearly set and evaluated with pre-determined evaluation criteria. The relationship between these individual metrics with other performance measurement system is not shown.
Fabbe-Costes and Jahre [2007, 2008] Narasimhan et al [2008]	• Logistics • Financial • Mixed • Marketing	The relationship between SC integration and performance is a complex and prior research. Some of the performance measures considered are purely firm based and cannot be concluded as SC performance measures.
Chopra et al [2010]	• Facility • Inventory • Transportation	Horizontal relationships in between metrics are clearly set and the metrics are inclusive and crosses the boundary of the firms. Lacks integration of

Authors	**Performance Attributes**	**Salient Features**
	• Information • Sourcing • Pricing	metrics and also the hierarchical nature of the metrics are ignored and only the horizontal tradeoffs in between metrics are considered.
Lin and Li [2010]	• Team structure • SC processes • Output	Proposed an integrated framework for SC performance measurement. Using six-sigma and validated using a case study. The dynamic of the SC was not treated in the study.
Olugu et al [2011]	• Upstream • Midstream • Downstream	A set of measures for evaluating the performance of the automobile green SC are developed. Full-fledged industrial survey is needed to claim the hypotheses.
Wagner et al [2012] Wright [2013]	• Financial Performance	The relationship between SC fit and the financial performance of the firm is investigated. The performance measure taken is not comprehensive to study the fit.

The works of different researchers can be grouped into 9 categories based on common features as given below.

1. Function based measurements
2. Dimension based measurements
3. Decisional level based measurements
4. Balanced Scorecard approach
5. SCOR model approach
6. Nature of measures
7. Theory of Constraints approach
8. Competitive priorities based measurements
9. Performance drivers based measurements

It may be noted that most of the categories do already exist in the literature. Further, there could be little amount of overlapping. Performance attributes considered in each category, and pros and cons of each category are shown in Table 2.5.

Table 2. 5: Pros and Cons of Supply Chain Performance Models

Performance Models	**Performance Attributes**	**Pros**	**Cons**
Function based measurements [32, 108, 117, 144, 151]	• Operations • Distributions • Services	It helps departments and focal companies clearly measure and evaluate their performances based on the categorized functions.	It is difficult to integrate the focal company's measures to other SC members since all companies are measuring their respective performances in a functionally arranged organization. Nowadays these measurement systems are said to be traditional and integrated measures in between the SC members are needed.
Dimension based measurements [12, 27]	• Resource • Output • Flexibility	Identify three types of performance measures and propose flexibility quantitative measurement approach for SCs	Lack of system thinking of measuring SC widely across the whole SC
Decisional level based measurements [18,74,76, 77]	• Strategic • Tactical • Operational	They are used to make the right decisions so that they can support each other in achieving the overall goals and objectives of an organization, since the success of strategy formulation depends upon the degree of alignment of strategies at different levels.-	Due to the complex nature of metrics, their interdependence is not easily measured by all level managers. Besides, it is difficult to align hierarchies of metrics when new product is introduced and a market demand changes abruptly.
Balanced Scorecard approach [7, 18, 23, 48, 86, 86,96,97,154, 192]	• Financial • Internal • Customer • Learning & Growth	The approach is simple to apply on a SC measures on using a single document. It considers the balanced view of financial and operational measures more comfortably than traditional financial measures.	Due to the differences in the size and nature of organization, it is somewhat difficult to apply the generic BSC to all Companies. Besides, BSC does not provide a framework for developing performance measures for interdependent activities or linking corporate with SC performance. The measure overlooked the position of competitors and suppliers in relation to the SC.
SCOR model approach [80,90,92 ,120, 158,178]	• Plan • Source • Make • Deliver • Return	It links performance metrics, processes, best practices, and people into a unified structure. The framework supports communication between SC partners and enhances the effectiveness of SCM, technology, and related SC improvement activities. Besides, SCOR processes extend from your supplier's supplier to your customer's customer.	It does not tell the organization about the condition of the competitors and the future advancements of technology that demand new performance metrics. Besides, the measures are internally focused and taken from the perspective of an individual firm rather than measuring performance across multiple firms or the overall SC. SCOR does not attempt to describe every business process or activity, including sales and marketing (demand generation), research and technology development, product development, and some elements of post-delivery customer support.

Table 2.5 (Contd.): Pros and Cons of Supply Chain Performance Models

Performance Models	**Performance Attributes**	**Pros**	**Cons**
Nature of Measures [34, 50,76,100, 102,108, 111,164, 184,187]	• Financial • Non-financial	Clearly identified measures in terms of financial and operational measures. It identified distinct performance measures for the intangible factors and avoided confusion on both measures.	It lacks methods how these non financial measures are converted to financial measures in which managers to seek to look at their overall performance measures easily. Besides, hierarchical structures of metrics are ignored while integrating both measures for aligning to the goals.
Theory of Constraints approach [2, 169, 180]	• Throughput • Inventory • Operating expenses	It is a simple approach to identify the problem where SC performance is not performing well using relatively small and clear measurements. It is a potential for tremendous increases in productivity with minimal changes to operations. TOC is most powerful and cost effective tool for increasing production capacity; simple to communicate and apply, making it ideal for shop floor teams; great for fostering teamwork as different areas become aware of the constraint and the need to work together to assist the constraint process. It also avoids local optimization.	It has seen to identify the bottlenecks in stations, lines and systems but it lacks the improvement tools. It can be difficult to apply if the constraint process is constantly moving (for example if the nature of the work sees dramatically different and difficult to predict demands on various production resources) It can also be difficult to apply in a jobbing environment.
Competitive priorities based measurements [33, 93,141]	• Cost • Quality • Time • Flexibility	The measures are universal and can be understood to any businesses which make measurements and evaluation of SC easy in terms of suppliers or its competitors. Non-financial performance metrics are clearly set without any confusion and the variables are easy to apply practically.	Financial measures did not get enough attention and the measures are more suitable to measure general over business measures than SC performance measures even though applied. It is not specific to SC performance measures
Performance drivers based measurements [38,182]	• Facility • Inventory • Transportation • Information • Sourcing • Pricing	Horizontal relationships in between metrics are clearly set and the metrics are inclusive and crosses the boundary of the firms.	Lacks integration of metrics and also the hierarchical nature of the metrics are ignored and only the horizontal tradeoffs in between metrics are considered

The function based measurements are developed in tracing the functions of SC and its vicinity. These functional measures include the SCS sub levels such as manufacturing, supplier lead time, inventory, purchasing, transportation metrics in addition to product development, marketing and sales, IT, finance and human resource measures. This category also contained measures based on value chain especially value chain in SCS, i.e., operations, distributions and services. Through chasing each function in the SC, the appropriate metrics for the functions are identified. This why it is called function based performance measurements. It is more commonly understood by academicians and researchers. This models can be attributed by the works of Lambert and Pohlen [2001], Otto and Kotzab [2003], Nienhaus [2003], Chae [2009], and Linand Li [2010].

The functional measurement models are more synchronized when Beamon first appears with his SC performance models. Beamon [1999] identified three types of performance measures as resources, output, and flexibility and called these measures as dimension based measurement system i.e., any SC can be measured on dimensions. Some examples from resource performance measures are total cost, distribution cost, manufacturing cost, inventory cost and return on investment. Output measures include sales, profit, fill rate, on-time deliveries, and customer response time, manufacturing lead time and customer complaints. Flexibility measurements measure in term of volume changes, delivery changes, mix and new product introduction. The individual measures chosen from each type must coincide with an organization's strategic goals. Cai et al [2007] extended the work of Beamon [1999] proposing a framework using a systematic approach for improving the key performance indicators (KPIs) in a SC context and developed innovativeness and information measures in addition to resource, output and flexibility measures partly developed earlier by the author and identified the respective metrics. The innovativeness metrics are rates of sales in new products, number of new products launched, process improvement, SC stability and information metrics are information accuracy, information timeliness, information availability and information sharing.

SCM requires many decisions relating to the flow of information, product, and funds. These decisions are strategy, tactical and operational. Based on this idea, Gunasekaran et al [2001] presented a long list of key SCPM, classified at strategic, tactical, and operational levels. While the list appears to be comprehensive, duplication and overlapping is an issue. Moreover, the designation of each performance metric to the three different levels remains questionable. Gunasekaran et al [2004] proposed a measurement framework by considering strategic, tactical and operational measures for the four SC activities/processes of plan, source, make/assemble and deliver. The authors suggest that this framework provides a starting point for an assessment of the need for SC performance measurement.

Developed by Kaplan and Norton [1992], the BSC is widely used to select and synthesize the SC performance measures from a balanced view. Indeed, it emphasized on balancing four categories, that are, financial, customers, internal processes, and innovations. The BSC includes traditional financial measures representing an organization's past and adds non-financial measures representing the drivers of future performance which are distributed among the four mentioned groups. The critical strength of the BSC is that it measures the performance in all four main areas which are connected to the strategic goals. Apart from Kaplan and Norton [1992], authors like Brewer and Speh [2000], Bhagwat and Sharma [2007a], Thakkar et al [2009] and Argyropoulou et al [2010] linked the SCM framework to the BSC to identify performance metrics of different companies in different part of World. The BSC is more commonly applied in both theories and practice with so many advantages over other models [Davis and Spekman, 2003]. Though, BSC approach is simple to apply on SC measures using a single document, there are flaws regarding the completeness and consistency of the metrics. Brewer and Speh [2000] argued that BSC does not provide a framework for developing performance measures for interdependent activities or linking corporate strategy with SC performance. Hoque and James [2000] also stated BSC as a simplistic approach and the limited number of performance measures cannot provide a holistic representation of the organization. Kanji and SA [2001] argue that even though BSC claims to represent the performance of an organization but some measures are overlooked. Examples include suppliers, partners, and competitors. Since the selected measures are chosen in such a way so as to be aligned with the strategy of a company at any given time, there is a need for frequent validation of the measures used [Papalexandris et al, 2004].

Another widely applied model is SCOR model. SCC developed the SCOR model containing performance attributes and metrics relying on five distinct management processes (plan, source, make, deliver and return). SCOR model was developed by SCC in 1996 and continuously updated then after. SCOR contains 13 metrics corresponding to level 1 which fall into five categories: SC reliability metrics, flexibility metrics, responsiveness metrics, cost metrics and assets metrics. The first three categories are directly linked to the customers and hence called customer facing. The rest metrics are measurements within the internal operation of the SC and are named as internal facing. As emphasised by the SCC (http://supply-chain.org), SCOR metrics are diagnostic metrics. SCOR recognises three levels of predefined metrics. Using SCOR model and modifying some of the SCOR processes, authors like Hausman [2004], Lockamy and McCormick [2004], Huang et al [2005], Shepherd and Gunter [2006] and Hwang et al [2008] applied SCOR model on different SCs and proposed several metrics for the whole processes. The SCOR model is widely used in the research and companies in measuring performance and benchmarking. However, it does not tell the organization about the condition of the competitors and the future advancements of technology (for example, IT) that demand new performance metrics. Besides, the measures are internally focused and taken from the perspective of an individual firm rather than measuring performance across multiple firms or the overall SC [Pohlen, 2003].

The nature of measures category includes financial and non-financial measures. Though financial measures were old enough in the measurement era, still their effect is significant. But in relation to SCPM, the more focused and outward looking measurements are non-financial measures. However, the non-financial measures must natured to the financial measures in order to derive meaningful conclusion from the managerial point of view. This is because managers want to tell performances in financial terms which can be presented easily. This phenomenon gives the classification of the metrics models as nature of measures. The difficulty of measuring SC using financial measures and the emergence of financial measures are discussed in Section 2.2. Regardless of these challenges, researchers tried to put effort in developing and identifying significant number of performance metrics for SC. For example, Suwignjo et al [1998], De Toni and Tonchia [2001], Lambert and Pohlen [2001], Kleijnen and Smits [2003] and Jammernegg and Reiner [2007] developed the framework for performance measures based on financial and non-financial (operational) and finally identified their respective metrics.

Most of the metrics developed and evaluated for the SC performances are not generic rather dependent on basic tools like BSC and SCOR model, and also on early developments. However a few researchers used different approach in measuring and evaluating SC metrics. Simatupangn et al [2004] applied theory of constraints (TOC) approach to overcome difficulties in realising the potential benefits of SC collaboration. In their study it is suggested that TOC approach can be used to expose an inherent dilemma of collaborative performance metrics so that the chain members can work together to advance SC profitability. Although the basic fertile application area for TOC is manufacturing, extending its application to SC may be difficult since SC undergoes various multiple parallel stages and various processes. Besides, the TOC's parameters (throughput, inventory and operating expenses) cannot capture measurements of the whole chain as determining some of the basic metrics such as innovation, flexibility and customer service would be difficult. In more general sense Santos, et al [2010] tried to apply concepts of TOC in SCM in order to improve the global SC performance using a case study in a Brazilian middle size appliances producing company. In their study the constraints of the firm's SC are identified using TOC, vendor managed inventory (VMI) and business-to-business (B2B) tools with an objective of avoiding the performance indicators getting worse, and assure that the end customer's needs are being fulfilled as per SCOR level 1 metrics. However, the metrics will no longer dictate to identify system constraints and improve it since the parameters used still are small compared to the large number of SC metrics given by different authors as indicated in literature review part. Ainapur et al [2011] conducted survey on 56 Indian foundries on their underutilized capacity due to the lack of coordination among the chain partners. The authors used SCOR and analytical hierarchy process to identify KPI for the SCs of foundries. They finally used TOC management philosophy to find the constraints, and as a result the enhancement of the constraints SC performance is achieved. However in the TOC approach the authors used one constraint at a time that made the execution of the variables difficult since SCs would have multi-stage with multi-variable scenario.

Another model is competitive priorities model. Basically the competitive priorities are used in the general performance measures of every organization. Even though some researchers add other priorities such as sustainability and innovativeness, the widely applicable priorities are cost, quality, time and flexibility. The priorities are used in determining order winners and order qualifiers in the market which contain both qualitative and quantitative measures. Based on these priorities some researchers attempted to develop SCM performance metrics. Chan [2003] presents SCM performance measurement approach which consists of qualitative and quantitative measures. Quantitative measures are cost and resource utilization and qualitative measures are quality, flexibility, visibility, trust and innovativeness. In other developments, Neely et al [2005] identified competitive priority measures of performance as the multiple dimensions of quality, time, cost and flexibility and categorizes different performance metrics under each performance attributes. Their performance metrics are basically used to measure the performance of the firm in general. However, since the SCM is one of the firms's major business functions, its application can be extended to SC performance measures. These are also reinforced by Jacoby [2010].

Performance drivers approach is a self-explanatory model in which the drivers determine the performance of any SC, and metrics can be used to gauge the performance of each driver. This model is attributed to Chopra et al [2010]. The authors classified the performance drivers of SC as logistical drivers such as facility, inventory and transportation, and functional drivers such as information, sourcing and pricing, and identified specific performance metrics related to these drivers. The hierarchical nature of the metrics did not clearly shown except comparing horizontal structure of metrics through trade-offs. However, it is difficult for managers to capture the effects of the metrics through trade-offs since the majority of them are interrelated and interdependent.

In general as the competitive priorities shifted from that of primarily reducing costs to that of including quality, speed of delivery, flexibility, and service, the strategy for the operations management function also has shifted. The strategy of minimizing production costs has been replaced with that of maximizing the value added. This emphasis on being competitive on more than one dimension might lead to the conclusion that there are no longer any trade-offs. What emerged instead was a realization of the need to establish a hierarchy among the different priorities. But Skinner [1974] assured that "there will always be trade-offs. Today, however, those trade-offs occur on what can be described as a superior performance curve."

2.4. Supply Chain Performance Measurement Framework

Framework in the context of performance measurement can be considered as conceptual structure depicting various components and linkages. Thus, SCPM framework should include the entities that make a SC, flows that occur among entities of SC, managerial practices and drivers that affect the SC performance, measures through which SC performance is evaluated, and the metrics that reflect the performance measures. Based on the conceptual understanding gained through review of literature and observation, a framework for SCPM is proposed as shown in Figure 2.2.

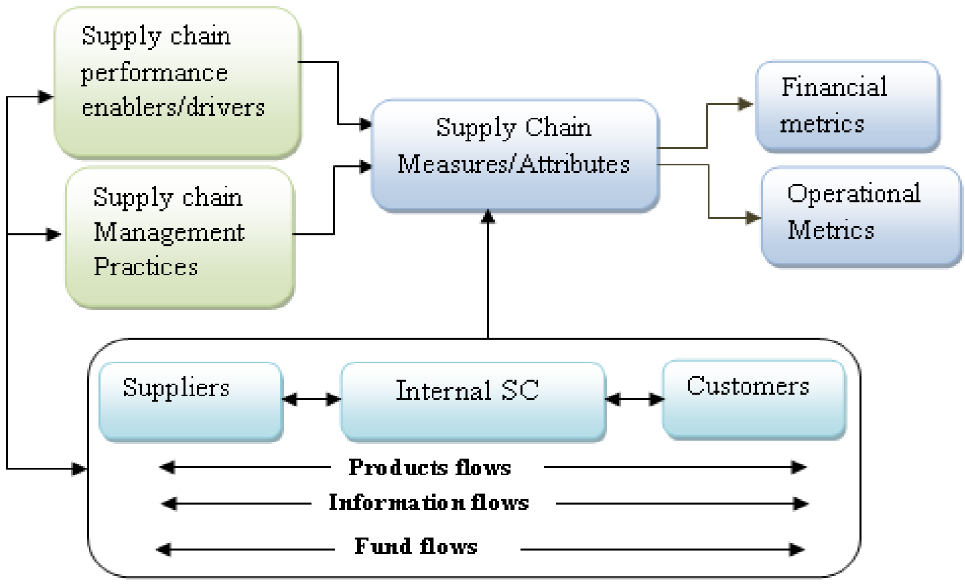

Figure 2. 2: Proposed SCPM Framework

The SC itself forms the base for the proposed framework. The focal company is considered as internal SC, which is integrated with other SC partners (inter-organizational) to complete the chain. Products, funds and information flows occur along the SC. The very objective of SCM is to enhance competitive performance by closely integrating the functions of internal SC and effectively linking them with the external operations of suppliers and channel members. Within the SCM, the adoption of distinct SC strategies to drive performance is clear. Performance of a SC having a specific configuration and adopting a particular strategy is affected by SC practices and performance drivers. Moreover, the selection of SC practices and performance drivers is also affected by SC configuration and strategy. Thus, there is two-way link between them. Performance of the SC is measured through specific attributes, and specific metrics are chosen to reflect the measures/attributes.The basis and justification for the proposed framework is explained in the following paragraphs.

Kotzab et al [2008] argue that due to increased globalization, firms must rely on inter-organizational relationships to ensure the efficient and effective movement of products and supplies, money, and information to all relevant parties in the SC, beyond restricted to core competencies. Thus, SC management and in turn SC performance measurement requires internal (intra-organisational) and external (inter-organisational) integration. Most authors concluded that there is a direct relationship between SC integration and performance measures, and Togar et al [2002], Fabbe-Costes and Jahre [2007, 2008] showed how SC performance is improved through integration. Besides, most authors [Beamon, 1999; Christopher, 2000; Giminez and Ventura, 2003; Kotzab et al, 2008; Miguel and Brito, 2011] studied the overall integration of intra-organizations and inter-organizations using different theories. More interestingly, Miguel and Brito [2011] explored the impact of the SCM as a multidimensional construct (information sharing, long-term relationship, cooperation and process integration) on different competitive priorities (cost, flexibility, quality and time). The empirical results provided evidence of a positive impact of SCM on operational performance; however the main contribution resides on the integrative model that tested SCM a multidimensional construct and the use of the competitive priorities literature to conceptualize dimensions of operational performance.

Referring to Figure 2.1, SC enablers or performance drivers are the main factors which determine the performance of any SC. Chopra et al [2010] identified the performance drivers as facility, inventory, transportation, information, sourcing and pricing and suggest that these drivers interact with each other to determine the SC's performance in terms of responsiveness and efficiency. The development and validation of a measurement instrument for studying SCM practices have identified so far by Li et al [2005]. SCM practices are defined as the set of activities undertaken by an organization to promote effective management of its SC. The practices of SCM are proposed to be a multi-dimensional concept, including the downstream and upstream sides of the SC [Li et al, 2006]. More comprehensive SC practices are studied by Cooper et al [1997]. The practices are: customer relationship management, customer service management, demand management, order fulfilment, manufacturing flow management, supplier relationship management, product development and commercialization and return management. Lockamy and McCormick [2004] also identified SCM practices as planning processes, process integration, process documentation, collaboration, teaming, and process ownership, process measures, process credibility and IT support from literature and found that the practices had an impact on performance measures. In a clear theoretical study, Li et al [2006] identified SC practices as strategic supplier partnership, customer relationship, level of information sharing, quality of information sharing, and postponement. Lin and Li [2010] formulated the SC practices as social support, communication and support, managerial support, participation, trust and commitment.

The study by Donlon [1996] considers supplier partnership, cycle time compression, continuous process flow and IT sharing as key dimensions of SCM. A study by Tan et al [2002] recognizes just in time capabilities, customer needs, geographic location, integration of SC activities, and information sharing as key dimensions of SCM. Therefore, there is a need to interlink these identified dimensions amongst themselves and finally to firm performance. Within the SCM, the existence of distinct SC strategies to drive performance is studied so far [Christopher and Ryals [1999], Chopra et al [2010], Narasimhan et al [2008], Wagner et al [2012], Wright [2013]. As a matter of fact, adoption of specific SC strategy leads to gaining advantage along some of the competitive priorities.

As discussed in Section 2.3, several classifications have been proposed by researchers to group the performance metrics/measures/attributes. A combination of nature of measures approach and competitive measures approach is adopted in the present work. That is, financial and operational classification with operational metrics further classified in tune with the competitive priorities of cost, quality, time and flexibility is adopted. Hervani et al [2005] suggested that financial measures are basically strategic measures while other measures such as customer service and inventory measures are operationally focused. Non-financial measures developed earlier are found in tactical and operational levels [Gunasekaran et al, 2004]. Maskell [1992] suggested that companies should have two kinds of measurements: financial performance measurements for strategic decisions and non-financial measures for day-to-day operations. The majority of the literature classifies performance measures into financial and non-financial (operational) metrics to make the measurement and evaluation of the performance of the company smooth and relatively communicable [Neely et al, 2000; Burgess et al, 2006]. There are also balanced frameworks pertaining to financial and operational measures in the literature [Kaplan and Norton, 1992; Bhagwat and Sharma, 2007a].

2.5. Conclusions

Maskell and Baggaley [2004] emphasized that in designing a performance measurement system, the goal is to reduce the number of measures to a minimum. To this end, a comparative study of metrics focussed by researchers and metrics used by industry was carried out. Based on the premise that metrics used by both researchers and practitioners are aligned, common metrics are identified. These metrics have been used in the works of remaining chapters. Based on the review, classification scheme of financial and operational with further operational classification based on competitive priorities has been adopted. Linking strategy and measures/metrics, testing of financial and operational metrics, and modelling of metrics under different strategies are presented in the following chapters.

Chapter 3

Linking SC Measures with SC Strategies of Manufacturers in Ethiopia

"If you don't know where you are going, you might wind up someplace else."

--Yogi Berra

3.1. Introduction

One of the main problems in performance measurement is the lack of proper mapping of metrics/measures to strategy which was clearly stated in Chapter 1 of the thesis. In most of the literature as discussed in Chapter 2 of the thesis, there is a problem regarding the proper selection of performance metrics/measures for different SC objectives be it SC integration or SC evaluation. The predominant problems in SCPM mentioned in most of the research as discussed in Chapter 2 are having a large number of metrics, failing to connect the strategy and the measurement, having a biased focus on financial metrics and being too much inward looking and lack of testing on practical scenario and not considering the dynamicity of the SC. Besides, the right choice of performance metrics and measures is critical to the success and competitiveness of any SCs. This is particularly difficult as companies nowadays face a series of challenges like shrinking product life cycles, the proliferation of product variants, and increasing uncertainty on both the demand and the supply side. Dealing efficiently with uncertainty is one of the most crucial points in SC design [Davis, 1993]. These uncertainties are demand, implied demand and supply uncertainties. To reduce uncertainties, proper SC design is needed [Davis, 1993; Lee, 2002]. Reducing the impact of these uncertainties improves SC performance [Davis, 1993; Mason-Jones and Towill, 1998; Geary et al, 2002; Yang et al, 2004; Prater, 2005]. Due to these uncertainties, different SCSs emerged. Due to these different types of strategies, it is practically impossible to develop the single performance measure models for all strategies. Besides, there is no "one fits all" approach for successful management of the SC, but different performance measures are appropriate for different strategies. Hence, setting the right SCS is compulsory for companies competing in the market [Fisher, 1997; Lee, 2002; Thun, 2005; Narasimhan et al, 2008; Chopra et al, 2010; Jacoby, 2010].

Within the SCM literature, the existence of distinct SCSs to drive performance is studied so far by several authors [Christopher and Ryals, 1999; Thun, 2005; Narasimhan et al, 2008; Chopra et al, 2010; Jacoby, 2010; Wagner et al, 2012; Wright, 2013]. However, there is no universal SCS. Even though several authors identified different SCSs, none of the authors developed SC metrics for each strategy. Although more than one strategy may exist in the SC, identifying the respective metrics for all SCSs is essential. However the works of Selldin and Olhager [2007] and Qi et al [2009] can be recognized in developing measures to each SCSs through empirical testing. Selldin and Olhager [2007] identified some measures based on efficient and responsive SCs. Qi et al [2009] identified measures based on lean, leagile and agile SCs. However, no researcher identified measures to Lee's [2002] SCSs.

Despite their well-recognized importance, researches on SC performance measures are still in its infancy. Most studies on SC performance measures are based on case studies of companies in western or highly developed countries and are highly descriptive. Very few studies have examined SC performance measures in emerging economies and cultural settings other than North America and Europe. Even though the SCs of BRICS gained some momentum from literature, there is no research revealing the study of mapping the SCSs with the SC metrics in the Ethiopian manufacturing SCs. Besides, no one has tested those of Lee [2002] classification on manufacturing companies in the world in general and Ethiopian manufacturing companies in particular. Hence, the aim of this Chapter is to test SCSs and their respective metrics on Ethiopian manufacturing companies.

3.2. Theoretical Background and Research Hypothesis

The studies of SCSs and SC measures are not new phenomena. The research on both titles is now getting attention as seen in the published research papers. However, the proper SC measures for the SC types had not been analyzed. Besides, there is no clear classification of the SCSs in common depending on types of companies. Their strategies are not tested empirically using large samples. The most common SCSs dictated by Fisher [1997] have been tested and validated by Selldin and Olhager [2007]. Similarly, the classification based on lean and agile is also tested by Qi et al [2009]. But, the classification given by Lee [2002] is not tested and validated using empirical testing. Furthermore, matching SC measures to the strategies are not yet studied. Hence, adopting Lee [2002] classification, the strategies and their respective SC measures have been tested. To do this the research map as shown in the Figure 3.1 is developed. The first task was to identify and classify companies according to their relation to SCS which is captured in Hypotheses H1a-H1d followed by identifying the SC measures for the strategies which are captured under Hypotheses H2a-H2d. The proper classification of companies in Ethiopia is also revised in this section for testing the hypotheses.

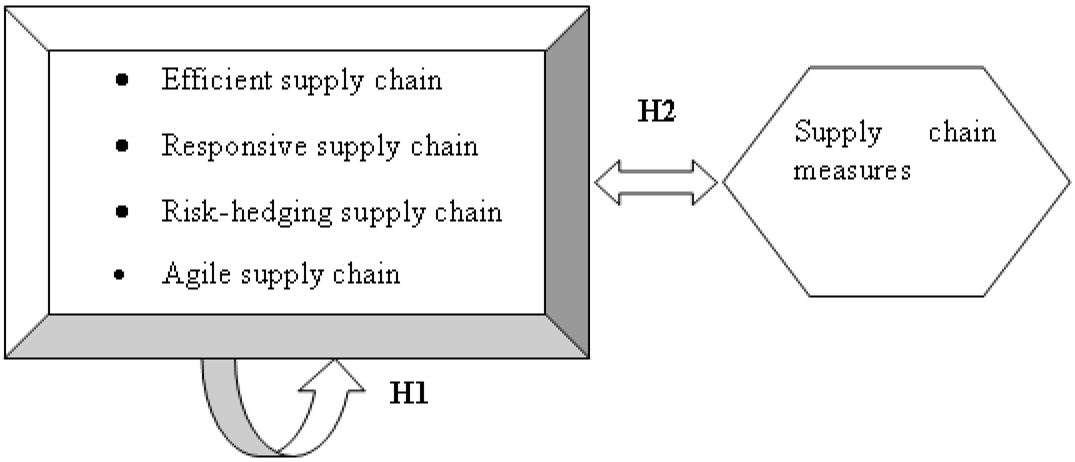

Figure 3. 1: Research Map

3.2.1. Company Classification

Ethiopian Ministry of Trade announced a new manufacturing companies' classification to be effective from July 2013. But for the purpose of study to ease the overlapping company verticals and reduce ambiguity, the above classification given has been revised to suit our analysis. Finally excluding insignificant responses and low response rate in specific company category, the following classification (note that the numbers in bracket shows the name code for the company classifications which were utilized in SPSS and AMOS software) was adopted:

1. Chemicals (20)
2. Consumer products (21)
3. Construction(22)
4. Food and beverages (23)
5. Glass, ceramics and plastics (24)
6. Metals and machinery(25)
7. Textile, clothing and leather (26)
8. Transportation equipment (27)
9. Wood, paper and furniture (28)

3.2.2. Supply Chain Strategies

The work of Fisher [1997] is a breakthrough in matching product types with SCSs. He asserted that functional products are matched with physically efficient SCs whereas innovative products match market responsive SCs. Then after several authors have taken Fisher's work and collected empirical data to support and refine the theory. In particular, much of this work has been focused on examining two fundamental SCSs: lean, which is roughly equivalent to Fisher's physically efficient and agile, which is roughly equivalent to Fisher's market-responsive. Some functional products may, however, also have quick response requirements of the SC - for example, milk and other dairy products are perishables with relatively stable demand patterns but limited shelf life. Also, companies often carry out promotions that can drastically change the otherwise stable and predictable demand patterns of products such as generic food. Therefore, there is a need to extend Fisher' [1997] classification of SCs.

Naim et al [1999] compared lean and agile SC based on the ability to cope with uncertainty, including variations, in production volume and the degree of product variety required and concluded that for products with low variety and high variability lean strategy is suited whereas for products with high variety and low variability agile strategy is suited. This strategy is supported and verified by Mason-Jones and Towill [1999], Christopher and Towill [2000] and Qi et al [2009]. Extending the classifications, some authors came with a leagile or hybrid SC arguing that the position of the decoupling point identifies the SC of lean and agile types [Christopher, 2000; Huang, et al, 2002; Agarwal et al, 2006; Christopher et al, 2006].

In more broad classification, Lee [2002] classified the SC into stable and evolving depending on the product type with uncertainty. He briefly categorized SCs into efficient, responsive, risk-hedging, and agile SCs based on supply and demand uncertainties and product characteristics (functional and innovative products). He further dictated that functional products with low supply uncertainties use efficient while functional products with high supply uncertainties use risk-hedging SCs. Innovative products with low supply uncertainties are termed as responsive while innovative products with high supply uncertainties are agile. This classification is a sound one based on uncertainties and also this is the source of motivation towards this research in finding the respective metrics among others.

Huang et al [2002] tried to match product characteristics (innovative products, hybrid products and standard products) to respective SC types (agile, hybrid and lean) using weighted sum to determine the desired SCS. There are authors who claim and support this classification that there are three distinct classifications of SCSs namely, lean, leagile/hybrid and agile SCs [Bruce et al, 2004; Agarwal et al, 2006; Christopher et al, 2006; Vonderembse et al, 2006] but failed to agree where the position of leagile or hybrid SC should be placed. Some other authors like Chibba [2007] and Xu et al [2007] supported this classification but further expanding the SCs through adding adaptive SCs into the category. The other classification of SCS is efficient and responsive. This classification is validated and tested by Davis [1993], Ramdas and Spekman [2000], Selldin [2005], Minnich [2007], Selldin and Olhager [2007] and Chopra et al [2010].

More specifically Selldin and Olhager [2007] tested Fisher's model on 128 Swedish manufacturing companies to test whether product types and SCSs match. They matched product type (functional vs innovative) with SCSs (physically efficient vs market responsive). They conclude that companies with functional products followed physically efficient SCS. They have also found that a considerable match between innovative products and market responsive SCs.

In closer look to developing countries, Qi et al [2009] investigated SCSs and empirically tests the SCS model that posits lean, agile, and lean/agile approaches using data collected from 604 manufacturing firms in China and found that companies can be distinguished on their SCS according to Fisher's framework. Özkir and Demirel [2011] extended the work of Agarwal et al [2006] and classified the SCs into five categories; lean, agile, leagile, risk-hedging and responsive SC and compared them based on performance attributes such as market demand, customer drivers, purchasing policy, cost, quality and lead time and service level, and concluded that while quality and lead time are the market qualifiers (minimum performance expected for any SC to stay as a competitor), cost and service levels are the market winners.

To test Fisher's model Lo and Power [2010] carried out a survey of Australian manufacturing companies and found that even though some companies match to the theoretical model, there are significant number of companies which mismatch to the model. According to them two-thirds of the companies follow mismatching strategy, and at the same time their operation is successful. They argue that it is difficult to conclude the classification into efficient and responsive alone. Motivated by Selldin and Olhager [2007] and Lo and Power's [2010] research, Nagy [2010] tested Fisher's model on 79 large Hungarian manufacturing firms. Nagy [2010] found that about 52 % of companies mismatch with the model and concluded that it cannot be stated that manufacturers of functional products operate exclusively physically efficient, and those of innovative products operate market-responsive SCs. Conducting research on 418 manufacturing companies in Romania, Wright [2013] concludes that larger companies and manufacturers rather than raw material and component suppliers are more likely to use a responsive SC. She also reported a considerable amount of companies which mismatched with Fisher's model.

Hence, through careful observations the main characteristics of SCSs are identified. The following assumptions were made in the study. First, the strategies are efficient, responsive, risk-hedging and agile. Second, the concepts and metrics given for lean SC are used for efficient SCs. Third, the meanings and metrics given by different authors for responsive SCs shared among responsive, risk-hedging and agile. Considering these assumptions the following are identifiedas the main characteristics of SCSs. It may be noted that the number within the parentheses shows the code given to them for further analysis.

Hence, the governing characteristics of efficient SCs are:

1. Minimize cost (ES1)
2. Minimize inventory (ES2)
3. High average utilization rate (ES3)
4. Cost-restricted lead-time reduction (ES4)
5. Long term supplier relationship with suppliers (ES5) and
6. Supplier selection criterion based on quality and cost (ES6)

Governing characteristics of responsive SCs are:

1. Capacity flexibility for demand uncertainty (RS1)
2. Excess buffer inventory for demand uncertainty (RS2)
3. Aggressive lead-time reduction (RS3)
4. Supplier selection criterion based on flexibility, reliability and quality (RS4)
5. High level of usage of modular design (RS5) and
6. Quick response to demand (RS6)

Governing characteristics of risk-hedging SCs are:

1. Intensive use of electronic market that reaches more suppliers (RHS1)
2. Sharing safety stock with other companies (RHS2)
3. Pooling of inventories and resources (RHS3)
4. Future contracts that lock-in price and delivery (RHS4)
5. Capacity flexibility for supply uncertainty (RHS5) and
6. Excess buffer inventory for supply uncertainty (RHS6)

Governing characteristics of agile SCs are:

1. High level of information accuracy between partners (AS1)
2. Excess manufacturing capacity (AS2)
3. Excess buffer inventory for both raw materials and finished inventories (AS3)
4. High delivery flexibility (AS4)
5. High level of new product flexibility (AS5) and
6. High level of responsiveness to volatile markets (AS6)

Research Hypothesis considered for SCSs is as follows:

Proposition 1: Ethiopian manufacturers can be mapped using the classification of efficient, responsive, risk-hedging and agile SCSs.

H1a: A subset of Ethiopian manufacturers pursues a SCS focused on efficient
H1b: A subset of Ethiopian manufacturers pursues a SCS focused on responsive
H1c: A subset of Ethiopian manufacturers pursues a SCS focused on risk-hedging
H1d: A subset of Ethiopian manufacturers pursues a SCS focused on agile strategy

3.2.3. Supply Chain Measures

There is a significant impact of SCS on the firm's performance [Selldin and Olhager, 2007; Qi et al, 2009; Wagner et al, 2012; Wright, 2013]. It is also indicated that some authors developed generic SC performance measures while the rest of them identified performance measures for limited SC types. The generic measures developed so far are too large to take for practical case study to validate them.

In generic terms, the performance measures identified by Beamon [1999] solve some of the difficulties in finding SC measures. In latter developments, some authors lists large numberof measures in the form of literature review and frameworks [Lambert et al, 1998; Gunasekaran et al, 2001; Lambert and Pohlen, 2001; Gunasekaran et al, 2004; Gunasekaran and Kobu, 2007].For example, Huang et al [2005] developed the metrics such as delivery reliability metrics, responsiveness metrics, flexibility metrics, cost metrics and asset metrics. Neely et al [2005] identified measures of performance as the multiple dimensions of quality, time, cost and flexibility.

Specifically, Waters [2003] explained lean SC as efficient operations and agile SC as flexible to meet demands arguing that the main metrics for lean SC are productivity and utilization whereas for agile SC are lead times and service level. Agarwal et al [2006] found that the cost and quality metrics are more suitable to lean SC, service level metrics are more aligned with leagile SC and lead time metrics are more comfortable with agile SC. Besides, Selldin and Olhager [2007] dictated that cost and delivery speed metrics are more matched with physically efficient SCs; whereas delivery dependability, volume flexibility, product mix flexibility and profitability are more aligned to market responsive SCs. Qi et al [2009] identified unit manufacturing cost, inventory turnover, overall labor productivity and obsolescence cost as lean metrics, whereas overall product quality, customer service level, pre-sale customer service, product supports, responsiveness to customers, delivery speed, delivery dependability, volume flexibility, product mix flexibility, new product flexibility as agile metrics. This is asserted by Behrouzi and Wong [2011] dictating that cost and quality metrics are more suitable for lean SC. Zaman et al [2012] identified lean metrics as accuracy of forecasting techniques, total cycle time, production efficiency/line, mutual assistance in solving problems, manufacturing cost, effectiveness of MPS/line /day, delivery lead time, ability to respond to demand as delivery metrics, buyer-manufacturer relationship level and quality of delivered goods.

SC measures are carefully identified from the literature above comprising both financial and operational measures as shown in Table 3.1. Special attention is given to those measures from Beamon [1999], Lambert and Pohlen [2001], Gunasekaran et al [2001, 2004], Huang et al [2005], Neely et al [2005], Gunasekaran and Kobu [2007], and Qi et al's [2009] classifications. Based on this, measures are identified, and are given in Table 3.1. It may be noted that the metrics are listed in alphabetical order, irrespective of their level of importance. The name codes are used in coding the variables in SPSS and AMOS software.

Table 3. 1: Metrics with their Name Codes

Metrics	**Code**	**Metrics**	**Code**
Average inventory level	PM1	On-time deliveries	PM16
Backorder or stock-out	PM2	Product mix	PM17
Capacity utilization	PM3	Profit	PM18
Cash to cash cycle time	PM4	Return on assets	PM19
Cost of goods sold	PM5	Return on investment	PM20
Customer complaints	PM6	Revenue growth	PM21
Customer response time	PM7	Revenue per employee	PM22
Delivery changes	PM8	Safety stock level	PM23
Fill rate	PM9	Shipping errors	PM24
Forecast accuracy	PM10	Total cost of manufacturing	PM25
Information accuracy	PM11	Total SCM cost	PM26
Information sharing	PM12	Unit manufacturing cost	PM27
Inventory turns	PM13	Value added employee productivity	PM28
Manufacturing lead time	PM14	Volume changes	PM29
New product introduction	PM15	Warranty/return processing cost	PM30

Research Hypothesis considered for measures is as follows:

Proposition 2: Different SCS uses different SC measures

To test what measures are appropriate for each SCSs, the following hypotheses are considered.

H2a: A subset of SC measures pursues a SCS focused on efficient strategy.

H2b: A subset of SC measures pursues a SCS focused on responsive strategy.

H1c: A subset of SC measures pursues a SCS focused on risk-hedging strategy.

H1d: A subset of SC measures pursues a SCS focused on agile strategy

3.3. Research Methodology

The input data are collected via personal distribution in contact with the respondents. The focus groups are those manufacturing companies with the number of employees more than 100. The target respondents within each company were managers whose work directly affects SCM practice. A questionnaire survey is used in the research. The manufacturing companies are categorized into raw material manufacturer (named as raw material suppliers), component manufacturer (components suppliers) or finished goods manufacturer (manufacturer) with more than buyer-seller relationships. In this study, efforts are made to achieve reliable data by finding respondents who were well informed about the topics asked in their respective organizations. Thus, the survey instrument has been given to middle and top managers who are responsible for SCM in their organizations- including, general managers, factory managers, operation managers, product design and development managers, marketing managers and SC managers. These managers are selected because it is believed that they have enough knowledge to answer the questions asked in the questionnaire, specifically the questions concerning the SCSs and SC measures exercised by their respective companies.

3.3.1. Questionnaire Design and Verification

The items to measure SCSs are referred from Fisher [1997], Lee [2002], Selldin and Olhager [2007], Qi et al [2009], Chopra et al [2010], Wagner et al [2012] and Wright [2013]. This is done through identifying independent characteristics of SCSs and followed by asking respondents to answer to what extent do you agree that the SC of your company's major product line has the following characteristics using five-point Likert scale (1= strongly disagree and 5= strongly agree). The items for SC performance measures are reviewed from various literature and companies' experience. The measures contain both financial and operational metrics. The respondents are asked to what extent your company perform compared with your competitors using five-point Likert scale (1= much worse and 5=much better). The complete questionnaire elements for SCSs and SC measures are shown in Appendix I and Appendix II respectively.

There are also other background and profile data that have meaningful influence on the mapping of performance measures on the respective SCSs. These include the position of the company in the SC (raw material supplier, component supplier or finished goods manufacturer), characteristics of the firm (leader or subordinate), ownership status (private, state owned, foreign owned or joint venture), size of the company (small, medium and large) and age (old/mature and young). The size of the company here is determined by the revenue and number of employees. The distinction in between small, medium and large companies in Ethiopia is clearly set earlier in this topic. Now this classification is based on further disintegration of large companies into groups (small, medium and large) based on the size of employees. Based on these assumptions, small groups are with those having less than 250 employees, medium groups are those with 251-550 and above 550 are large groups. Regarding the age, newer establishments with an age of less than 20 years are considered young and more than 20 are said to be mature. This is to find out that how the age influences the performance measures and SCS.

Questionnaires are prepared in English and then revised by the experts in the field and two university professors regarding its content and suitability towards the respondents. The edited version was pilot tested on 7 general managers of different companies in order to know whether the items suit the target before distribution. The items in SCSs are widely accepted by managers but the items in performance measures are not widely recognized. Hence, the feedback from the response is taken and reduced the number of measures from 48 to 30 as indicated in Table 3.1. The revised version of the questionnaire is then distributed for the target samples.

3.3.2. Data Collection and Non Bias

Only large companies with the number of employees more than 100 are considered because Li et al [2005] suggest that those are the companies that often engaged in SCM issues. There are 223 large manufacturing companies with more than 50 employees found in Addis Ababa which are labeled as large companies. Companies with large varieties and multiple production lines as well as those with unidentified SCSs are excluded. Companies with vertical integration are omitted. Besides, those company classifications with less or equal to three responses are also ignored. In doing so, the study area diminished to 145 companies. Deleting vague, missing value and incomplete responses, 134 complete respondents are selected as shown in Table 3.2. To assess non response bias, the company distributions of the respondent and the population are compared. As shown in Table 3.2, the percentages of the respondents were close to the percentages of companies in the population for most companies. To test statistically for no significant difference, a chi-square test is used (χ^2=1.68) which supported the assumption of no bias with $p < 0.05$.

Table 3. 2: Company Distribution of Respondents and Population

Companies	Respondents (%)	Population (%)
Chemicals	6.7	7.2
Consumer products	4.5	3.8
Construction	7.5	8.4
Food and beverages	15.7	16.7
Glass, ceramics and plastics	14.9	15.1
Metals and machinery	12.7	10.3
Textile, clothing and leather	14.2	16.1
Transportation equipments	3.7	3.5
Wood, paper and furniture	20.1	18.9
Total	100	100

3.3.3. Profile of Respondents

Executives in the areas of operations/production, supply and purchasing, marketing, product design and development and overall plant in charges are considered as target respondents due to their exposure to SCM issues. The detail of their frequencies and experience within the companies are shown in Table 3.3.

Table 3. 3: Respondents' Profile

	Frequency	Percent (%)
A. Job Title		
Plant manager	45	33.58
General manager	21	15.67
Operational manager	57	42.54
Product design and development manager	4	2.99
SC manager	2	1.49
Others	5	3.73
Total	134	100
B. Experience within the company		
<=2	17	12.69
3-6	42	31.34
7-10	33	24.63
11-14	18	13.43
15-17	16	11.94
>17	8	5.97
Total	134	100.00

3.3.4. Assessing Reliability and Validity

Using those managers as target respondents, 134 companies filled and returned the questionnaire successfully. Hence the response rate here is considered sufficient compared with Forza's [2002] claim of 20% response rate. The categories, responses and profile of the companies are tabulated and shown in Table 3.4. The majority of the companies are private, about 15% are state owned, and about 28% are wholly foreign owned and joint ventures. Regarding the position of the companies in the SC, the majority (70.9%) considers themselves as a leader and the remaining companies as followers. The majority of the firms are manufactures (75.4%) and about 7.5% are raw material suppliers and the rest are components suppliers. The rest of the profiles can be referred from Table 3.4.

Table 3. 4: Companies' Profile

	Percent (%)
A. No. of employees	
<250	38
251-550	34
>550	28
B. Annual sales (in millions of USD)	
<10	35
10-20	20
20-30	15
30-40	10
40-50	8
>50	12
C. Age	
Young	43
Mature	57
D. Ownership	
State owned	14.9
Private owned	57.5
Joint Ventures	13.4
Foreign owned	14.2
E. Position of the company in the SC	
Manufacturer	75.4
Component suppliers	17. 3
Raw materials suppliers	7. 5
F. Role of company within SC	
Leaders	70.9
Followers	29.1

Content validity was undertaken to ascertain whether the content of the questionnaire was appropriate and relevant to the study purpose. In this case, the majority of the items in questionnaire are derived from the literature and the remaining items are checked for its contents by experts in the fields and university professors. Hence, it is believed that the content validity is met. Face validity indicates the questionnaire appears to be appropriate to the study purpose and content area. It is also known as pilot test used by other researchers. It evaluates the appearance of the questionnaire in terms of feasibility, readability, consistency of style and formatting, and the clarity of the language used. To check this validity, the questionnaire prepared by the researchers is checked by two professors. After unsuitable items are discarded, the final version of the questions is distributed to the pilot test to the concerned managers of large manufacturing firms; 33 managers responded successfully. The feedbacks from the responses are included and the final questionnaire is distributed in the target respondents. Hence, again it can be claimed that the face validity is met.

The most widely accepted measure of internal consistency is Cronbach's alpha [Sekaran, 2003]. It is found that the Cronbach's alpha for overall data is 0.733 which is slightly more than the acceptable level (0.60) suggested by different authors. Hence, the data suggest that the constructs possess sufficient reliability.

As suggested by different authors, an exploratory factor analysis for each construct is performed to ensure the unidimensionality of the scales. Prior to factor analysis sampling adequacy is checked using Kaiser-Meyer-Olkin (KMO) and the result (0.899) revealed that the factor analysis will yield distinct and reliable factors. As suggested by Field [2005] a threshold KMO value of greater than 0.5 is acceptable. Based on this result, factor analysis subsequently applied on items ES1-ES6, RS1-RS6, RHS1-RHS6 and AS1-AS6 which are accepted. The same is true for PM1-PM30. Besides, all factors together accounted for 66.66% of the total variance in the data. Hence, the constructs are considered valid.

Exploratory factor analysis (EFA) is a tool intended to help generate a new theory by exploring latent factors that best accounts for the variations and interrelationships of the manifest variables [Henson and Roberts, 2006]. In this model, the initial set of items are first screened by principal component analysis (PCA); the remaining items are subjected to EFA and the extracted factor solution using SPSS is finally examined via confirmatory factor analysis (CFA) using AMOS as recommended by Matsunaga [2010]. For screening using PCA, most authors recommend rotation by promax expecting some correlation in-between the items. The loading cut offs are set to 0.4 to avoid low loadings.

Regarding the number of factors in EFA, there is no consensus among the researchers. However, three distinct methods are mentioned and their uses are closely related how the independent researchers utilize them. The first is using those items with eigen values greater than 1; the second method is drawing scree plot and observing when the factor increases abruptly. The third is parallel analysis in which alternative data are generated to compare with the original data values with an average eigen values. In this thesis the combinations of the first two methods is used. Fortunately, the same number of factors is observed using both methods. In CFA, a finding that indicators have high loadings on the predicted factors indicates convergent validity. In an oblique rotation, discriminant validity is demonstrated if the correlation between factors is not so high (ex., >0.85) as to lead one to think the two factors overlap conceptually. In this case the correlation between factors are less than the threshold value and ensures discriminant validity.

After assessing reliability and validating on the EFA, determining the model fit indices for CFA continues even though there are a wide gap in the type and value of model indices used to validate the data. However, in most research papers, it is observed that one of the Incremental Fit Indices (IFI) is more commonly used in addition to chi square fit. Error based Root Mean Square Error of Approximation (RMSEA) and residual based Standard Root Mean Square Residual (SRMR) are also recommended by Hu and Bentler [1999] citing the cut off values are 0.08 and 0.1 and less respectively. It is also mentioned that either of the values of IFI with loadings more than 0.9 are considered valid. The most commonly used IFI are Comparative Fit Index (CFI), Tucker-Lewis Index (TLI) and Relative Nonconcentrality Index (RNI). It is clearly seen in the result that the good fit of the model except the higher values of chi-square which is inflated by relatively large sample size. The overall model fit indices are chi-square = 2005.13, RMSEA = 0.063, CFI = 0.92, and TLI = 0.91, which are better than the threshold values. Furthermore, all of the factor loadings in the CFA model are greater than 0.5 and the t-values are significantly greater than 2.0. As a result, convergent validity is ensured in the study. To assess discriminant validity, the unconstrained model with the constrained models of the constructs is compared in this study. A significant difference of the χ^2 between the constrained and unconstrained models would indicate high discriminant validity. In this study, all of the differences of χ^2 are significant, which shows support to the discriminant validity of the constructs.

Finally, it is important to determine whether there is a strong correlation between SC measures by using Pearson correlation analysis. In general, if the Pearson's correlation coefficients are all below 0.6, the performance metrics are mutually independent. The result found from the analysis partially supports the claims but insignificant numbers of performance variables are nearer to the threshold value. However, it can be inferred that there are no strong relationships in between SC measures.

3.4. Results and Discussions

Using factor analysis, it is found that four distinctive strategies as assumed in the hypothesis s are valid. It is shown here that the characteristics are independent and match to the respective strategies. For example, characteristics liable to efficient strategies (ES1-ES6) are more common in efficient SC than others. Characteristics liable to risk-hedging strategies (RHS1-RHS6) are more common in risk-hedging SC than the rest of strategies. The same is true for the rest of the instruments. Hence this instrument now can be used to further map SCSs to companies. Besides, depending on the scree plot, the number of significant factors is shown in Figure 3.2, from which it can be observed that there could be up to five factors to be used.

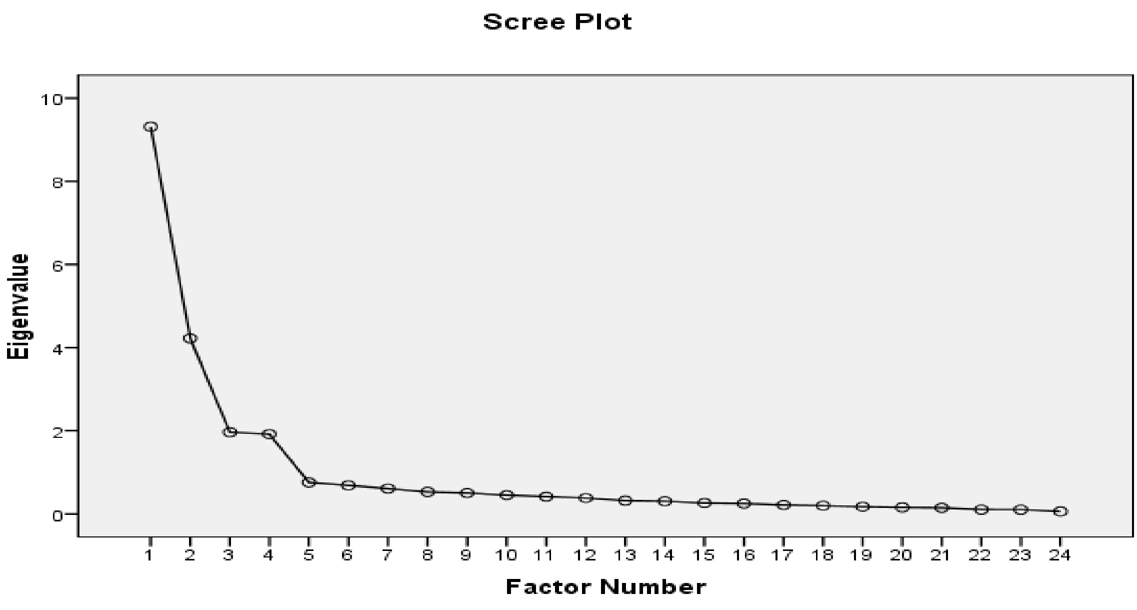

Figure 3. 2: Scree Plot to Show Number of Possible Factors

Hence using this information, clusters of similar forms are formed to verify which strategies match the companies and characteristics. First, hierarchical method of clustering is used to find the optimum number of clusters. Through iterating it, it is found that four clusters is optimum.

Then, these are analyzed using k-means clustering method and found the distribution as in Table 3.5. It can be seen from Table 3.5 that there are significant numbers in each cluster and it is believed that these are normally distributed. Hence, the clusters identified are also tested to characteristics of each SCSs in order to reject or accept the first hypothesis.

Table 3. 5: Cluster Distributions

Cluster	N	% of Combined	% of Total
1	27	20.10%	20.10%
2	41	30.60%	30.60%
3	28	20.90%	20.90%
4	38	28.40%	28.40%
Combined	134	100.00%	100.00%
Total	134	100.00%	100.00%

Here, the number of clusters is fixed to four so that no item fall outside of these four clusters. It is seen that some items with weakest correlation exist in small number and are assumed insignificant. The reason is that the assumption of all companies fall under four categories. However, some researchers like Qi et al [2009] classify those as traditional SC and Selldin and Olhager [2007] commented them as the mismatch. Hence, the clusters identified in Table 3.5 are also tested to characteristics of each SCSs in order to reject or accept the first hypothesis. Accordingly surpassing the loadings below 0.4, the complete classification is shown in Table3.6. Based on this, the next step is mapping companies to specific SCSs. The loadings in Table 3.6 shows that cluster 2 is matched to responsive SC, cluster 1 is matched with efficient SC, cluster 3 is matched with agile SC and cluster 4 matched with risk-hedging SC. Referring the codes for each construct in supply strategy section, Table 3.6 tells us the relation (loadings) between the characteristics and SCSs.

Besides, using ANOVA to test group differences in the mean values as shown in Table 3.7, the results from the factor loading based on clustering can be supported. From the table, it can be inferred that since the F-value for all groups/clusters are significant, it can be said that there are four different strategies exist in the study. In addition, looking into the higher value of the means towards each match, it can be told that which clusters belongs to which strategy. ANOVA is used to test whether there is a significance difference among clusters. It is found that there is a significance difference among clusters and can be claimed that the hypothesis H1a-H1d is met as shown in Table 3.7.

Table 3. 6: Clusters for Supply Chain Strategies

Items	**Clusters**			
	Cluster 2 (N=27)	**Cluster 3 (N=28)**	**Cluster 4 (N=38**	**Cluster 1 (N=41)**
RS2	0.918			
RS1	0.892			
RS5	0.819			
RS3	0.816			
RS4	0.781			
R56	0.726			
AS3		0.973		
AS2		0.823		
AS6		0.790		
AS4		0.779		
AS1		0.733		
AS5		0.625		
RHS2			0.830	
RHS4			0.821	
RHS3			0.813	
RHS5			0.794	
RHS1			0.735	
RHS6			0.692	
ES2				0.995
ES1				0.959
ES4				0.682
ES5				0.611
ES6				0.595
ES3				0.474

Table 3. 7: Analysis of Variance for Supply Chain Strategies

	N=27 Cluster 2	N=28 Cluster 3	N=38 Cluster 4	N=41 Cluster 1	F-Value
Efficient SC: Cluster mean	2.76	2.23	3.42	3.75	109.04*
SE	0.05	0.06	0.05	0.03	
Risk-Hedging SC: Cluster mean	3.12	2.35	4.12	3.22	69.28*
SE	0.06	0.05	0.03	0.03	
Responsive SC: Cluster mean	4.24	3.52	2.48	2.20	126.29*
SE	0.03	0.05	0.07	0.09	
Agile SC: Cluster mean	3.43	3.77	2.14	1.81	143.47*
SE	0.05	0.03	0.06	0.07	

SE = standard error *Significant at .01

Besides clusters of companies to match to strategies, there are other profile and background data to be studied whether these influence the type of the strategies. The ANOVA result for the types of companies by SCS is shown in Table 3.8. From the table, it is observed that food and beverages, glass, ceramics and plastics and consumer products favored efficient SCs. This result is contrary to the findings of Selldin and Olhager [2007] in which most companies are exercising responsive SCs. Most textiles, clothing and leather companies and metals and machinery are suited in agile category, while most of chemicals and construction companies' category fall under risk-hedging SCs. The majority of wood, paper and furniture and transportation equipment are categorized under responsive SCS based on the responses by managers. It is observed that some consumer products companies reported in the responsive SC. Again it is seen in the classification that small number of textile, clothing and leather companies responds to risk-hedging SC.

Table 3. 8: Analysis of variances for company types by SCSs

	N=9 (20)†	**N=6 (21)**	**N=10 (22)**	**N=21 (23)**	**N=20 (24)**	**N=21 (25)**	**N=20 (26)**	**N=17 (27)**	**N=19 (28)**	**F-Value**
Efficient SC: Cluster mean	2.46	3.54	2.33	4.32	4.21	2.42	2.26	2.45	2.45	7.34*
SE	0.11	0.04	0.03	0.08	0.1	0.09	0.05	0.04	0.07	
Risk-hedging SC: Cluster mean	4.12	2.43	3.78	2.68	2.32	2.36	2.67	2.46	2.47	4.38*
SE	0.03	0.05	0.08	0.03	0.1	0.04	0.09	0.07	0.06	
Responsive SC: Cluster mean	2.58	1.88	2.86	2.4	2.92	2.48	2.8	3.94	4.23	3.92*
SE	0.08	0.1	0.05	0.05	0.06	0.07	0.03	0.05	0.04	
Agile SC: Cluster mean	2.84	1.76	3.34	2.81	2.14	4.08	3.73	2.73	2.67	9.34*
SE	0.06	0.07	0.03	0.03	0.1	0.09	0.05	0.04	0.07	

SE = standard error. * Significant at .01 level. † Name code given under Section 3.2

In addition to types of companies, there are also other profile and background data to study the effects of them on SCS. One-way ANOVA is used to test the effect of these variables like age, position, role, size, and ownership as clearly tabulated in Tables 3.9-3.12. Regarding the ownership, it can be seen that the F-value is significant on efficiency SCs in the private companies and can be said that major private companies are running within the efficient SC. There are no significant values observed for other ownership structures. For the other profile and background data (size), small and large companies favor the efficient and responsive SCs respectively. This means that small size companies prefer efficient SCs while the larger one prefers responsive SCs. There is no role tested for roles of the companies (leaders vs. followers) in the SC. Finally, the manufacturer in the SC is seen significant in agile SCS and there are no significant values for raw materials and components suppliers in this study.

Table 3. 9: ANOVA for ownership Structures of Companies

Ownership	N=77	N=20	N=19	N=18	F-Value
	Private	State	Foreign	Joint	
Efficient SC: Cluster mean	2.85	2.26	2.63	2.42	4.63*
SE	0.1	0.07	0.04	0.06	
Risk-hedging SC: Cluster mean	3.12	3.23	2.77	2.48	1.32
SE	0.06	0.05	0.09	0.03	
Responsive SC: Cluster mean	2.56	1.78	2.84	3.2	3.92*
SE	0.07	0.04	0.06	0.09	
Agile SC: Cluster mean	2.74	2.46	2.34	2.81	1.14
SE	0.06	0.04	0.08	0.12	

Table 3. 10: ANOVA for the Size of Companies

Size	N=51	N=46	N=37	F-Value
	Small	Medium	Large	
Efficient SC: Cluster mean	3.76	3.14	2.44	5.67*
SE	0.09	0.03	0.07	
Risk-hedging SC: Cluster mean	3.18	3.26	2.97	1.34
SE	0.06	0.05	0.09	
Responsive SC: Cluster mean	3.43	3.48	3.64	4.42*
SE	0.11	0.09	0.08	
Agile SC: Cluster mean	2.76	2.68	2.84	2.14
SE	0.03	0.06	0.09	

Table 3. 11: ANOVA for the position of the Companies in the Supply Chain

Position	N=10	N=23	N=101	F-Value
	Raw Material Suppliers	Components Suppliers	Manufacturers	
Efficient SC: Cluster mean	2.74	2.96	2.63	1.13
SE	0.03	0.14	0.08	
Risk-hedging SC: Cluster mean	3.14	3.23	3.41	1.05
SE	0.03	0.05	0.09	
Responsive SC: Cluster mean	2.86	2.78	2.82	1.05
SE	0.11	0.09	0.08	
Agile SC: Cluster mean	2.84	2.56	3.34	4.62*
SE	0.06	0.05	0.03	

Table 3. 12: ANOVA for the Age of Companies

Age	N=10	N=77	F-Value
	Young	Mature	
Efficient SC: Cluster mean	4.64	2.56	19.30*
SE	0.1	0.13	0.09
Risk-hedging SC: Cluster mean	2.44	2.23	1.04
SE	0.07	0.06	0.09
Responsive SC: Cluster mean	3.14	3.32	0.82
SE	0.1	0.07	0.09
Agile SC: Cluster mean	2.72	3.56	2.49*
SE	0.05	0.06	0.03

* Significant at .01 level.

To test the second preposition on the relation between SC measures and strategies, again factor and cluster analysis is employed. Table 3.13 shows the factor analysis for performance measures. In the table the dominant loadings are shown and less significant values are omitted. After identifying the possible number of factors, k-means factor analysis is used to map SC measures to respective SCSs. The values in the table indicated with bold shows significance of measures with respect to each strategy. The loadings shown in the table also indicates that some of the measures of agile are strongly related to the responsive SC. Similarly, some of the measures used for efficient are also can be used for risk-hedging SCs. These measures can be called common for each pairs. According to this result, it can be called that PM6, PM7, PM8, PM9, PM15, PM16, PM17 and PM29 are common measures for both responsive and agile SCs. But PM15, PM17, PM9, PM29 and PM16 are more common to agile than responsive. Similarly, PM6, PM7 and PM27 are more aligned to responsive SCs. In the same way PM1, PM3 and PM4 is common to efficient and risk-hedging SCs with PM3 more weight to risk-hedging SC. Another more important result from the mapping is PM10, PM12, PM18, PM19, PM20 and PM21. These measures are used to all companies and there is no significant differences between the strategies occurred. The majority of these measures is financial measures and can be concluded that financial measures are almost equally understandable and usable to all SCSs. Hence, operational measures are more important to classify SCSs. The other one is information sharing. These measures are regarded as most important to all levels of the chains. As in this case, it can be named as an order qualifier for all SCSs. This result is supported by Gunasekaran and Ngai [2004] dictating that effective information sharing for either lean or agile is usually an essential part of a collaboration strategy, and firms will often rely on the application of information and communication technology for this purpose. Based on the factor loadings, importance and clustering of performance measures, measures are classified as order winners and order qualifiers for each respective SCSs in descending weights. The complete classification is shown in Table 3.14. Note that financial measures and information sharing measures are common measures for all SCSs. Both can be named as order qualifiers for all strategies even though not listed in Table 3.14. Besides, the ANOVA results for matching SC measures to the SCSs, given in Table 3.15, show that there is a significant difference in means of performance clusters into SCSs. Hence, the results support the hypothesis H2a-H2d.

Table 3. 13: Matching Supply Chain Measures to Strategies

Performance Measures	**SCSs**			
	Agile	**Responsive**	**Efficient**	**Risk-hedging**
PM15	**0.89**	**0.632**		
PM17	**0.87**	**0.543**		
PM9	**0.76**	**0.75**		
PM11	**0.75**	0.492		
PM3			**0.524**	**0.722**
PM25	**0.67**	0.421		
PM29	**0.66**	**0.625**		
PM16	**0.61**	**0.539**		
PM24	**0.6**	0.419		
PM14	**0.58**	0.478		
PM30	0.44	**0.596**		
PM23	0.42	0.197		**0.672**
PM7	**0.6**	**0.893**		
PM6	**0.53**	**0.89**		
PM8	0.73	**0.733**		
PM2	0.34	**0.624**		
PM27			**0.867**	**0.516**
PM26			**0.832**	0.442
PM28			**0.801**	0.477
PM13			**0.662**	0.455
PM22			**0.594**	0.499
PM18			0.49	0.142
PM21			0.355	0.179
PM19			0.309	0.173
PM20			0.227	0.008
PM4			**0.556**	**0.552**
PM1			**0.523**	**0.542**
PM5			0.497	**0.844**
PM10			0.461	0.463
PM12	0.16	0.08		

Table 3. 14: Order Winners and Qualifiers for Supply Chain Measures

Strategies	**Order winning measures**	**Order qualifying measures**
Efficient	PM4,PM13,PM22,PM26,PM27, PM28	PM1, PM3
Responsive	PM2,PM6,PM7, PM8,PM27	PM6,PM9,PM15,PM16,PM17,PM29
Risk Hedging	PM1, PM3, PM5, PM23	PM4,PM27
Agile	PM9,PM11,PM14, PM15, PM16, PM17, PM24, PM25, PM29	PM6, PM7, PM8

Table 3. 15: Analysis of Variance for Measures by Supply Chain Strategies

	N=27 Responsive SC	N=28 Agile SC	N=38 Risk-hedging SC	N=41 Efficient SC	F-Value
Efficient Performance measure					
Cluster mean	2.44	2.58	3.48	3.78	12.24*
SE	0.03	0.05	0.05	0.06	
Risk-hedging performance measure					
Cluster mean	3.12	3.35	4.02	3.42	16.38*
SE	0.04	0.05	0.03	0.08	
Responsive performance measure					
Cluster mean	4.84	3.62	2.58	2.60	6.52*
SE	0.08	0.03	0.05	0.04	
Agile performance measure					
Cluster mean	3.40	4.17	2.44	2.31	3.49*
SE	0.06	0.08	0.09	0.1	

* Significant at .01 level.

3.5. Conclusions

In this chapter, it is found that there is distinct matching of companies into SCSs based on classification given by Lee [2002]. Regarding types of companies matching SCS, it is found that most of food and beverages, glass, ceramics and plastics and consumer products match with efficient SCs. Most companies in textiles, clothing and leather companies and metals and machinery are suited in agile category, while most of chemicals and construction companies category fall under risk-hedging SCs. The majority of wood, paper and furniture and transportation equipments are categorized under responsive SCS. Regarding profile and background data, private companies favor efficient SCs in the ownership structures and manufacturers favor agile SC in the positions of the SC. There are no significant values observed for other ownership structures and positions in the SCs. Small and large companies favor the efficient and responsive SCs respectively.

It is also indicated that efficiency, risk-hedging, agile and responsiveness strategies can be mapped independently and their respective measures are also identified. Further, the order winning and qualifying measures for each strategy are clearly identified. It is also found that metrics for efficient SC can be adapted to the risk-hedging SC on varying the scales of measurements. In the similar manner the metrics developed for agile SC can be used for responsive SCs on varying scales of measurement. It is found that information sharing and financial measures are common to all SCSs. Regardless of the difficulty in the interdependence of the SC measures, this research is one of the significant research in matching SC measures to the strategies.

SCS is directly adopted from Lee [2002] classification. While the research is done on one of the developing countries, it has significant contribution to the SCM academicians and practitioners. It has also advantage for Ethiopian and foreign companies. For Ethiopian companies, it helps to identify SCS to compete effectively and to evaluate how well SC models fit with theoretical findings and suggestions. For foreign companies, it shows the position of Ethiopian manufacturers towards SCM for further collaboration and entry into the country using the companies as partners.

Chapter 4

Financial Performance Metrics: A Comparative Study

When you can measure what you are speaking about, and express it in numbers,
You know something about it
---Lord Kelvin, 1824-1907

4.1. Introduction

It is mentioned in the previous chapters that SCPM have not been tested on actual SC scenario to check and balance the well being of a SC. Hence, this chapter tries to test financial metrics on consumer goods SCs. Financial metrics which reflect the assessment of a firm by factors outside of the firm's boundaries have been identified by numerous researchers. However, the metrics identified are simply conventional indicators which do not consider the size and the strategy of individual entities in the SC. Looking only into conventional measures such as net income and revenue do not foresight the future progress of the SCs. Hence, it is imperative to analyze the financial metrics in the form of ratios to check and balance the well-being of the SC. Since companies' size and efficiency differ, it is advisable to compare those using financial metrics in terms of ratios. Based on these identified financial measures in the form of ratios such as revenue growth, profit margin, operating margin, return on assets (ROA) and revenue per employee have been identified to see how the company is doing efficiently and effectively in the SC and in competitors perspectives and it is believed that this ratio can capture unbiased performances of the SCs within the same industrial category i.e. consumer goods SC.

Consumer goods have relatively low profit margin so that an average consumer can purchase the goods. This typical affinity towards high volume purchases is accompanied with a substantial cumulative profit. Because consumer goods are frequently manufactured and sold, clear track of their respective SC performance is highly indispensable. Since consumer goods are broader in category, fast moving consumer goods (FMCGs) that are consumed by customers on daily basis are considered. Products such as processed foods, personal cares, soft drinks, etc. can be regarded as FMCGs. Characteristics of these companies include low value, low-involvement goods, impulsive customer purchases, short usage cycles, and high repurchasing need [Diehl and Spinler, 2013].

As indicated in Chapter-1, most of the studies in SCPM are undertaken in developed countries. Even these studies are highly descriptive. While these studies help us understand the concept of SC performance measures, there remains a need for large-scale empirical testing and validation of the conceptual frameworks employed by various researchers. Furthermore, most studies on SC performance measures have excluded developing countries with some exceptions of BRICS countries. There is no or limited research done in developing countries, like different regions of Africa. The most underrepresented region in this category is eastern Africa, in which Ethiopia is the single largest political and economic driver of the region.

Ethiopia has one of the fastest-growing economies in the world and is Africa's second most populous country. In her current form, the economy of Ethiopia is largely based on agriculture, which accounts for 46.6% of the gross domestic product (GDP) and 85% of total employment. The manufacturing sector constitutes about 4 percent of the overall economy, although it has shown some growth and diversification in recent years. Currently, she strives for industrialization-led policy to take the lead in both GDP and employment over agriculture-led policy. This is done through integrating agriculture products with industry through value chain policy. The whole of the feeding of products to industry and then to customers involves an effective and efficient SC. Following these developments, Ethiopia, is now receiving attention from transnational corporations who are global SC leaders. Currently, Ethiopia has attracted foreign direct investments mainly from European countries, China, India, USA and Arab countries.The effectiveness and efficiency of these chains can be checked and balanced by proper SCPM. To measure and correct their SC, the proper benchmarks or experiences need to be applied. Hence, in this chapter the proper financial metrics are identified from the best operating SCs and applied on Ethiopian SC to find the performance gap between each SC within the country and abroad.

4.2. Review of Literature

In the literature many attributes of performance measures are identified so far. Some authors identified as financial [Lambert and Pohlen, 2001; De Toni and Tonchia, 2003], some other as operational [Beamon, 1999; Lapide, 2000; Kleijnen and Smits, 2003; Neely et al, 2005; Tan and Adebanjo, 2011] and the rest financial and operational [Gunasekaran et al, (2001, 2004); Chan, 2003; Gunasekaran and Kobu ,2004; Qi et al, 2009; Akyuz and Erkan, 2010] with customer service included in operational measures. Some other authors tried to come up with balanced measures of those identified measures [Kaplan and Norton, 1992; Brewer and Speh, 2000; Papalexandris, et al, 2004; Bhagwat and Sharma, 2007a]. Besides, any focal company in a SC must manage a flexible mix of operational tasks and business relationships in dynamic customer and supplier environments.

Suwignjo et al [1998] classified performance measures, based on the survival strategy, a short term and long term performance measures. Measure which relate to short-term survival of the company usually contains aggregated financial indicators such as value added cost and total costs, both of which are key measures, whereas performance measures which relate to the long-term survival of the company consists of performance measures which relate to customer satisfaction (market share and number of complaints), the drivers of customer satisfaction (quality, on time delivery, and flexibility), and learning and growth (Corporate, IT, etc).

Brewer and Speh [2000] linked the SCM framework to the balanced scorecard to identify measures. They identified financial benefit metrics as profit margin by SC partner, cash-to-cash cycle time, customer growth and profitability, return on SC assets. Applying financial measures such as profitability and rate of return, Keebler [2000] used the Du Pont Model to analyse financial issues in SCM and identified three ways of managing them by margin management, asset management and financial management. His studies showed that inefficiencies in the SC can waste up to 25% of the operating costs and that leading companies enjoy a 45% SC cost advantage over their median competitors.

Huang et al [2005] identified financial metrics as cost of goods sold, total SCM cost, warranty or return processing costs and value-added employee productivity. Hendricks and Singhal [2005] used a sample of 884 glitches announced by publicly traded firms and tested them against a sample of control firms of similar size and companies empirically, and documents the association between SC glitches and operating performance at macro level. On average, the glitches lead to 6.92% lower sales growth, 10.66% higher growth in costs and 13.88% higher growth in inventories. The main financial measures used here are operating income, return on sales, ROAs and inventories.

According to Shepherd and Gunter [2006] financial metrics include sales, profit, return on investment, net profit vs productivity ratio, total SCM costs, cost of goods sold, asset turns, etc. The identified financial metrics such as ROA, return on investment (ROI) are used to measure SC performance [Ramaa et al, 2009], and this idea is also supported by the works of Stewart [1995], Gunasekaran at al [2001], Kennerley and Neely [2002] in which financial measures are set clearly.

Thakkar et al [2009] also classify financial metrics as profit margins, pre-tax return on assets, after tax return on investment, return on investment, return on assets, total SC cost, growth in market share, return on capital employed, improved cash flow and warranty or returns processing cost. Those financial metrics such as return on investment, return on sale, market share, growth in ROI, growth in return on sales (ROS) and growth in market share are also identified and verified by Qi et al [2009]. These lists are also further validated by Flynn et al [2010] in addition to growth in sales and growth in profit. More specifically Wagner et al [2012] used ROA to study the impact of SC fit on firm's financial performance using survey of 259 US and European manufacturing firms and observed that the higher the SC fit, the higher the ROA of the firms.

Based on the literature and companies' metrics, the average values of each performance metrics are used since all companies are the leading SC performers. Comparing other SCs with the best performing chain may create a lot of gap that in turn create frustration rather than improvement. Hence, the robust benchmarks are the average values of ROA, revenue growth, operating margin, profit margin and revenue per employee (human productivity). One of the main measures of productivity is revenue per employees. Productivity is attained through human capital [Kumar et al, 2010]. For example, experienced employees are more competent in verifying design, performing total cost analysis and resolving conflict between suppliers and customers. Hence, human capital has a direct effect on organizational performance. According to the authors organizational performance comprises of competitive performance like meeting the preferences of customers in terms of, for example, quality, price, time and service level, reverse logistics, value network effectiveness, SC configuration effectiveness and business performance like profits, market share and employee development and concludes that SCs with low human capital scores are expected to be from firms that do not invest much in employee training, and do not expect staff to be aggressive, proactive and/or innovative. This will result in low revenue per employee.

It is dictated that revenue per employee is a commonly used measure of management efficiency. Though this metric varies widely from company to company, it nonetheless provides an interesting view into how well a company is run. It can show for example how you're doing against your competition while providing a simple long-term tracking metric for both public and private companies. The best run companies have high revenue per employee figures. For example, Harnish [2006] compared smaller firms to those with the Fortune 500 and found that the revenue per employee for smaller firms is close to $100,000 and those of for Fortune 500 is $300,000. Specifically, Wal-Mart averages $170,000 revenue per employee; General Electric is standing at $436,000; Microsoft is averaging $646,000; and the oil companies are generating over $2 million [Harnish, 2006]. Hence, the above literature made us interested in selecting revenue per employee measure as one of the financial and key SC measures.

4.3. Research Methodology

The research method is purely a case study approach. Case study methodology is appropriate and applicable for explorative theory development [Yin 1994; Diehl and Spinler 2013].The financial metrics are identified from extensive literature review and companies metrics reports. To find the performance gaps of Ethiopian companies, the best-in-class companies of the world are identified and their performance measures/metrics are used as the benchmarks for the study from 2008-2012. These best-in-class companies are selected from Gartner®'s 2013 top 50 rankings in which the companies are rated in accordance with their performance related to the SCM. Eleven company types are identified based on industry type as shown in Table 4.1. Accordingly, the consumer goods companies are identified as Unilever, P&G, Colgate-Palmolive and Kimberly-Clark. Some of these companies are praised by Diehl and Spinler [2013] as leading FMCG companies that are highly proficient in SC management and have received several awards for their SC performance. The financial performances of the identified top FMCG companies in the world are shown in Appendix III.

Table 4. 1: Category by Company Type for Gartner®'s top 50 Rankings

Chemical	Consumer Products	Food and Beverages	Heavy Machinery	Network and Communication Equipment	Pharmaceu- ticals	Restaurants	Retailers	Semi- conductors	Consumer Electronics	Automotive
BASF	Unilever	Coca Cola	Caterpillar	Cisco Systems	Johnson & Johnson	McDonald's	Amazon	Intel	Apple	Ford
DuPont	P&G	PepsiCo	Cummins	Qualcomm	AstraZeneca	Starbucks	Inditex	Texas Instruments	Samsung	BMW
Syngenta	Colgate- Palmolive	Nestlé	John Deere		Lilly		Wal-Mart		Dell	Volkswagen
Dow	Clark	Kraft Foods					H&M		Lenovo	Hyundai
		General Mills					Costco		Haier	Tata

Ethiopian manufacturing companies are classified as micro and small, medium and large enterprises depending on the number of employees and capital engaged. Based on this category, if the number of employee is more than 50, the company is categorized under large enterprise irrespective of the intensity of capital invested. Here, to compare and set benchmarks with best practice; consumer goods SCs in Ethiopia are taken, where current trends in investment are attracting large companies. But the primary focus of the thesis is on indigenous consumer goods manufacturing SCs for similar pattern benchmarks. Ethiopia as one of the developing countries, lack infrastructure in all of its cities, so that the expansion of major companies are limited to the capital city, Addis Ababa and the surrounding towns within the radius of 110 km from the city. Once the target city and surrounding towns were determined, Li et al's [2005] suggestion is followed by focusing on those manufacturing firms with more than 100 employees because the manufacturers with less than 100 employees seldom engage in sophisticated SCM. Based on this suggestion, several companies come into picture.

Basically there are 1733 establishments of small, medium and large manufacturing enterprises in Ethiopia in 2012. From these establishments about 223 are large manufacturing companies with more than 50 employees found in Addis Ababa, capital city. 155 companies have more than 100 employees and are selected as an area of study. But, since the focus here is on those of consumer product SC, 52 consumer products' companies came into picture. To further screen to suit the problem, only FMCG companies' SC are considered for this particular study. Using this criterion, 36 best performing consumer goods SCs are selected based on their net income, number of employees and capital. Finally due to some difficulties such as financial secrecies, bureaucracies and inefficient data handling in collecting data from some companies, only complete performance data for 25 companies have been collected. The data pertaining to number of employees and sales for these 25 companies in 2010 is shown in Table 4.2.

Table 4. 2: Companies under Study in 2010

Companies	No. of Employees	Sales (1000$)	Companies	No. of Employees	Sales (1000$)
East Africa Companies	221	29929	Great Absynian Water	136	1218
Ethiopian Pulp and Paper	537	11487	EPHARM	578	6248
Oxford Companies	799	6068	Star Soap and Detergents	178	3538
Zenith Gebs-Eshet	568	6105	Mekbeb Cosmetics	185	2524
Fafa Food Factory	257	3020	Dugde Agro Company	273	1624
Health Care Foods	110	2280	Yekatit Paper SC.	314	1017
Kality Food Factory	287	1473	MAMCO	112	1037
KOJJ Food Complex	219	2058	National Tobacco	583	37533
Shewa Bakery	676	1269	Kokeb Pasta and Macaroni	191	1407
Wonji Sugar Factory	3625	22693	Addis Modjo Edible SC.	291	5984
Awash Wines	525	5342	Hakammaz Confectioneries	123	513
East African Bottling	541	24275	Repi Soap and Detergent	210	4212
MOHA Soft Drinks	832	21483			

To apply on the real scenario on Ethiopian consumer goods SCs, appropriate data are collected. The primary data are collected in the form of observations, field visits and interviews to the corresponding managers. The secondary sources of data that the researcher used are different companies' manuals and annual reports, available organizational chart, brochures, magazines and electronic retrievals. Based on the collected data, financial performance metrics of these companies for the years 2008-2012 are calculated and are shown in Appendix IV.

4.4. Analysis of Financial Metrics: Top FMCG Companies in the World

Based on the annual reports and case studies, the performance ratios are calculated for the years 2008-2012. The ratios are revenue growth, profit margin, operating margin, ROA and revenue per employees to see how the company is doing efficiently in the SC perspectives. The results of comparison of the companies are shown in Tables 4.3 - 4.7 and Figures 4.1 - 4.5. The average values of the metrics are also included, which are used as benchmarks for Ethiopian companies.

4.4.1. Comparison Based on ROA

ROA, on the whole, is decreasing from 2008 to 2012 as can be seen from Table 4.3 and Figure 4.1 due to either companies are more responsive than efficiency through global network reach through minimum profit or investing in infrastructure such as IT and transportation which increase responsiveness too. Colgate-Palmolive is the leading efficient company in converting assets to profit. Its main competitor P&G performs low by this metrics. Hence, even though many factors are determining the efficiency-responsiveness of the SC, using ROA metrics it can be concluded that Colgate-Palmolive is more efficient than its competitors.

Mathematically,

$$ROA = \left(\frac{NI}{AA}\right) \times 100 \quad \text{.......................... (1)}$$

Where, ROA=Return on Asset; NI=Net Income; AA=Average Asset

Table 4. 3: ROA Values of the Companies

Year	**Consumer Goods Companies**				**Average ROA**
	Unilever	**P&G**	**Colgate-Palmolive**	**Kimberly Clark**	
2008	14.39	9.00	19.48	10.01	13.22
2009	10	9.64	21.70	10.69	13.01
2010	11.76	9.68	19.75	9.95	12.79
2011	10.43	8.85	20.35	8.58	12.05
2012	10.56	7.95	18.93	9.32	11.69

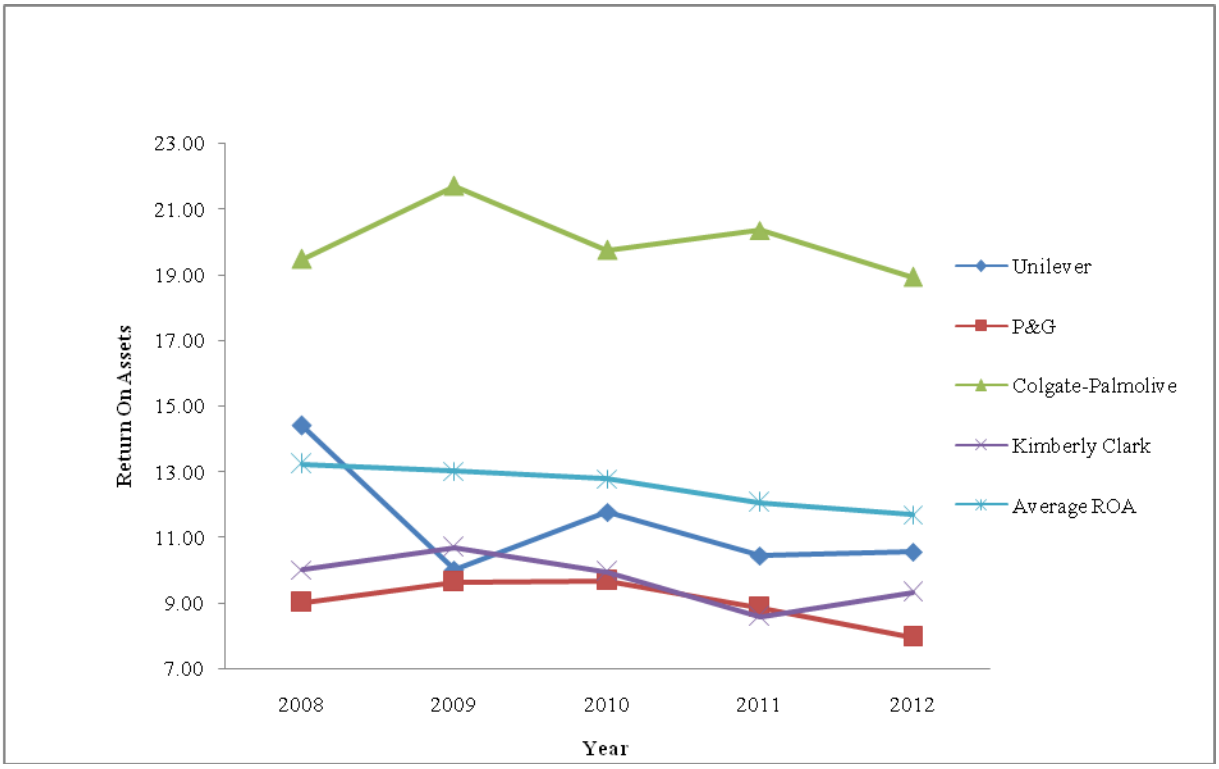

Figure 4. 1: ROA for Consumer Products Companies

4.4.2. Comparison Based on Revenue Growth

Regarding revenue growth, most of the companies hit by financial crisis of 2008 -2009 and the majority of them revealed negative growth except Unilever which were less sensitive because it is an EU based MNC. This is because intuitively the crisis majorly hit the western companies. From the Table 4.4 and Figure 4.2, it can be seen that almost all companies' revenue growth is fluctuating due to uncertainties and risks. The only exception is Unilever which consistently showed increase in revenue. Mathematically,

$$RG = \left(\frac{RCY - RPY}{RPY}\right) \times 100 \qquad (2)$$

Where, RG=Revenue Growth; RCY=Revenue of Current Year; RPY=Revenue of Previous Year.

Table 4. 4: Revenue Growth Values of the Companies

Consumer Goods Companies	**Year**				
	2008	2009	2010	2011	2012
Unilever	0.84	3.5	4.1	6.5	10.5
P&G	9.31	-3.11	3.28	4.29	3.18
Colgate-Palmolive	11.17	-0.02	1.55	7.52	2.10
Kimberly Clark	6.29	-1.55	3.30	5.57	1.04
Average Revenue Growth	6.90	-0.30	3.06	5.97	4.21

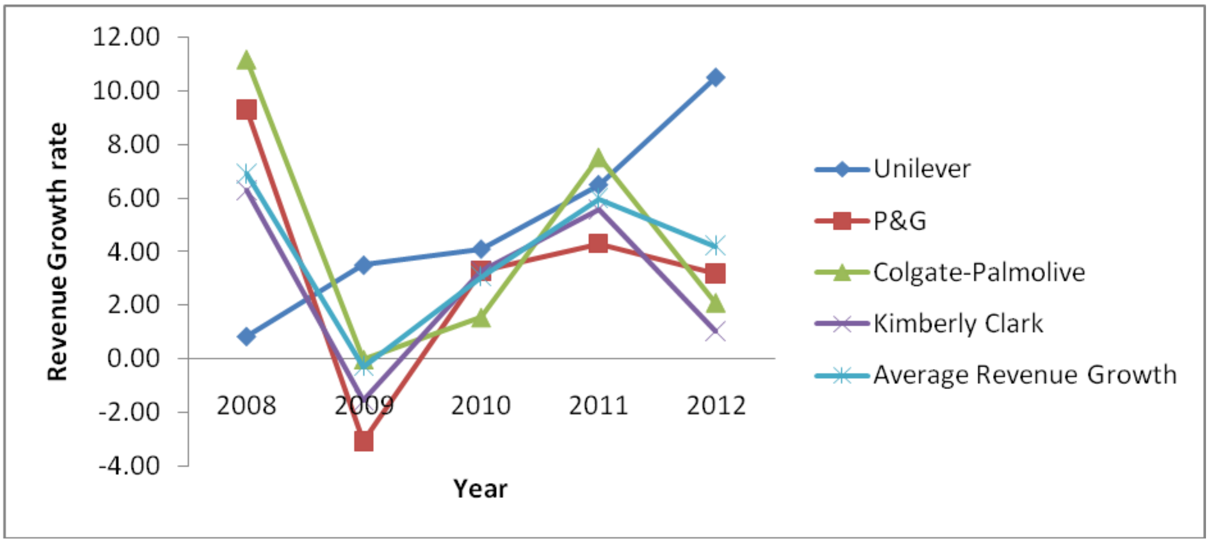

Figure 4. 2: Revenue Growth for Consumer Products Companies

4.4.3. Comparison Based on Operating Margin

Table 4.5 and Figure 4.3 show a comparison of companies on operating margin. Operating margin is a ratio used to measure a company's pricing strategy and operating efficiency. It is a measurement of what proportion of a company's revenue is left over after paying for variable costs of production such as wages, raw materials, etc. A healthy operating margin is required for a company to be able to pay for its fixed costs, such as interest on debt. It is clearly seen from Figure 4.3 that all companies' operating profit is in a decreasing trend and the most efficient in operations and pricing strategies is of that Colgate-Palmolive and the least one is Kimberly Clark. In this ratio, the average value seems to be very stable through the years. Analytically, Operating Margin (OM) can be found as the ratio of Operating Income (OI) to Revenue:

$$OM = \left(\frac{OI}{revenue}\right) \times 100 \quad \text{.......} \quad (3)$$

Table 4. 5: Operating Margin Values of the Companies

Consumer Goods Companies	**Year**				
	2008	2009	2010	2011	2012
Unilever	17.69	12.61	14.32	13.84	13.62
P&G	20.26	20.17	20.23	19.11	15.88
Colgate-Palmolive	21.30	23.59	24.39	23.05	22.76
Kimberly Clark	13.12	14.78	14.04	11.71	12.75
Average Operating Margin	18.09	17.79	18.25	16.93	16.25

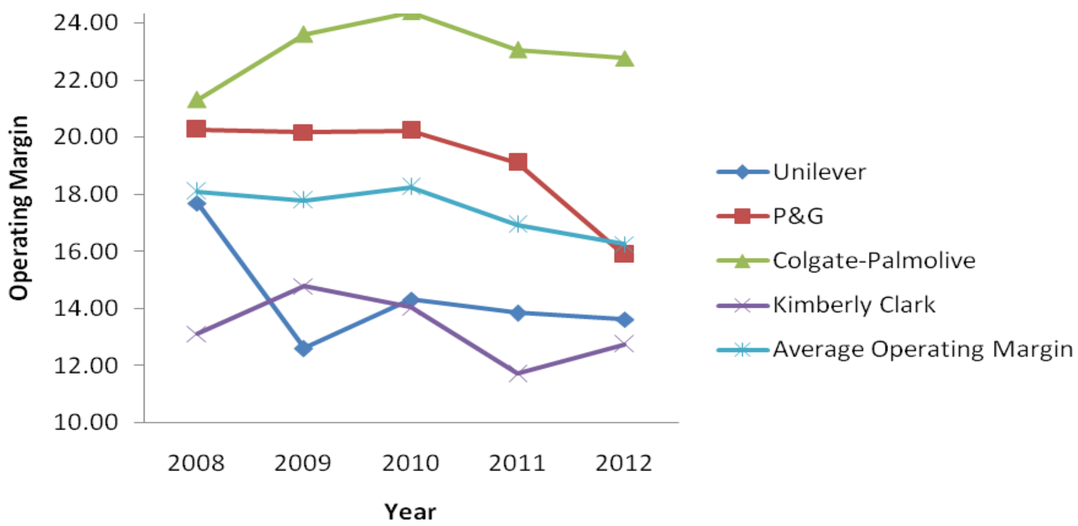

Figure 4. 3: Operating Margin for Consumer Products Companies

4.4.4. Comparison Based on Profit Margin

Table 4.6 and Figure 4.4 tell us the companies' comparison based on the profit margin. Profit margin is a measure of profitability which measures how much out of every dollar of sales a company actually keeps in earnings. A higher profit margin indicates a more profitable company that has better control over its costs compared to its competitors. Based on this premises and comparing with Figure 4.4, it can be inferred that Colgate-Palmolive has a remarkable profitability ratio and Unilever is the least profitable. The average profit margin again is stable over the period. Profit Margin (PM) can be calculated as the ratio of Net Income (NI) to Revenue as shown below.

$$PM = \left(\frac{NI}{revenue}\right) \times 100 \qquad (4)$$

Table 4. 6: Profit Margin Values of the Companies

Consumer Goods Companies	**Year**				
	2008	2009	2010	2011	2012
Unilever	13.04	9.19	10.39	9.95	9.64
P&G	15.54	17.84	16.38	14.55	12.85
Colgate-Palmolive	21.30	23.59	24.39	23.05	22.76
Kimberly Clark	13.12	14.78	14.04	11.71	12.75
Average Profit Margin	15.75	16.35	16.30	14.82	14.50

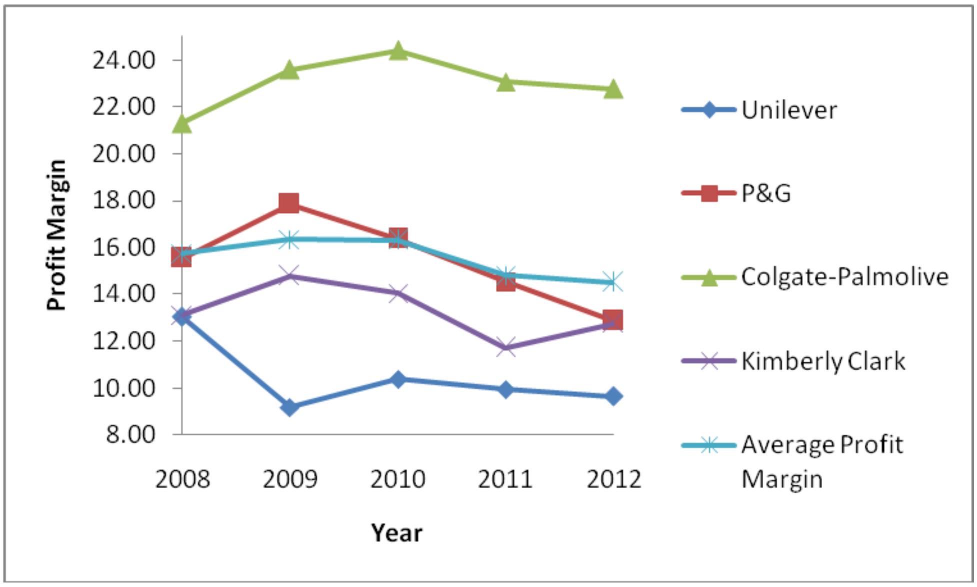

Figure 4. 4: Profit Margin for Consumer Products Companies

4.4.5. Comparison Based on Revenue per Employees

Finally, the revenue per employees shown in Table 4.7 and Figure 4.5 tell how productive the employees in each company. This ratio is most useful when compared against other companies in the same category. Ideally, a company wants the highest revenue per employee possible, as it denotes higher productivity. In this particular case, P&G is the most productive and Unilever is the least productive based on employee productivity. One can argue in this case that the average value of the ratio has uniform trend and can be used for benchmarks. Revenue per employees (RPE) is the ratio of revenue to total number of employees (TNE) in the same year.

$$RPE = REVENUE / TNE \quad \text{.......} \quad (5)$$

Table 4. 7: Revenue per Employees Values of the Companies

Consumer Goods Companies	**Year**				
	2008	2009	2010	2011	2012
Unilever	0.17915	0.18234	0.20635	0.21150	0.22953
P&G	0.57566	0.57042	0.61234	0.62871	0.66413
Colgate-Palmolive	0.41885	0.40228	0.39704	0.43352	0.45318
Kimberly Clark	0.33474	0.33535	0.34642	0.37225	0.39742
Average Revenue per employees(millions dollar)	0.37710	0.37260	0.39054	0.41150	0.43606

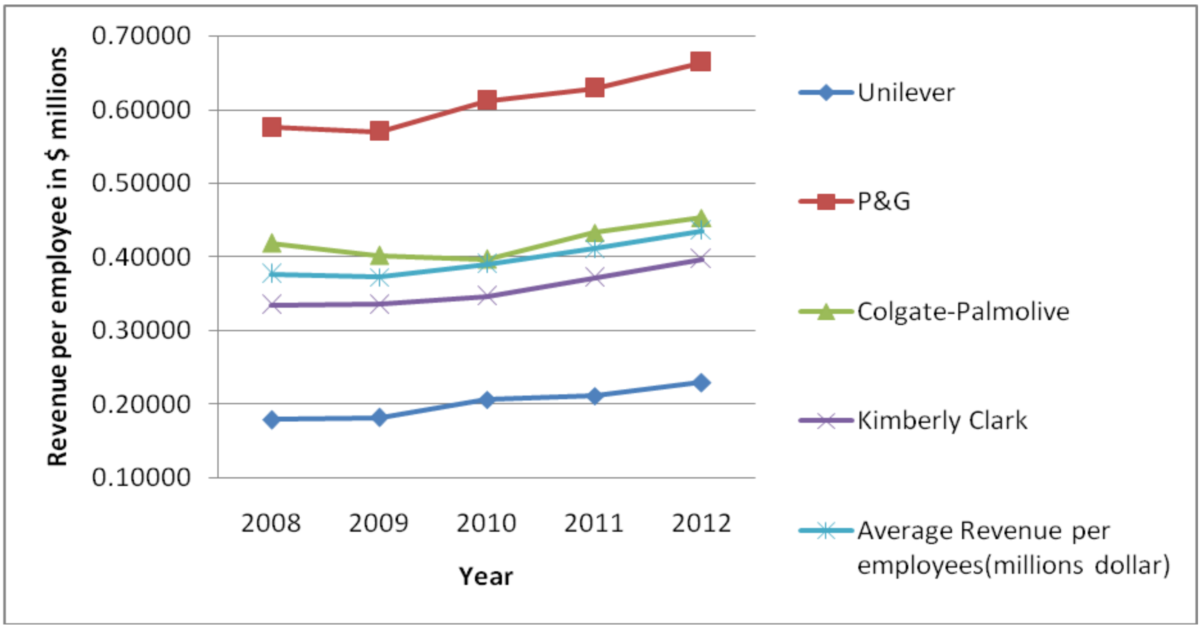

Figure 4. 5: Revenue per Employees for Consumer Products Companies

The average values of each of the performance metrics are used to compare other SCs since all companies are the leading SC performers. Comparing other SCs with the best performing chain may create a lot of gap that in turn create frustration rather than improvement. Hence, the robust benchmarks are the average values of ROA, Revenue Growth, Operating Margin, Profit Margin and Revenue per Employees.

4.5. Analysis of Financial Metrics: Ethiopian FMCG Companies

Based on the annual reports, the performance ratios under consideration, i.e., revenue growth, profit margin, operating margin, ROA and revenue per employees are calculated during for the years 2008-2012 for the Ethiopian FMCG companies considered for the study. These are shown in Appendix IV.

4.5.1. ROA Comparison

The total trends in ROA of Ethiopian SCs for the years 2008 to 2012 are shown in Figures 4.6 and 4.7. As the figures containing all the companies looks clumsy, figures containing only a sample companies are also shown. From the Figure 4.7, one can infer that MOHA soft drink, Dugde Agro Company, National Tobacco SC, Ethiopian Pulp and Paper SC, Zenith Gebs-Eshet, and Addis Modjo Edible Oil Factory are the leading efficient companies in converting assets to profit. These SCs seem to be competent in their ROA with SC leaders performing around and above 8 on an average from 2008-2012 compared to those 9-15 for best class SCs in the same period. The results are awesome for Ethiopian SCs as compared to the result found by Wagner et al [2012] for World manufacturing companies whose SC fit has the average value of above 7.41. Most of the consumer SCs considered performed above and nearer to ROA of 6 which is also acceptable level to continue in the efficient frontier. However, companies like EPHARM and Hakammaz performed worst under this measures, which are considered inefficient compared with both the SCs within the country and abroad. Good news from Ethiopian SCs is that their trends in ROA are increasing while world leader SCs are decreasing.

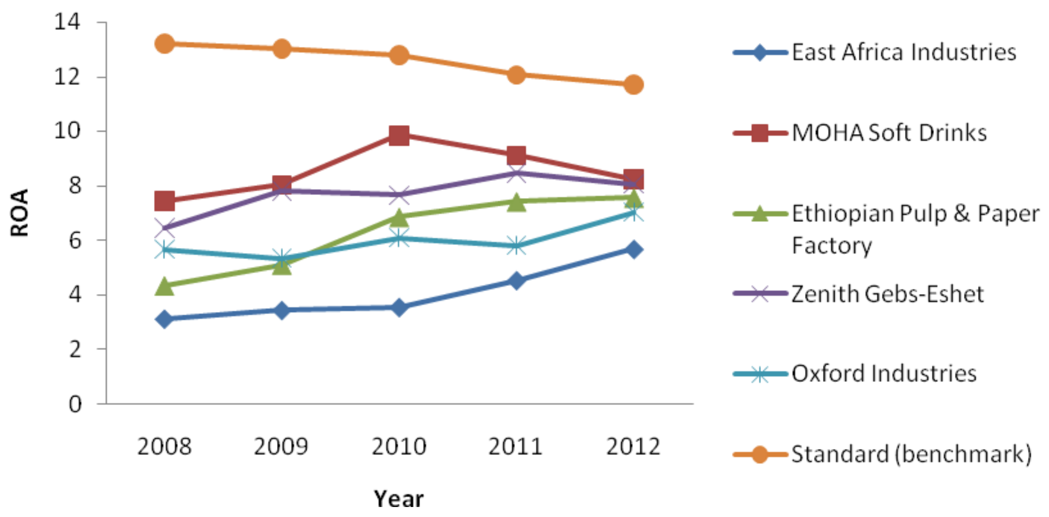

Figure 4. 6: ROA Comparison of Sample Companies against Benchmarks

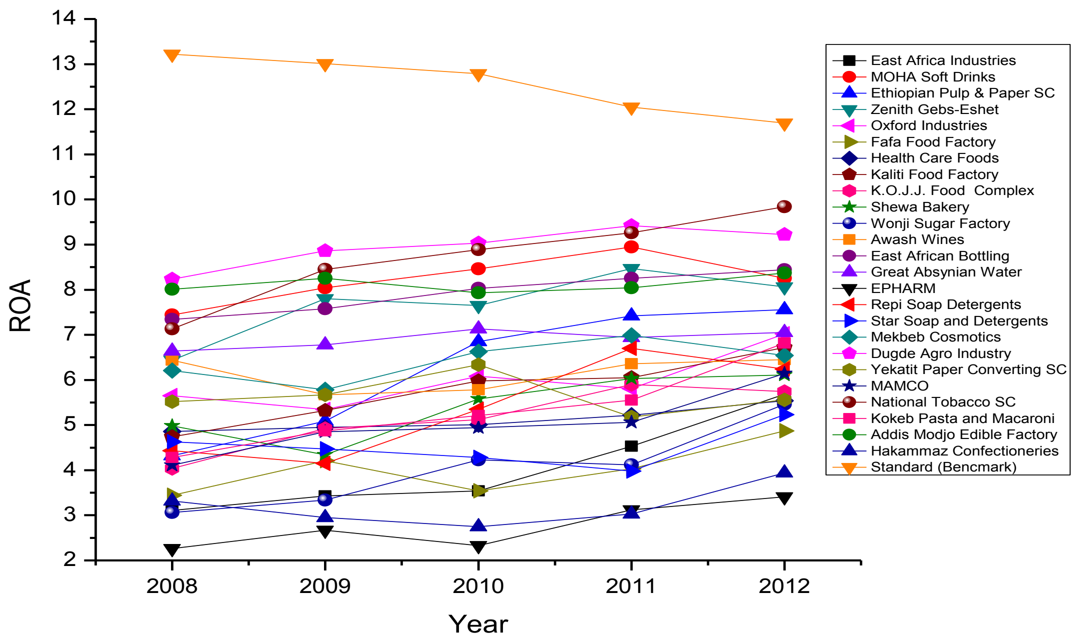

Figure 4. 7: Comparison of All Companies against Benchmarks

4.5.2. Revenue Growth Comparison

Regarding revenue growth, most of the companies in the leading SCs are hit by financial crisis of 2008 -2009 and the majority of them revealed negative growth where as Ethiopian SCs have shown a magnificent increase in their revenues. This is because institutively the crisis majorly hit the American companies (US is the source of that crisis). Figure 4.8 shows that the revenue growth of for some sample SCs against best-in-class SCs to show the positions of most of the SCs in Ethiopia. The complete comparison of all consumer SCs with the leading SCs is shown in the Figure 4.9. From Figure 4.9, one can infer that almost all companies' revenue growth is increasing consistently. Besides, it can be conferred that Ethiopian SCs are performing well with respect to this metric. It is also seen that MOHA Soft Drinks, East African Bottling, National Tobacco SC and Addis Modjo Edible Oil Factory showed a persistent increase in revenue growth and also comparable to the world class SC leaders performing the revenue growth of 10 on an average. Most SCs perform nearer to 7-9 growth in revenue and are not bad under this metric. Some SCs like Health Care Foods, Oxford Companies, Zenith Gebs-Eshet, and Star Soap and Detergents performed nearer to 3% increase in revenue on average and these SCs performed in a lesser extent compared to those within the SC found in the country. However, overall revenue growth of the benchmark showed a cyclical pattern due to uncertainties and risks mentioned earlier.

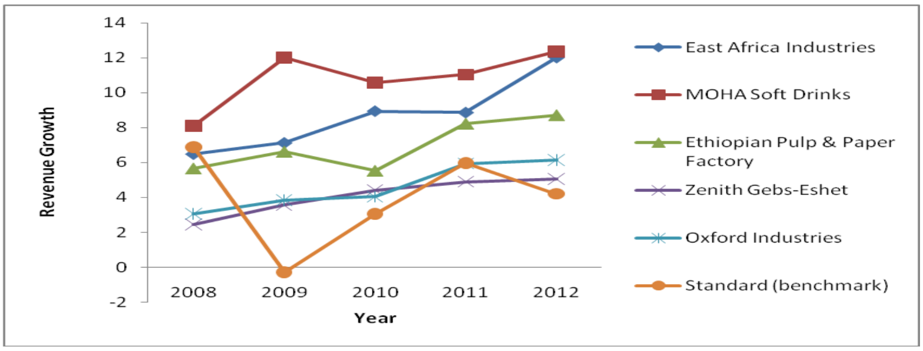

Figure 4. 8: Revenue Growth Comparison of Some Companies against Benchmarks

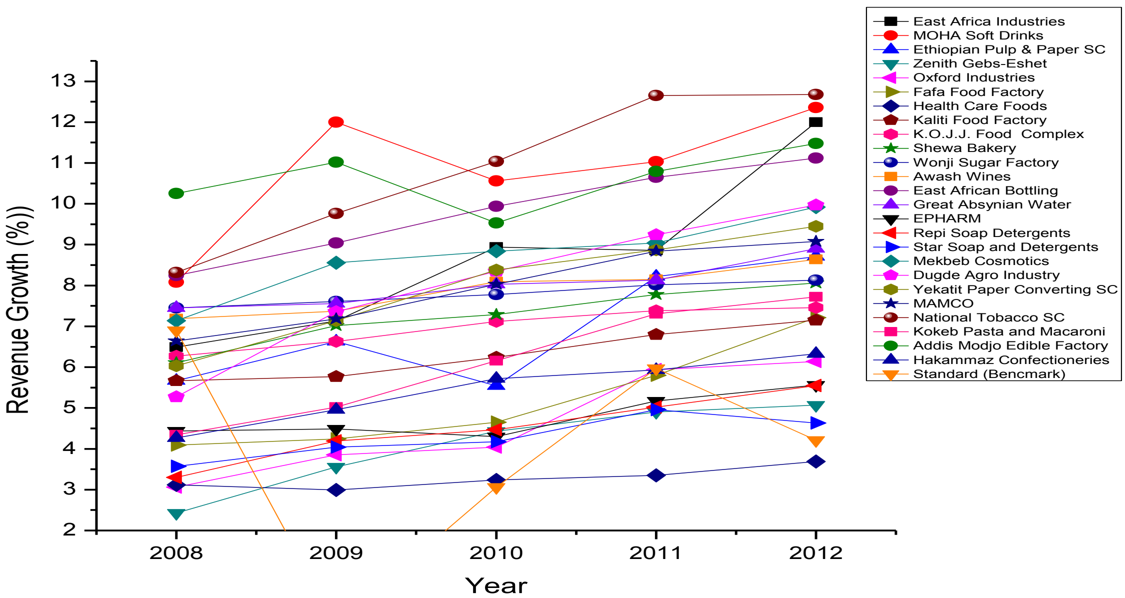

Figure 4. 9: Revenue Growth Comparison of All Companies against Benchmarks

4.5.3. Operating Margin Comparison

Figure 4.10 and 4.11 show a comparison of companies on operating margin. It is clearly seen from Figure 4.10 that the benchmark's operating profit is in a decreasing trend. But, for Ethiopian companies, again is in an increasing trend and the most efficient in operations and pricing strategies are National Tobacco SC, East African Bottling and Addis Modjo Factory performing about 12% operating margin on average. In contrary, companies like Repi Soap and Detergents, Fafa Food Factory, Star Soap and Detergents have lower values of operating margin. In this ratio, the Oxford Companies seems to be very stable through the overall years.

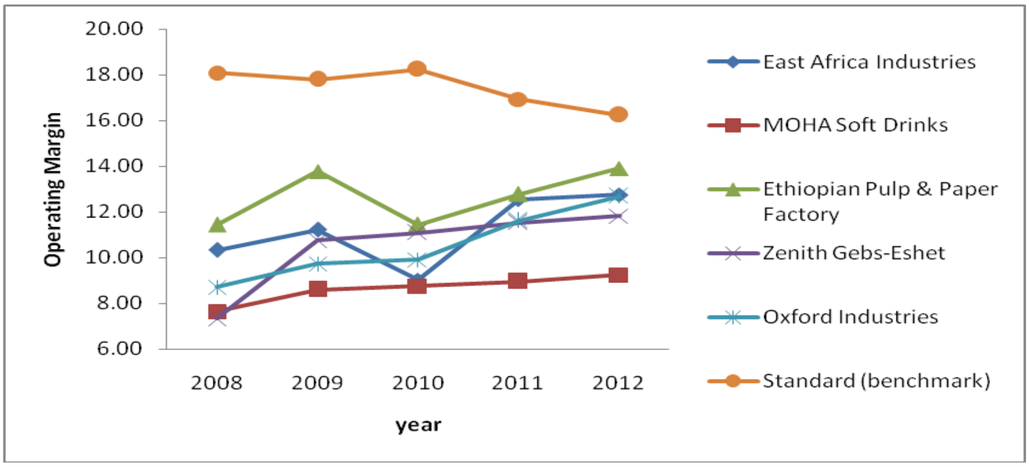

Figure 4. 10: Operating Margin Comparison of Some Companies against Benchmarks

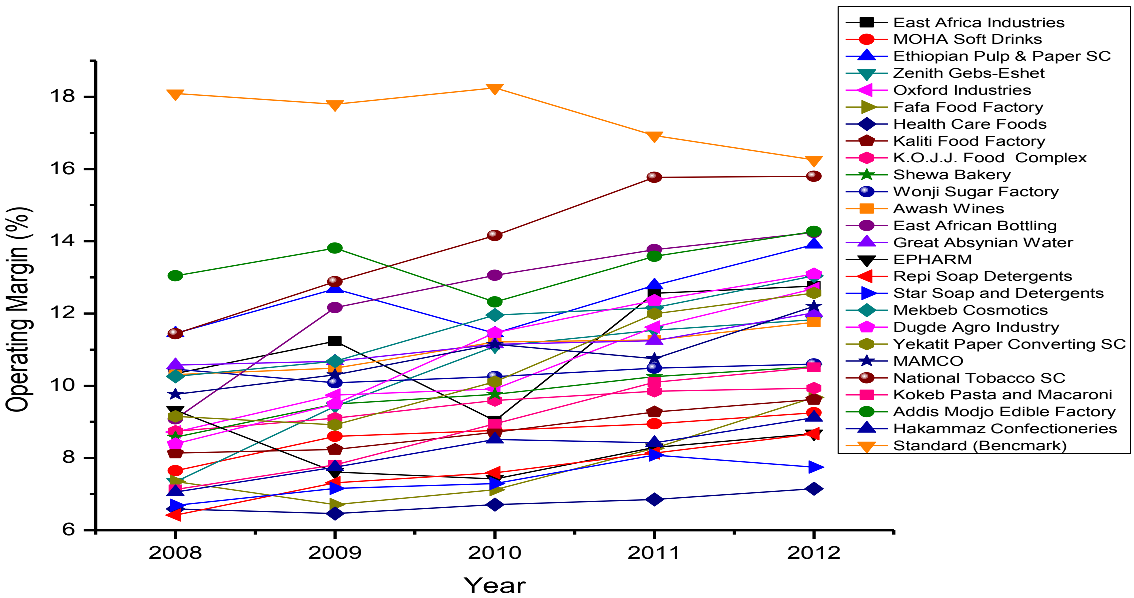

Figure 4. 11: Operating Margin Comparison of Companies against Benchmarks

4.5.4. Profit Margin Comparison

Figure 4.12 and Figure 4.13 tell us the companies' comparison based on the profit margin. Based on this premises and comparing with Figure 4.12 and Figure 4.13, it is shown that National Tobacco, Addis Modjo and East African Bottling had a remarkable profitability ratio even very closer to the world class performers. However, most personal cares and confectionery are the least profitable. In this margin, Ethiopian consumers SCs are seen competitive to the benchmarks. East African Companies is maintaining stable profit margin over the period and those of benchmarks are decreasing over the period.

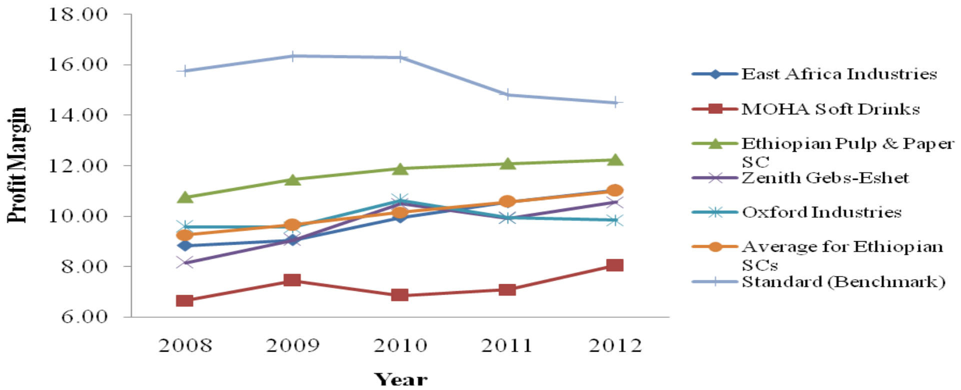

Figure 4. 12: Profit Margin Comparison of Some Selected Companies against Benchmarks

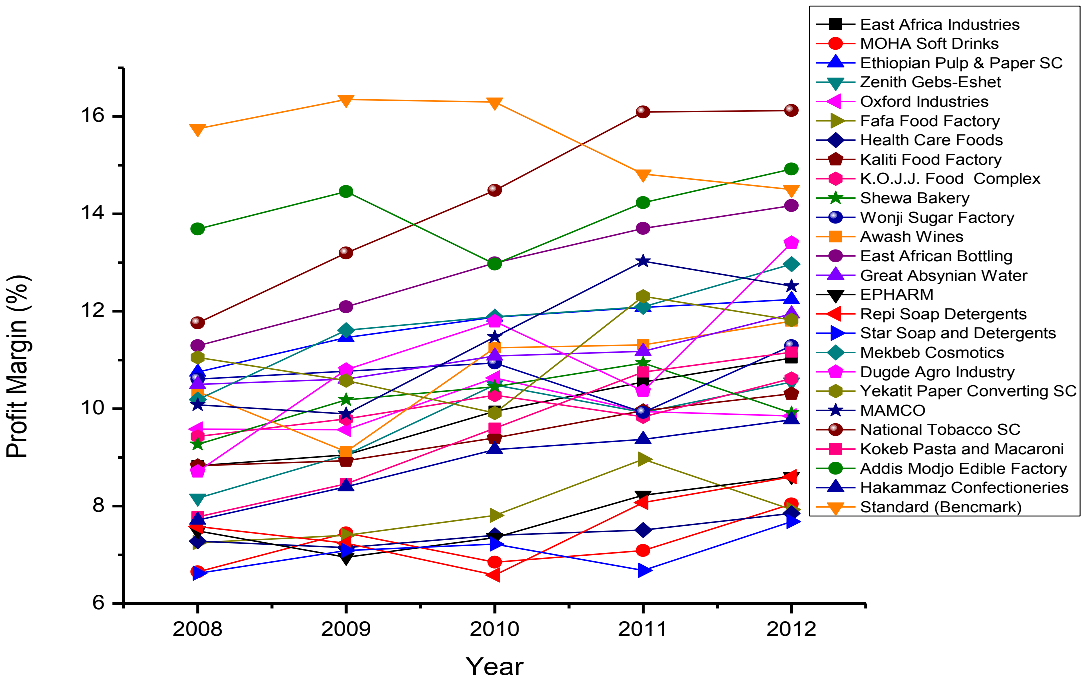

Figure 4. 13: Profit Margin Comparison of Companies against Benchmarks

4.5.5. Revenue per Employees Comparison

Finally, the revenue per employees shown in Figure 4.14 and 4.15 tells how productive the employers in each companies. In this particular case, no single Ethiopian SCs are closer to the benchmarks. This shows that most of the companies are unproductive. But comparing within the companies, East African Companies, East African Bottling and National Tobacco are the most productive with respect to their employees. Health Care Foods, MOHA Soft Drinks, Ethiopian Pulp and Paper SC, Addis Modjo and Star Soap and Detergents showed better productivity. Mekbib Cosmetics had the stable performance throughout the years. However, Shewa Bakery, Hakammaz Confectionaries, Kaliti Food factory and Yekatit Paper Converting SC are the least productive based on employee productivity.

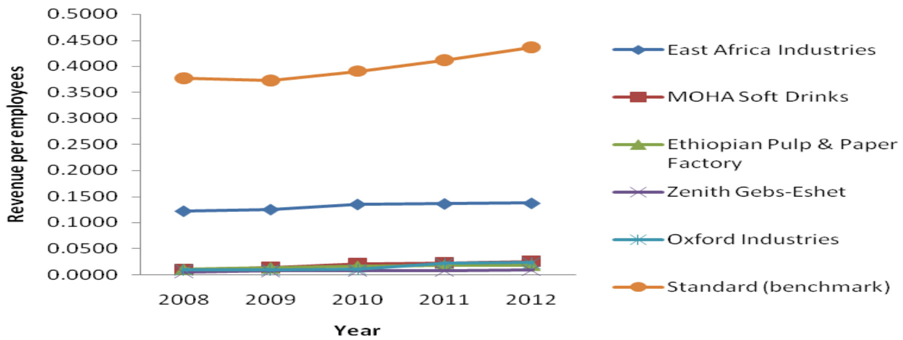

Figure 4. 14: Revenue per Employee Comparison of Some Companies against Benchmark

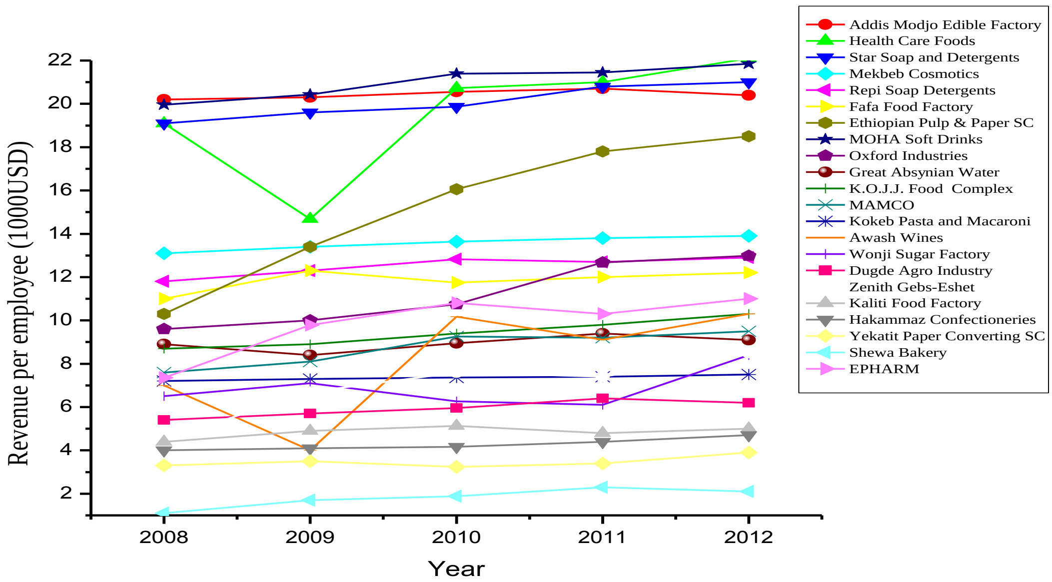

Figure 4. 15: Revenue per Employee Comparison of Companies against Benchmarks

4.6. Conclusions

Financial metrics are used to check the positions of Ethiopian FMCG companies. Based on ROA, revenue growth, operating margin, profit margin and revenue per employee, companies are compared with best companies of the world. The result shows that the Ethiopian SCs are performing well under revenue growth metric and low under revenue per employee metric. The SCs are also seen unproductive in their employee productivity compared to benchmarks. It canbe concluded that MOHA soft drink, Dugde Agro Company, National Tobacco SC, Ethiopian Pulp and Paper SC, Zenith Gebs-Eshet, and Addis Modjo Edible Oil Factory are the most efficient of the SCs. This result is supported by Wagner et al [2012] that ROA as the net income divided by total assets shows how effectively a firm utilizes its assets in generating profits. Looking into revenue growth, MOHA Soft Drinks, East African Bottling, National Tobacco SC and Addis Modjo Edible Oil Factory showed the greatest growth. Based on operating and profit margins, National Tobacco, Addis Modjo and East African Bottling are the effective and efficient SCs. It can be concluded also that East African Companies, East African Bottling and National Tobacco are the most productive in their employees. In general Tobacco and beverage SCs performs better under the SC measures against the benchmarks. However, personal care SCs are performing low compared to Tobacco and beverage SCs.

Chapter 5

Operational Metrics: An Empirical Study

"If you cannot measure it, you cannot control it. If you cannot control it, you cannot manage it. If you cannot manage it, you cannot improve it".

---Harrington

5.1. Introduction and Background of the Study

Identifying the proper SC practices and metrics is highly essential to check and balance the normal health condition of any organization. This chapter deals with the possible SC practices and metrics which are tested on 5 Ethiopian Alcohol and Liquor manufacturing SCs. The practices and metrics are derived from literature. To further clarify the SC metrics, questionnaire is designed and distributed to different levels of managers of the companies to formulate hypotheses. Using the data obtained, the significance of hypotheses is tested. For item reliability, Cronbach's alpha test was calculated to all items arranged in a five point Likert scale. It has been discussed in previous chapters that one of the problems regarding SCPM is not testing on the practical SCs. Hence, this chapter is aimed at seeking solution for the problems mentioned with special focus on operational metrics.

The general state of the Ethiopian economy was discussed under Section 4.1. Recently, the IMF report revealed that the manufacturing share of GDP is about 3.3% in 2013. The same trend but slightly increased share in GDP of manufacturing sub-sector for year 2014 also.

However, the share of service sector overtaken that of agriculture in recent years. For example, in 2013/14 the shares of services, agriculture and company stand at 46 percent, 40 percent and 14 percent, respectively, in contrast to 45 percent, 43 percent and 12 percent, respectively, in the preceding year. This shows that the industrial development in Ethiopia is still in its infant stage.

It is generally believed that the Ethiopian manufacturing companies are facing serious weaknesses and constraints hindering their productivity and competitiveness. According to the study made by Dandena [2000], these companies faced a wide variety of problems. Some of the problems faced are:

1. Poor market access
2. Lack of information and advice
3. Lack of premises and land
4. Shortage of raw materials
5. Lack of suitability to new technology
6. Problems regarding government rules and regulations

In some cases, for example, Berhane [2007] argued that most of the manufacturing companiesare plagued with the problems of low financial & managerial capacity, lack of machineries & facilities, shortage of highly qualified workers. Moreover, they have been seriously affected by under-capacity utilization and declining total resource productivity. Even though the contribution of the manufacturing sector to export earnings has increased over the last few years, considering the unutilized capacity, unexploited potential, and low market share of the manufacturing company, a lot remains to be done.

To mitigate the major problems mentioned in the above paragraph, Ethiopia devised Industrial Development Strategy. The Ethiopia's Industrial Development Strategy prioritizes the leather products, garment/textile, meat processing, construction, small and medium sized enterprise (SME), and IT companies [Van der Loop, 2003]. However, currently its field of export is getting backlash from the lack of proper SCM especially financial and product flows [Reporter Megazine]. In the other edition, the magazine reported that the export performance from manufacturing sector falls by more than 50%. The main reason for this failure as reported in the magazine was pointed to the SCM problem.

The current practices of Ethiopian manufacturing companies with regard to SCM is traditional in that, partners involved across the SC act independently in designing, developingand executing strategies with minimum effort made to align strategies with the partners particularly suppliers, wholesalers, distributors, and customers [Balada, 2011; Garoma, 2011]. Even if there is SC by default it is not well managed, and implemented for getting the benefits resulted from effective SCM. Each partner within the SC is using their own individual efforts to improve their own competitiveness (like, quality, cost, delivery lead time, and etc) rather than looking into the whole SC.

As also pointed out by Lissanwork [2013], the Ethiopian SC has several problems including non availability, unaffordability, lack of proper SC performance measures, poor storage, lack of stock management and financial issues. Besides, major manufacturing SCs lack proper quality management practices and measurements [Beshah, 2011]. Thus, the problems which contributed a lot towards the above limitations & backwardness of the sector should be rectified by implementing a SCM system on the manufacturing companies of Ethiopia. Among the manufacturing companies, the alcohol and liquor companies contributes a significant amount in the GDP share of industrial sector. In more than any other sector, alcohol and liquor sector is dominating in daily flow of products and finances. That is why the sector is selected for this particular problem.

Currently, there are around 16 large enterprises producing alcoholic beverages in Ethiopia. These can be classified into Beer (5 establishments), Wine (2 establishments) and Alcohol and Liquor (9 establishments) manufacturing companies as shown in Table 5.1.

Table 5. 1: Categories of Alcoholic Beverages in Ethiopia

Beer Breweries	**Wineries**	**Alcohol & Liquor Factories**
1. Abo Brewery	1. Awash	1. National Alcohol & Liquor SC
2. Harar Brewing	2. Gudar	2. Balezaf Alcohol and Liquor Factory PLC
3. Bedele Brewery		3. Silvana Testa
4. BGI Ethiopia		4. Molla Maru Liquor Factory
5. Dashen Brewery		5. Kokeb Liquor Factory
		6. Bissirat Liquor factory
		7. Awash brewery
		8. Asnake Liquors Company
		9. Desta Alchol and Liquor Factory

Among these, five cases- Balezaf Alcohol and Liquor Factory PLC, National Alcohol & Liquor SC, Kokeb Liquor Factory, Molla Maru Liquor Factory and Silvana Testa are selected for this study considering their maturity and size of the SCs.

It is mentioned in Chapter 1 of this thesis that the importance of SC is well recognized in developed countries. For example, according to State of Logistics Report during the year 2000, the US companies spent $1 trillion (10% of GNP) on supply-related activities (movement, storage, and control of products across SCs). It was also stated that the cost of SC is 20% of the total cost of manufactured goods. Hence eliminating inefficiencies can save huge amount of money. The projected would be greater proportion in the developing country like Ethiopia, where a large amount of capital is tied up in inventories and in transportation systems for moving materials. Ethiopia is one of the developing countries where more value is not given to increase customer service level and product expectation, which result in loss of customers that have large economical impact on the organization.

Even if the above chronic problems need the design and analysis of SCM, there is yet little framework to address SC practices and SC metrics to improve organizational performance and competitiveness in Ethiopia. Hence, this chapter addresses the SC performance measures using some SCM practices. SCM practices are defined as the set of activities undertaken by an organization to promote effective management of its SC. The practices of SCM are proposed to be a multi-dimensional concept, including the downstream and upstream sides of the SC [Li et al, 2006]. The SC practices are the values and experiences that are developed in the SCs to keep the SCM moving forward to attain the goals. The literature review regarding SCPM and SC practices has been presented already in Chapter 2.

The work includes both qualitative and quantitative data. The qualitative are converted into quantitative using the questionnaire method. Qualitative work involves a diagrammatic representation of interaction between individuals which enables concrete data to be collected, measured and compared with a standard. To summarize in short regarding the qualitative and quantitative methods, the work of Oghazi [2009] is considered here as an accepted definition. In this study, qualitative methods are used to collect information regarding the case under study and converted into quantitative using statistical methods. These methods include observations, interviews, questionnaires and reports to investigate and analyse the SC performance metrics and practices and to apply on alcohol and liquor SCs in Ethiopia.

5.2. Brief Background of Alcohol and Liquor Supply Chains

Most of the factories own their own fermentation facilities. Using the raw materials all factories distil to produce pure and denatured alcohols. The secondary process (liquor production and packaging) is similar for most of the factories. Most of the factories use similar upstream process. Most of them purchase the majority of raw materials within the country. Some rugged sizes containing additives and flavours are purchased from abroad. These factories use different distribution mechanism. The final outcome will be reaching differentiated customers throughone or all of the distribution channels as shown in the Figure 5.1.

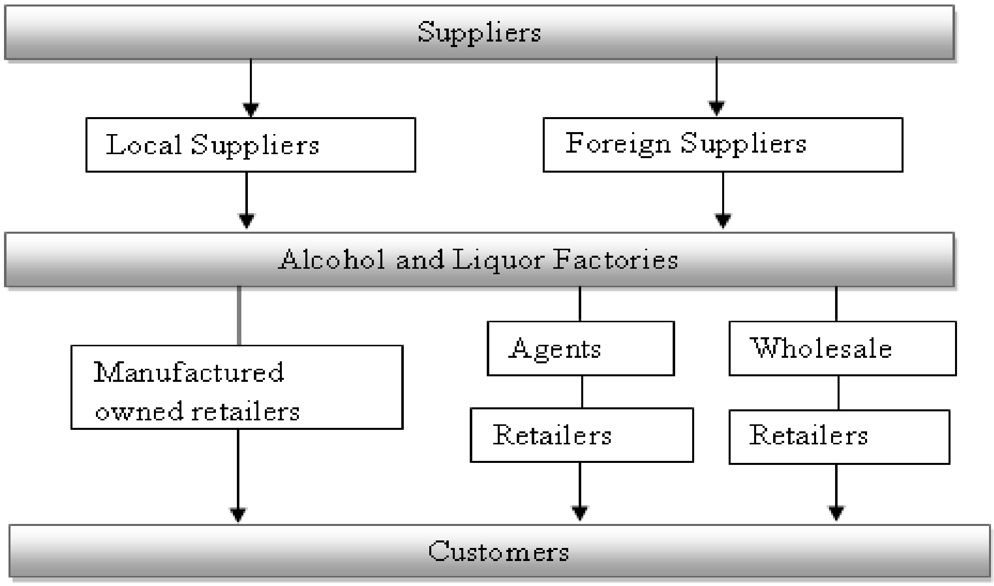

Figure 5. 1: Alcohol and Liquor Factories Supply Chain

5.3. Research Methodology

In line with previous research in the field of SCM, this study also measures firms' SC performance using the respondent's perception of performance in relation to major company competitors. Respondents were asked to indicate, using a five-point Likert scale (1 = very low, 2=low,3=average,4=high and 5 = very high), the extent of the 8 qualitative SC practices and Likert scale (1=Strongly disagree, 2= disagree,3=moderate, 4= agree and 5= strongly agree), the extent of the 6 qualitative SC metrics.

5.3.1. Sample, Population and Participant

The persons who were well informed about the topics asked in their respective organizations are chosen as respondents to achieve reliable data. The target respondents within each company were managers whose work directly affects SCM Practice. Thus, the survey instrument has been given to 45 middle line managers responsible for SCM in their organizations- operation managers, purchasing and supply managers, marketing managers, Information System officers and inventory managers. Middle-line managers were chosen for this study because they are the executors of strategic decisions. They effectively implement SC practices in their organization. They also interact with top management in laying out the SC plans.

Nine questionnaires were distributed to each organization. In terms of response rate, 33 out of 45 (Balezaf Liquor Factory (BALF) 8, Silvana Testa (ST) 6, National Alchohol and Liquor Factory SC (NALFSC) 6, Maru Molla Liquor factory (MMLF) 7, and Kokeb Liquor factory (KLF) 6) responded which is nearer to 60% response rate. Hence the response rate here is considered much higher to that of Forza's [2002] claim of 20% response rate.

5.3.2. Research Instrument

Figure 5.2 shows the overall instrument development process that is used in the chapter according to the problem constructs. The variables under each of the constructs are identified from literature and evaluated to use in developing the initial instruments to measure the constructs. After the initial instruments are identified, pre-testing them, developing content/face validity and refined, the inclusive data is gathered depending on the instruments (instruments includes both the structured and unstructured questionnaires). Finally the data are tested for construct validity, uni-dimensionality, consistency and reliability using different analysis tools and software.

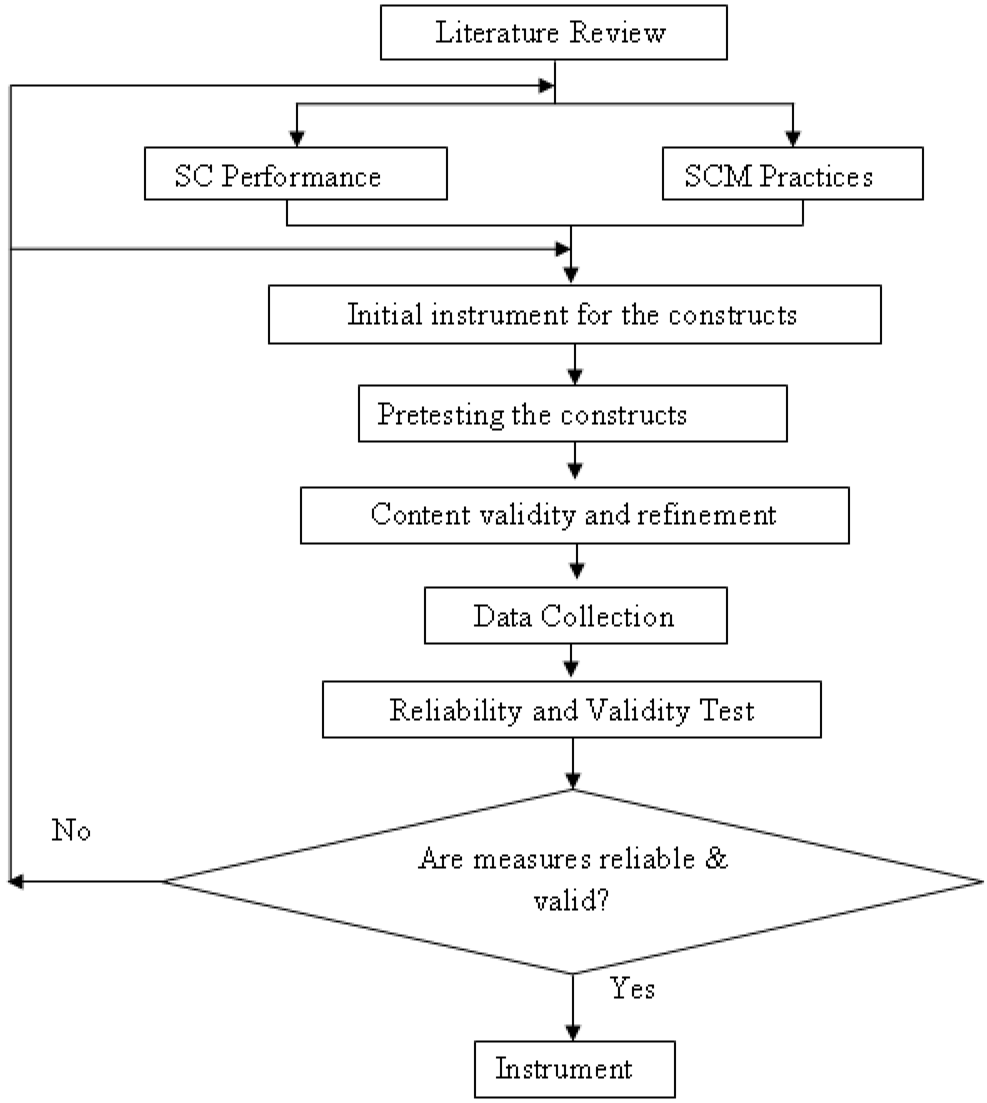

Figure 5. 2: The Instrument Development Process

5.3.3. Data Analysis, Validity and Reliability

Since the questions are derived from an extensive literature review the measures are generally considered to have content validity. For item reliability, Cronbach's alpha test was calculated to all items arranged in a five point Likert scale. The overall Cronbach's alpha for items is 0.713 and the test result shows the reliability of the items. The data obtained through questionnaire are analysed using descriptive statistics. For the purpose of descriptive analysis, for each and every item the mean value was calculated for each firm under study. The mean value was computed by adding the response of managers within each firm and dividing it by the number of the respondents in that firm. Thus, the result has been considered as the performance of a given firm in SC in that particular practice/metric. In addition, Analysis of Variance (ANOVA) was performed using SPSS software to compare the mean SCM performance differences among the case firms. In the analysis, the term group was used to represent firm. Thus, five groups indicate five firms selected for the study.

Data obtained through questionnaire with respect to the practice 'frequent introduction of new products and improvement of existing models', and analysis there off is presented below as an illustration

SC Practice: Frequent introduction of new products and improvement of existing models

Firm	**N**	**Responses**	**Mean**	**Std. Dev.**	**Std. Error**	**95% Confidence Limits for Mean**	
						Lower Bound	**Upper Bound**
NALF	6	1, 2, 1, 1, 2, 2	1.5	1.23	0.5	0.21	2.79
BALF	8	3, 3, 3, 3, 3, 4, 3, 3	3.13	0.99	0.35	2.3	3.95
ST	6	4, 4, 4, 3, 4, 4	3.83	1.33	0.54	2.44	5.23
MMLF	7	3, 3, 4, 2, 3, 4, 4	3.29	0.76	0.29	2.59	3.98
KLF	6	4, 4, 3, 4, 4, 3	3.67	0.82	0.33	2.81	4.52
Total	33		3.09	1.26	0.22	2.64	3.54

ANOVA for 'frequent introduction of new products and improvement of existing models'

Source	Sum of Squares	DOF	MSS	F-Calculated	Significance Level
Between Groups	20.757	4	5.189	4.848	0.004
Within Groups	29.970	28	1.070		
Total	50.727	32			

Degrees of freedom (DOF) for 'between groups is 5-1=4 as there are 5 firms. Since there are a total of 33 responses, total DOF is 33-1=32. DOF for 'within groups' or 'error' is 32-4=28. F-ratio is obtained by dividing mean sum of squares (MSS) of 'between groups' with 'within groups'. Significance level represents the probability of getting an F value larger than the obtained value of F by chance. A cut-off significance level (α) of 0.05 is considered as is the usual practice. When $p<\alpha$, the event is considered rare, and this in turn means that null hypothesis – there is no difference among firms in their SC practice/metric – has to be rejected (or) not accepted. In that case there is, at most, α chance that the decision will be wrong.

5.4. Results and Discussions

5.4.1. Internal Operation Practices and Flexibility

Descriptive Analysis

Results obtained from descriptive analysis of data are presented in Table 5.2. Since average performance is given a weight of 3, mean value below 3 means inferior performance and mean value above 3 means better performance.

In the case of frequent introduction of new products and improvement of existing models, an overall mean of 3.09 was reported, which shows unsatisfactory level of the practice. However, to rank firms performance level in the practice requested, Selvana Testa (ST) was better in its experience related to new product introduction with a mean of 3.83, followed by Kokeb Liquor Factory (KLF) with mean of 3.67, Molla Maru Liquor Factory (MMLF) with a mean of 3.29 and Balezaf Alcohol and Liquor Factory (BALF) with a mean of 3.13. However, National Alcohol and Liquor Share Company (NALFSC) is in a lower level in its new product development practices with a mean of 1.50 which significantly affected the overall mean.

In the case of production process up-to-datedness, the respondents reported an overall mean of 3.12, which is not satisfactory for organizations who operate in a dynamic business environment. However, it was rated higher by MMLF with a mean value of 3.71, followed by KLF and ST with mean of 3.67 and 3.33 respectively; while, BALF and NALFSC take the least in this practice with mean values of 2.63 and 2.33 respectively.

In regard to material and product flow management, an overall mean of 3.48 was revealed, which shows a slightly better internal material flow management for main products; where, ST was rating it in higher level with a mean of 3.88, followed by MMLF with a mean of 3.71 and KLF with a mean of 3.50. In addition, BALF was slightly better than average with a mean of 3.38, while NALFSC reported a mean of 3.00, i.e., average performance. From the overall mean it is clear that, these case firms are better in internal material flow management.

Regarding flexibility of production system to handle order pattern, although the overall mean value of 3.67 was revealed, it was rated in a higher level by MMLF at a mean of 4.29, which indicate its production system flexibility to serve any kind of order from customers. ST and BALF are second and third in their level of flexibility with 4.17 and 3.88 respectively.

However, NALFSC was rating its mean at an average level; while, lower practice level was reported by KLF at a mean of 2.83, which shows that, there is a low level of flexibility in firms reported below average, which can reduce their capacity to address different order pattern.

In terms of Made-to-Stock production, the overall mean was identified as 3.27. BALF was rating this practice in a better than average level at a mean of 3.63 followed by MMLF with a mean of 3.57, and KLF with a mean of 3.50. It was also indicated that NALFSC is at an average level in its Made-to-stock production with a mean of 3.00; in addition, ST was in a lower level at a mean of 2.5. The result from the overall mean revealed that firms did not give sufficient attention to Made-To-Stock production which is related with producing standardized product for inventory and customer will be served from the available inventory.

MTO production performance is rated in the overall higher mean of 4.06. ST was in a very high level of MTO production with a mean of 4.83 which can be interpreted as they are able to serve customers individualized need when ordered, it was followed by MMLF a mean of 4.71, and BALF with a mean of 4.13. However, KLF and NALFSC not scored a higher level, as the other firms are, with means of 3.50 and 3.00 respectively.

In regard to production process automation, the overall mean of 3.12 was reported, which shows the low level of computerized equipment utilization in the production process of the case firms. However, MMLF has a higher level of automation in its production process with a meanof 4.14, followed by NALFSC and KLF whose practice level is at an average level with a mean of 3.00, while, BALF and ST reported a lower level of process automation with a mean of 2.75 and 2.63 respectively. It can be understood from the result that except MMLF all firms are not goodat implementing production process automation.

In terms of modular system application, the overall mean of slightly better than average was reported. MMLF was good in its modular system application for production with a mean of 3.86, it is considered as a good practice for firms like MMLF to concentrate on modular design if they preferred an MTO production system, in order to reduce cost of production. And it was followed by KLF with a mean of 3.67 and BALF with a mean value of 3.25 while NALFSC reported a slightly better than average mean value of 3.17. However, ST is in a lower level of this practice with a mean value of 2.67, which wouldn't be favourable for firms who rely on MTO production such as ST, to set modular system aside, since the cost of producing each design will be aggravated.

Table 5. 2: Descriptive Statistics Significance of SC Practice and Flexibility of the Supply Chains

SC Internal Practice	**Firms**	**N**	**Mean**	**Std. Dev.**	**Std. Error**	**95% Confidence for Mean**	
						Lower Bound	**Upper Bound**
1) frequent introduction of new products and improvement of existing models	NALF	6	1.5	1.23	0.5	0.21	2.79
	BALF	8	3.13	0.99	0.35	2.3	3.95
	ST	6	3.83	1.33	0.54	2.44	5.23
	MMLF	7	3.29	0.76	0.29	2.59	3.98
	KLF	6	3.67	0.82	0.33	2.81	4.52
	Total	33	3.09	1.26	0.22	2.64	3.54
2) up-to-datedness of production process	NALF	6	2.33	0.82	0.33	1.48	3.19
	BALF	8	2.63	0.52	0.18	2.19	3.06
	ST	6	3.33	0.82	0.33	2.48	4.19
	MMLF	7	3.71	0.95	0.36	2.83	4.59
	KLF	6	3.67	0.82	0.33	2.81	4.52
	Total	33	3.12	0.93	0.16	2.79	3.45
3) internal material and product flow management for main product	NALF	6	3	0	0	3	3
	BALF	8	3.38	0.74	0.26	2.75	4
	ST	6	3.83	0.41	0.17	3.4	4.26
	MMLF	7	3.71	0.49	0.18	3.26	4.17
	KLF	6	3.5	0.55	0.22	2.93	4.07
	Total	33	3.48	0.57	0.1	3.28	3.69
4) flexibility of production system to handle order pattern	NALF	6	3	0	0	3	3
	BALF	8	3.88	1.25	0.44	2.83	4.92
	ST	6	4.17	0.75	0.31	3.38	4.96
	MMLF	7	4.29	0.76	0.29	3.59	4.98
	KLF	6	2.83	0.41	0.17	2.4	3.26
	Total	33	3.67	0.96	0.17	3.33	4.01
5) the extent of made to stock production	NALF	6	3	0	0	3	3
	BALF	8	3.63	1.51	0.53	2.37	4.88
	ST	6	2.5	0.55	0.22	1.93	3.07
	MMLF	7	3.57	0.79	0.3	2.84	4.3
	KLF	6	3.5	0.55	0.22	2.93	4.07
	Total	33	3.27	0.94	0.16	2.94	3.61
6) the extent of made to order production	NALF	6	3	0	0	3	3
	BALF	8	4.13	0.99	0.35	3.3	4.95
	ST	6	4.83	0.41	0.17	4.4	5.26
	MMLF	7	4.71	0.49	0.18	4.26	5.17
	KLF	6	3.5	0.55	0.22	2.93	4.07
	Total	33	4.06	0.9	0.16	3.74	4.38
7) the extent of production automation for main product	NALF	6	3	0	0	3	3
	BALF	8	2.75	0.71	0.25	2.16	3.34
	ST	6	2.67	1.51	0.62	1.09	4.25
	MMLF	7	4.14	0.38	0.14	3.79	4.49
	KLF	6	3	0.63	0.26	2.34	3.66
	Total	33	3.12	0.93	0.16	2.79	3.45
8) the extent of modular system application for production	NALF	6	3.17	0.41	0.17	2.74	3.6
	BALF	8	3.25	1.04	0.37	2.38	4.12
	ST	6	2.67	1.51	0.62	1.09	4.25
	MMLF	7	3.86	0.9	0.34	3.03	4.69
	KLF	6	3.67	0.82	0.33	2.81	4.52
	Total	33	3.33	1.02	0.18	2.97	3.7

ANOVA

ANOVA results for internal practices and flexibility measures are shown in Table 5.3. It can be observed that, with a 5% significance level, null hypotheses one and two are not accepted, since, these five firms significantly differ with the practices related to frequent introduction of new product and improvement of existing design (F(4, 28)=4.848, P=0.004) and up-to-datedness of production system (F(4, 28)=4.131, P=0.009). However, null hypothesis three is accepted because there is no significant difference identified among firms in regard to internal material flow management (F(4, 28)=2.388, P=0.075). Nevertheless, hypothesis four is not accepted due to the fact that firms significantly differ in their flexibility of production system to handle order pattern (F(4, 28)=4.426, P=0.007). With 5% significance level, hypotheses five and eight are accepted because there is no significance difference identified among firms with respect to made-to-stock production (F(4, 28)=1.846, P=0.148) and modular system application (F(4, 28)=1.376, P=0.267). However, surveyed firms significantly differ in hypotheses six and seven, i.e., made-to-order production F(4, 28)=10.030, P=0.00) and production process automation for main products (F(4, 28)=3.888, P=0.012), and accordingly hypothesis six and seven are not accepted and hypothesis eight is accepted. The conclusions are summarized in Table 5.4.

Table 5. 3: ANOVA Results for Internal Operations and Flexibility Variables from Questionnaire

Variables		Sum of Squares	DOF	MSS	F	Significance Level
1) frequent introduction of new products and improvement of existing models	Between Groups	20.757	4	5.189	4.848	0.004
	Within Groups	29.970	28	1.070		
	Total	50.727	32			
2) up-to-datedness of production	Between Groups	10.212	4	2.553	4.131	0.009
	Within Groups	17.304	28	0.618		
	Total	27.515	32			
3) internal material and product flow management for main product	Between Groups	2.606	4	0.651	2.388	0.075
	Within Groups	7.637	28	0.273		
	Total	10.242	32			
	Between Groups	11.363	4	2.841	4.426	0.007
4)Flexibility of production system to handle order pattern	Within Groups	7.637	28	0.273		
	Total	10.242	32			
5) the extent of made to stock production	Between Groups	5.956	4	0.148	1.846	0.148
	Within Groups	22.589	28	0.807		
	Total	28.545	32			
6) the extent of made order production	Between Groups	15.242	4	3.810	10.030	0.000
	Within Groups	10.637	28	0.380		
	Total	25.879	32			
7) the extent of production process automation for main product	Between Groups	9.825	4	2.456	3.888	0.012
	Within Groups	17.690	28	0.630		
	Total	27.515	32			
8) the extent of modular system application for production	Between Groups	5.476	4	1.369	1.376	0.267
	Within Groups	27.857	28	0.395		
	Total	33.333	32			

Table 5. 4: Conclusion in Relation to Internal Operations

Hypothesis HO: There is no performance difference among the selected five alcohol and liquor manufacturing organizations in the Following Internal Operation practices	**ANOVA Among Firms**		
	Significance	**F-Calculated**	**Decision**
HO : frequent introduction of new products and improvement of existing models	0.004	4.848	Not accepted
HO : up-to-datedness of production	0.009	4.131	Not accepted
HO :internal material and product flow management for main product	0.075	2.388	Accepted
HO : flexibility of production system to handle order pattern	0.007	4.426	Not accepted
HO : the extent of made to stock production	0.148	1.846	Accepted
HO : the extent of made to order production	0	10.03	Not accepted
HO : the extent of production process automation for main product	0.012	3.888	Not accepted
HO : the extent of modular system application for production	0.267	1.376	Accepted

Significance level (α) = 0.05

5.4.2. Supply Chain Performance Metrics

Descriptive Statistics

Results obtained from descriptive analysis of data are presented in Table 5.5. With regard to faster delivery of products and service to customers in comparison with competitors, firms reported an overall mean of 3.52. MMLF performed better in its faster delivery performance compared with its competitors with a mean of 3.71. The second in faster delivery performance was ST with a mean of 3.67 followed by BALF and KLF with mean values of 3.63 and 3.5 respectively. However, the performance of NALFSC was moderate at a mean of 3.00. In regard to on-time delivery performance, overall mean of 3.70 was revealed. Furthermore, MMLF was in a higher on-time delivery performance with a mean of 4.29, followed by ST and KLF equally with a mean of 3.67 and BALF with a mean of 3.63, whereas, NALFSC was slightly better than average with a mean of 3.17. In terms of product and service quality, it is shown that ST has a very higher level of quality performance with a mean of 4.83 followed by NALFSC, BALF, MMLF and KLF with mean values of 4.00, 3.88, 3.71 and 3.67 respectively. A higher cost reduction performance was reported by NALFSC with a mean of 4.00 followed by MMLF and KLF with mean values of 3.86 and 3.83 respectively. However, lower performance was also indicated by BALF and ST with means of 2.63 and 2.17 respectively. In terms of damage reduction, it can be observed that, ST was in a better position with a mean of 4.17 at reducing damage in the order to customers, followed by MMLF, BALF and NALFSC with mean values of 4.14, 3.88 and 3.17 respectively. A lower performance level (2.83) was reported by KLF. Regarding responsiveness to customer order, both ST and MMLF reported a higher level of performance with a mean value of 4.00, followed by BALF and KLF with mean values of 3.88 and 3.50 respectively. However, NALFSC performed a lower level of responsiveness with a mean of 2.17.

Table 5. 5: Descriptive Statistics of SC Metrics for the Supply Chains

SC Performance Metrics	**Firms**	**N**	**Mean**	**Std. Dev**	**Std. Error**	**95% Confidence Interval for Mean**	
						Lower Bound	**Upper Bound**
1) we deliver our products and services faster than our competitors	NALF	6	3	0	0	3	3
	BALF	8	3.63	0.52	0.18	3.19	4.06
	ST	6	3.67	0.52	0.21	3.12	4.21
	MMLF	7	3.71	0.76	0.29	3.02	4.41
	KLF	6	3.5	0.55	0.22	2.93	4.07
	Total	33	3.52	0.57	0.1	3.31	3.72
2) our on-time delivery performance is better than our competitor	NALF	6	3.17	0.41	0.17	2.74	3.6
	BALF	8	3.63	0.52	0.18	3.19	4.06
	ST	6	3.67	0.52	0.21	3.12	4.21
	MMLF	7	4.29	0.49	0.18	3.83	4.74
	KLF	6	3.67	0.52	0.21	3.12	4.21
	Total	33	3.7	0.59	0.1	3.49	3.9
3) our product and service quality is better than our competitors	NALF	6	4	0	0	4	4
	BLF	8	3.88	0.35	0.13	3.58	4.17
	ST	6	4.83	0.41	0.17	4.4	5.26
	MMLF	7	3.71	1.11	0.42	2.69	4.74
	KLF	6	3.67	0.52	0.21	3.12	4.21
	Total	33	4	0.71	0.12	3.75	4.25
4) our operating costs are lower than our competitors	NALF	6	4	0	0	4	4
	BALF	8	2.63	0.52	0.18	2.19	3.06
	ST	6	2.17	0.41	0.17	1.74	2.6
	MMLF	7	3.86	1.07	0.4	2.87	4.85
	KLF	6	3.83	0.41	0.17	3.4	4.26
	Total	33	3.27	0.94	0.16	2.94	3.61
5) no damage in the order to the customer	NALF	6	3.17	0.41	0.17	2.74	3.6
	BALF	8	3.88	0.35	0.13	3.58	4.17
	ST	6	4.17	0.41	0.17	3.74	4.6
	MMLF	7	4.14	1.22	0.46	3.02	5.27
	KLF	6	2.83	0.41	0.17	2.4	3.26
	Total	33	3.67	0.82	0.14	3.38	3.96
6) responsiveness to the customer orders	NALF	6	2.17	0.41	0.17	1.74	2.6
	BALF	8	3.88	0.35	0.13	3.58	4.17
	ST	6	4	0	0	4	4
	MMLF	7	4	0.82	0.31	3.24	4.76
	KLF	6	3.5	0.55	0.22	2.93	4.07
	Total	33	3.55	0.83	0.15	3.25	3.84

ANOVA

ANOVA results are presented in Table 5.6. It can be identified that with a 5% significance level, except the first null hypothesis all other hypothesis are not accepted. That is, there is no significant difference among surveyed firms with respect to delivery of products faster than own competitors ($F(4, 28)=1.811$, $P=0.155$). However, there is significant difference among the firms in terms of on-time delivery to customer, product and service quality, operating cost reduction, damage to customer order and responsiveness. The conclusions are tabulated in Table 5.7.

Table 5. 6: ANOVA Results for Supply Chain Performance Variables from Questionnaire

SC Performance Metrics		Sum of Squares	DOF	MSS	F	Significance Level
1) we deliver our products and services faster than our competitor	Between Groups	2.106	4	0.526	1.811	0.155
	Within Groups	8.137	28	0.291		
	Total	10.242	32			
2) our on-time delivery performance is better than our competitor	Between Groups	4.166	4	1.042	4.286	0.008
	Within Groups	6.804	28	0.243		
	Total	10.97	32			
3) our product and service quality is better than our competitors	Between Groups	5.53	4	1.382	3.697	0.015
	Within Groups	10.47	28	0.374		
	Total	16	32			
4) our operating costs are lower than our competitors	Between Groups	18.147	4	4.537	12.22	0
	Within Groups	10.399	28	0.371		
	Total	28.545	32			
5) no damage in the order to the customer	Between Groups	9.101	4	2.275	5.208	0.003
	Within Groups	12.232	28	0.437		
	Total	21.333	32			
6) responsiveness to customer order	Between Groups	14.973	4	3.743	14.54	0
	Within Groups	7.208	28	0.257		
	Total	22.182	32			

Table 5. 7: Conclusions from ANOVA in Relation to Supply Chain Performance

Hypothesis	**ANOVA Among Firms**		
HO: There is no difference among these five Large and Medium size alcohol and liquor manufacturing organizations in the Following SC performances	**Significance**	**F-calculated**	**Decision**
HO : we deliver our products and services faster than our competitors	0.155	1.811	Accepted
HO : our on-time delivery performance is better than our competitor	0.008	4.286	Not accepted
HO : our product and service quality is better than our competitors	0.015	3.697	Not accepted
HO : our operating costs are lower than our competitors	0	12.215	Not accepted
HO : no damage in the order to the customer	0.003	5.208	Not accepted
HO : responsiveness to customer order	0	14.541	Not accepted

Significance level (α) = 0.05

5.5. Conclusions

The supply, manufacture and distribution of alcoholic beverages in general and alcohol and liquor in particular in Ethiopia are significant as the large percentage of the nation of 90 million consume alcohol on daily base. Even though, the SC of these beverages is typical, it is difficult to conclude the overall SC practices and metrics of Ethiopian manufacturing SCs because of small sample size. However, overcoming those limitations, the conclusion for this chapter is drawn. As revealed in the study, each firm has had different performance level in implementing those SCM practices and metrics.

The results also indicated that, with 5% significance level, firms significantly vary in their new product development, flexibility of production process, the extent of made to order production and production process automation. Due to this fact, the null hypotheses for the above practices are not accepted. Whereas null hypotheses related to internal material flow management, made to stock production and modular system application for production are accepted because of the no significance difference identified among surveyed firms. It was also discovered that, these five alcohol and liquor companies significantly differ in all SC performance metrics except, the first hypothesis which claims, faster delivery service to customer in comparison with their competitors, thus all null hypotheses except the first one were not accepted. Regarding the best performance of firms under study, the scholar finally arrived at the following conclusion from the analysis.

It can be also concluded that NALFSC is good at SC performance related to customer aspects and delivering products on-time to customers. MMLF's efforts exerted to develop new products and improve the existing design and to make their production process flexible to handle order pattern is also appreciably good. ST's production process they implemented is up-to-date which help them to better adopt with the changing business environment. BALF performed well in its flexibility to handle order pattern. Finally, KLF' new product development function and the flexibility of its production process to handle different order from customers are good.

To cross check the accuracy of the information given by the respondents, the financial metrics of each firm are referred briefly. It is observed that firms under study performed well in their financial performance. As operational performance drives financial performance, it can be said that the better the operational performance, the better is their financial performance. For example, NALF's on time delivery performance may have impact on increased revenue growthof about 11% in 2013. MMLF's effort to develop new product and improve the existing design might have increased its ROA to 8% in the same year. The same is true for ST to its adaptation to changing business environment. BALF's performance to handle different customer order pattern may be considered as a reason for its profit margin of 11%. The same is true for KLF's performance of new product development function and flexibility of its production process. In general these firms are in better position in their financial performances against other Ethiopian manufacturing companies. Hence, the responses may be taken as a cross check against biased reporting of their company's performance.

Chapter 6

Performance Modelling and Simulation using System Dynamics Approach

"Always model a problem. Never model a system."
---John Sterman

6.1. Introduction

Every business sees its processes and strategies in order to improve its performance. Different strategies are tested in different regions of the world to improve their performance. Six-Sigma, just-in time, total quality management, business process re-engineering, Toyota's production system, total preventive maintenance, etc are implemented in the companies. But, it is getting difficult to solve companies' problems by these strategies alone since today customers need variety of products and services at lowest cost with highest delivery speed. Since organizational links currently are involving series of companies to meet the supply-demand, SCM stands as the potential remedy. To meet and exceed customer's expectations, it is necessary to properly design firm's internal processes as well as the SC processes, including upstream and downstream partners.

In the manufacturing SC, because of the emerging economic nations, the competition in between the SCs is becoming fierce. Manufacturing in developing nations like China, Mexico, Brazil, India, South Africa, Ethiopia, etc are increasing in volume and quantity so that they need further market places in other regions of the world. Besides, the cost of labour and capital in these developing nations is lower than those in developed nations. As more number of manufacturing companies (multinational and transnational companies) migrated, especially, to Ethiopia, due to the supply and demand balances, the complexity of the SCs increases. Besides, due to import-export of raw materials, semi-finished products, and final goods from and to their manufacturing firms, the control over their overall SC performance is complex. This complexity inhibits the managers from assessing the performance improvements of their own SCs from their competitors. This is because the complexity of the relation between metrics is difficult for the managers for visibility and performance improvement.

However, to make use of clear understanding of the function and performances of the SCs in the manufacturing, it is a must to start with the internal supply chains (ISC) consisting of procurement, production and distribution process. The nature of ISC is discussed in Chapter 1 of the thesis. The study in this chapter uses the causal loop diagram for hypothesizing the dynamic relationship between the system performances and system behaviours. Then using stock and flow diagram in order to understand and relate physical variables accumulations and flows. Employing mathematical models and system dynamics (SD) software, Vensim®, the interrelationships between the variables are shown. Besides, improvement strategies in SC performances are compared and proposed.

The improvement strategies using pure push, push-pull and pure pull are evaluated distinctively using manufacturing SC in Ethiopia as a case study. Large number of researches are available on the push-pull strategies in the SC (For example, Olhager and Ostlund, 1990; Olhager, 2000; Hopp, 2003; Corniani, 2008). To locate the demand point in the SC, simulation is applied. One of the main objectives of SC simulation is reproducing and testing different decision-based alternatives among others [Campuzano and Mula, 2011]. Simulation in a SC plays an important role, above all for its main property to provide what-if analysis and to evaluate quantitative benefits and issues deriving from operating in a co-operative environment rather than playing a pure transaction role with the upstream/downstream tiers [Terzi and Cavalieri, 2004]. In a dynamic business environment a notion of time is of utmost important as contract parameters, relationship types, and business environment parameters will change over time. As a consequence, analytical models are often inappropriate due to the complexity of resulting models [Petrovic, 2001]. This complexity does not allow for an analytical solution. Simulation is chosen because SC performance measures cannot be obtained analytically due to the presence of various sources of uncertainty and the complexity of the relations describing SC processes. Besides, the use of analytical methods is generally impractical because mathematical models for realistic cases are usually too complex to be solved.

Hence, SD simulation is selected for this particular problem. The Vensim® software is used in this study because it uses a modelling approach that combines systems dynamics concepts [Sterman, 2000] and the simulation of discrete events to represent a SC's events and uncertainties in detail, and to subsequently analyze its performance with its structure and any existing causal relations among its components [Campuzano and Mula, 2011]. Hence, this study will contribute to the theory of SD in SC metrics and improving SCSs in Ethiopian Tobacco SCs in practice.

6.2. Related Literature

Practically, the SC is too complex to be studied inclusively. So, the complex arrays of suppliers, manufacturers, warehouses, customers, transportation networks and information systems need to be reduced to simpler chain structure to study the behaviour and performance of the SCs. It is already known that each individual SC members undergoes complex processes. For example, a manufacturer may undergo series of consecutive and parallel operations. Hence, due to the presence of series of operations in the manufacturer, the operations are named as ISC.

ISC is defined as the flow of materials from the procurement of raw materials to the delivery of finished products to the immediate customers of an organization [Shah and Singh, 2001]. Hence the ISC consists of purchasing/procurement, production/operations and distribution. Through purchasing, the manufacturer interacts with the suppliers and through distribution; a manufacturer interacts with the immediate customers. These operations are integrated internally to give better operational performances that further help to improve the total SC [Jammernegg and Reiner, 2007].

There are several reasons to simulate the SC. It could prove difficult or costly to observe certain processes in a real SC, for instance, sales in forthcoming years, performance analysis, setting strategies, etc without employing simulation. A SC can be too complex to describe in mathematical equations. Even if a mathematical model was formulated, it could be too complex to obtain a solution by means of analytical techniques. SC simulation can provide a valuable idea about the most important variables and how they interact. It can also be used to experiment with new situations about which little or no information is available (uncertainty), and to check new policies and decision rules before risking experiments with the real SC.

In the literature, there are different types of simulations reported (For instance, Kleijnen and Smits [2003], Brailsford and Hilton [2004], Borshchev et al [2004], Akkermans and Dellaert [2005]; Poles [2010], Tako and Robinson [2012]; Owen [2013]). Among those reported SD is one of the common and widely applied simulations and is used for continuous, dynamic and strategic decisions.

While reviewing SC metrics, the work of Otto and Kotzab [2003] was mentioned. They examined the needs for sets of metrics for SC measurement and identified SD as one of the six disciplines that made the greatest contribution to this field. SD as the name indicates is the study of the dynamic relationship of the components in a system or combination of systems. In actual environment(s), the relationship between variables or parameters is not linear or straight forward as many researchers and writers made consecutive assumptions to reach at the approximate desired level of accuracy. This means that the actual systems and its relationships are complex in nature and it is difficult to relate all variables together to show the sensitivity of the parameters over time. No methodology could capture the cause and effects in the complex system more effectively than SD. Hence, SD simulation relies on the basic assumption that the structure of the system drives its behaviour over time.

The choice of using a simulation approach and in particular the SD approach, rather than other methods, in particular discrete event simulation (DES), was due to the recognition that the use of SD can help in modelling the entire system in which several policies and factors can be used for effective strategies evaluation in order to improve the performance of the system. Moreover, SD can handle the issues arising from those models in which dynamic forces and nonlinear relationships play a significant role. The selection of an SD approach for this study was based on its ability to model systems with complex feedback structures using visual representation which can then be converted into mathematical formulas by software as suggested by Poles [2010]. The complex feedback structures are obtained by iterations of the physical and informational flows and managerial policies defined by the system variables. The SD model can then be simulated in order to reproduce the dynamic behaviour of the system, which in turn enables an evaluation of the system improvement strategies. Besides, SD is suitable for modelling and simulating systems that contain multiple nonlinear relationships and dynamic forces that render the use of an analytical approach infeasible in solving model equations [Angerhofer and

Angelides, 2000]. A SD simulation is well represented in the literature, with a significant bibliography having developed since Forester's industrial dynamics. Since then, SD is applied for wide range of disciplines and applications. However, very little appear in the literature regarding SC measures.

Referring to the literature, within SC context, SD was used in wide varieties of problems in different topics such as: SC analysis [Lertpattarapong, 2002; Rabelo et al, 2004], reverse SC [Kumar and Yamaoka, 2007], performance measures [Barton and Tobias, 1998;Kleijnen and Smits, 2003; Campuzano and Mula, 2011;Asgari and Hoque, 2013; Petterson and Segerstedt, 2013], understanding of SCs [Minegishi and Thiel, 2000; Bell et al, 2003], SCSs [Gonçalves et al, 2005;Minnich, 2007; Carvalho et al, 2013], capacity augmentation [Kamath and Roy, 2007], bullwhip effect [Lee et al, 1997], warehouse management [Cagliano et al, 2011], benchmarking ISCs [Shah and Singh, 2001], value addition [Santos et al, 2002], closed loop SCs [Vlachos et al, 2007], cycle time compression [Mason-Jones and Towill, 1999], stock management structure [Sterman, 2000], SC redesign [Towill, 1995], information control [Sanghwa and Maday, 1996] and inventory costs [Bolarin et al, 2008].

Even though SD is a robust methodology to view the relationships of variables over time in the complex system, it is not without flaws. The effectiveness of SD depends on how much accurately the necessary information about the environment system is conveyed to the model. Due to this reason, sometimes incomplete information and bias can influence the outcome of the model. Furthermore, the decision made by human may be subjected to psychological and cognitive limitations to incorporate all the necessary and sufficient inputs to the system's model. Besides, it is very difficult to reflect the real data with high accuracy in SD, since approximate methods are used for estimation, the error in the simulation result is inevitable [Barton and Tobias, 1998]. Akkermans and Dellaert [2005] also articulated issues remaining not well positioned under SD as underdeveloped mathematics for the experiments and compatibility with other research approaches for detail outcomes.

6.3. Research Methodology

Model development entailed interviewing planners with diverse decision scopes and responsibilities to understand the decision-making processes in Tobacco's production system. In addition, managers in diverse areas of the corporation, such as operations, SCM, information technology, demand forecasting, marketing and sales were interviewed. In total, almost 34 semi-structured interviews have been conducted through site visits and weekly feedback calls. The study also involved reviewing company's logs detailing guidelines for decision-making, and collecting related quantitative and qualitative data. The quantitative data included time-series data on weekly capacity, utilization, production, shipments, forecasts and service levels and also annual financial performances. Qualitative data included managers' decision heuristics, company's guidelines and incentives, and information dependencies among business areas. These data used to establish the assumptions used in the model that captures tobacco manufacturing. Besides, similar performances from world class tobacco manufacturers have been referred from company's reports and case studies.

After conceptual part is conceived, causal loop diagram (CLD) is used for developing dynamical hypothesis. Mathematical models are developed for each entities and is in turn used as an input for stocks and flows diagram (SFD), which is a causal diagram that aids in visualising how different variables in a system are interrelated and a beginning of simulation. The sign of links and causal loops are in accordance with the assumption given by [Sterman, 2000].

In SFD, the definitions and assumptions of each element (levels, rates, and auxiliaries) are set in accordance to Minnich's [2007] label. The aim of this Chapter is to relate SC measures of ISC and explore the improvement of the performances using the policy design. The policy design are named here as scenarios. These strategies are the traditional or push strategy, push-pull strategy or hybrid strategy and pure pull strategy. Hence, scenario 1 is purely push production as it depends on demand forecasting; scenario 2 is push-pull strategy and scenario 3 is purely pull production based on customer demand. Using the same SC measures, the scenarios are evaluated. This research has two objectives. First, it relates the SC measures using SD. Second, it iterates the best scenario for the company in order to be efficient and effective. In addition to the two objectives, it is testing the SCS for the firm selected. To do this, the proper SC measures are carefully selected from the companies and literature. The relationships between the SC measures are found from literature, surveys, mental models and conference and workshop feedbacks as shown in Figure 6.1.

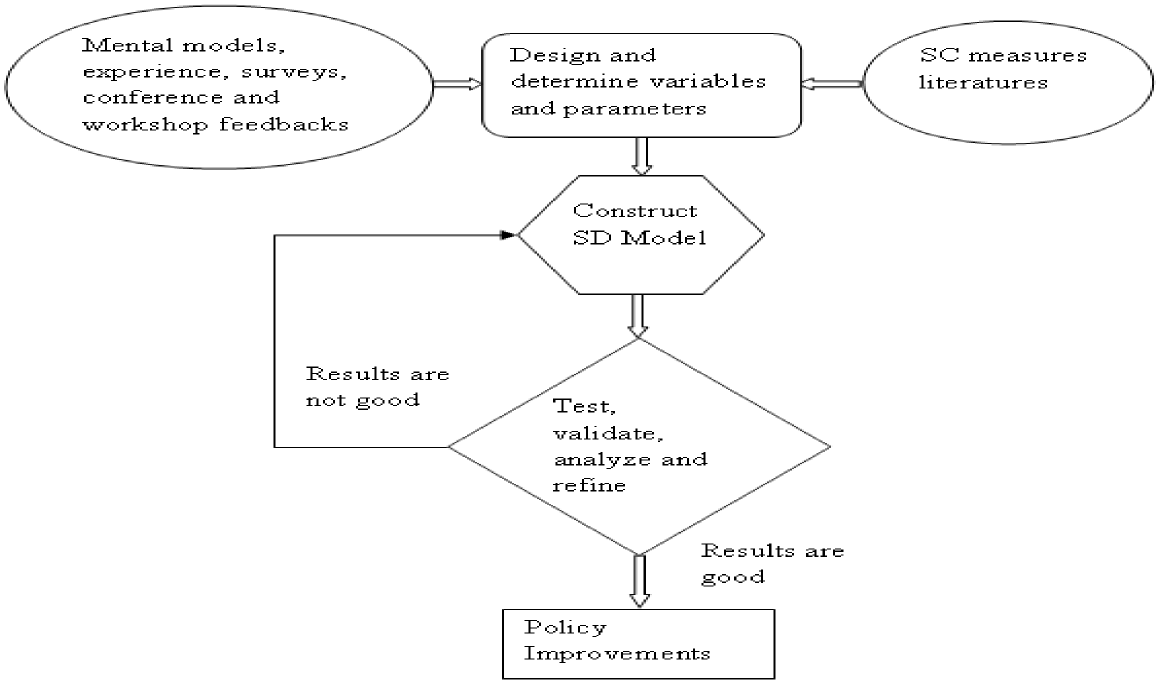

Figure 6. 1: Research Map

6.4. Background of the Study

Tobacco production has two divisions. A tobacco processing unit is called primary manufacturing division (PMD). The cut tobacco is then sent to the secondary manufacturing division (SMD) for making and packing cigarettes. At the primary process, the reconstituted tobacco sheet and tobacco leaf go through mixing and wetting, blending and cutting. Alternatively, tobacco stem goes through wetting, crushing, cutting and drying. The above materials mix together and enter the secondary process. At the secondary process, the reconstituted tobacco sheet, the tobacco leaf, the tobacco stem, and rag from waste cigarettes together go through mixing, drying and cooling. The product of this process is called cigaretterag which passes through cigarette making machines and packing and labelling machines.

In Ethiopia, where the case study is done, National Tobacco Enterprise (Ethiopia) S.C. is a state-run monopoly where the government strictly controls cigarette production and distribution. The Tobacco Monopoly Administration takes charge to select retailers to sell cigarettes. Retailers have to order cigarettes from the Tobacco Monopoly Administration. The company is earning $ 50 million annually and is hiring large number of employees both in manufacturing companies and tobacco farms. The company manufactures local cigarette brands like Nyala, Gissila, Elleni, Delight and Nyala Premium and imports international brands like Marlboro and Rothmans. Since the Nyala brand share in sales and production is about 89.98 % in 2013, the production lines of the Nyala brand is considered here. The demand data for the factory is taken from actual sales in 2013. The units of measure is in cases which is in 50 cartoons, each cartoon contains ten-20 cigarettes packet. This means 1 case contains 10,000 cigarettes. Alternatively, 1 case =10 kgs. The demand follows normal distribution with a mean of 7714.7 cases or 77147 KGS per week and a standard deviation of 1655. The factory runs two shifts with 8 hours effective working hours each shift for six days a week with holiday on Sunday.

The Tobacco enterprises as seen from their experience use a make-to-stock production strategy, in which the orders are produced for storage in according to a forecast where the company tries to maintain a sufficient stock of finished products in the inventory so that incoming customer orders may be filled from the stock. However, three methods are proposed whether the company may change orders against the large stocks. To do this, ISC are taken first and then customer order rate is treated as exogenous. The model can be regarded as a batch-wise processing company.

The ISCs mainly focused using the control of materials from raw materials entry to the shipment of the product. In this case there are about 8 modules or major activities namely, customer order rate, backlog, order fulfilment, production scheduling, demand forecasting, replenishment, production, master production schedule (MPS) which are covered in the model and each module is incorporated in the model equations section based on Sterman [2000] and Campuzano and Mula’s [2011] suggestions. First the CLD is discussed and SFD will follow subsequently.

6.5. Model Scenarios

In ISC perspective, the push or pull strategy is directly related to the work release policy. Referring to authors like Hopp and Spearman [2003], the distinction between push and pull seems in their consideration of work releases based on forecasted demand and customer order via MPS. In an alternative to pure-push and pure-pull strategies, a hybrid push-pull strategy uses some information feedback of the system to update the MPS based on the current status of the line. This is because it is practically impossible for a firm to be pure-push since it will create congestions in the lines. Hence in the push-pull strategy, the production in the primary manufacturing area be solely based on the MPS, i.e., a pure-push strategy, and the production in secondary area will depend on demand pull. The other issue here is originating where the demand-pull signal should originate from secondary lines of manufacturing.

6.5.1. Scenario I: Pure-Push

This scenario is based on the decisions of product releases purely on MPS which acts as a demand signal for the process lines in primary manufacturing area which are shown in Figure 6.2 through the feedback arrows from the MPS to the desired production variable for each production line. The scenario completely ignores the depletion of intermediate inventory; rather the production lines fill the intermediate inventory following the MPS and their line production schedule, pushing production downstream. The intermediate inventory is depleted by the production start rate of P2 which is solely based on the master production schedule, with consideration now taken to downstream WIP or the FGI. Hence, products are manufactured according to the demand forecast and the master production schedule, and pushed down the manufacturing system. Here, to show the system's performance in pure push system, the scenario does not consider the feedback from FGI to the production scheduling. The complete SFD diagram is shown in Figure 6.3.

6.5.2. Scenario II: Push-Pull

In this scenario (Figure 6.4), production start rates in the secondary manufacturing determine production for the upstream production lines. The complete SFD is shown in Figure 6.5. Hence, the MPS is no longer acting as a demand signal for the desired production variable of the production lines in primary production area. Instead, this signal originates from the downstream production lines in the secondary manufacturing area and through the P2 Demand variable.

6.5.3. Scenario III: Pure-Pull

This scenario implements the replenishment of both inventories, i.e., the intermediate inventory (II) and FGI, and from where the demand-pull signal originates and targets the same variables in the simulation (Figure 6.6). The calculation of desired production in secondary production is solely based on the information feedback from the adjustment variable for the FGI, which regulates the increase or decrease of the desired production, depending on the inventory balance of the FGI. The complete SFD is shown in Figure 6.7.

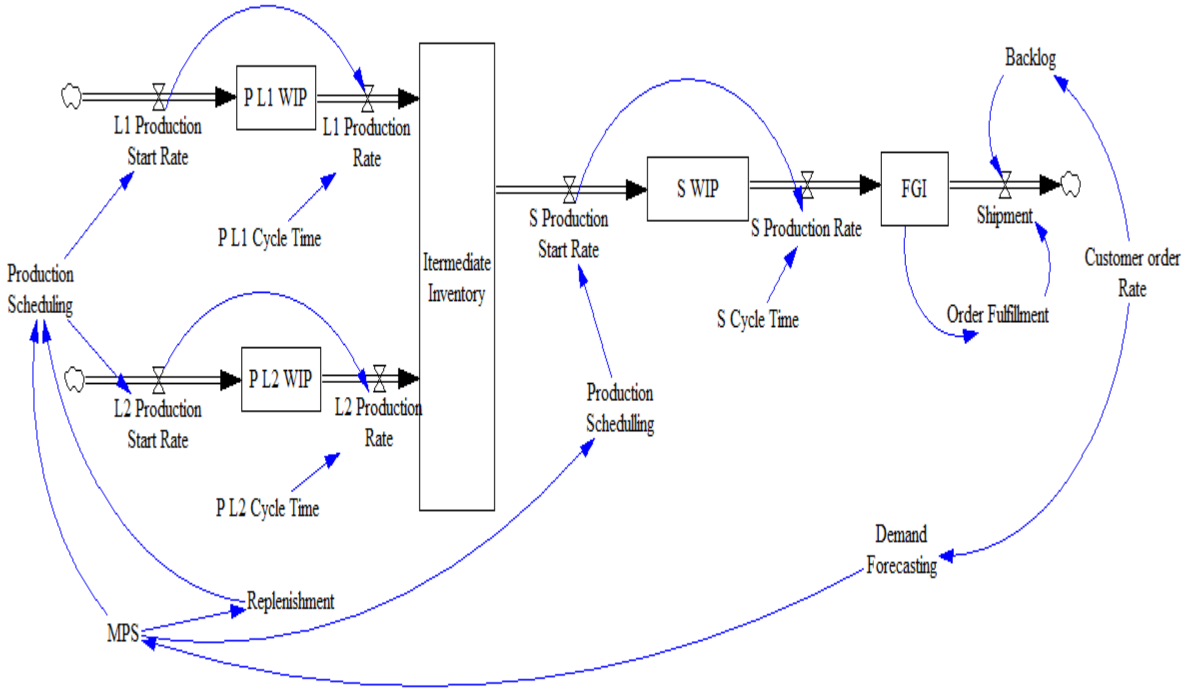

Figure 6. 2: Pure-Push Scenario

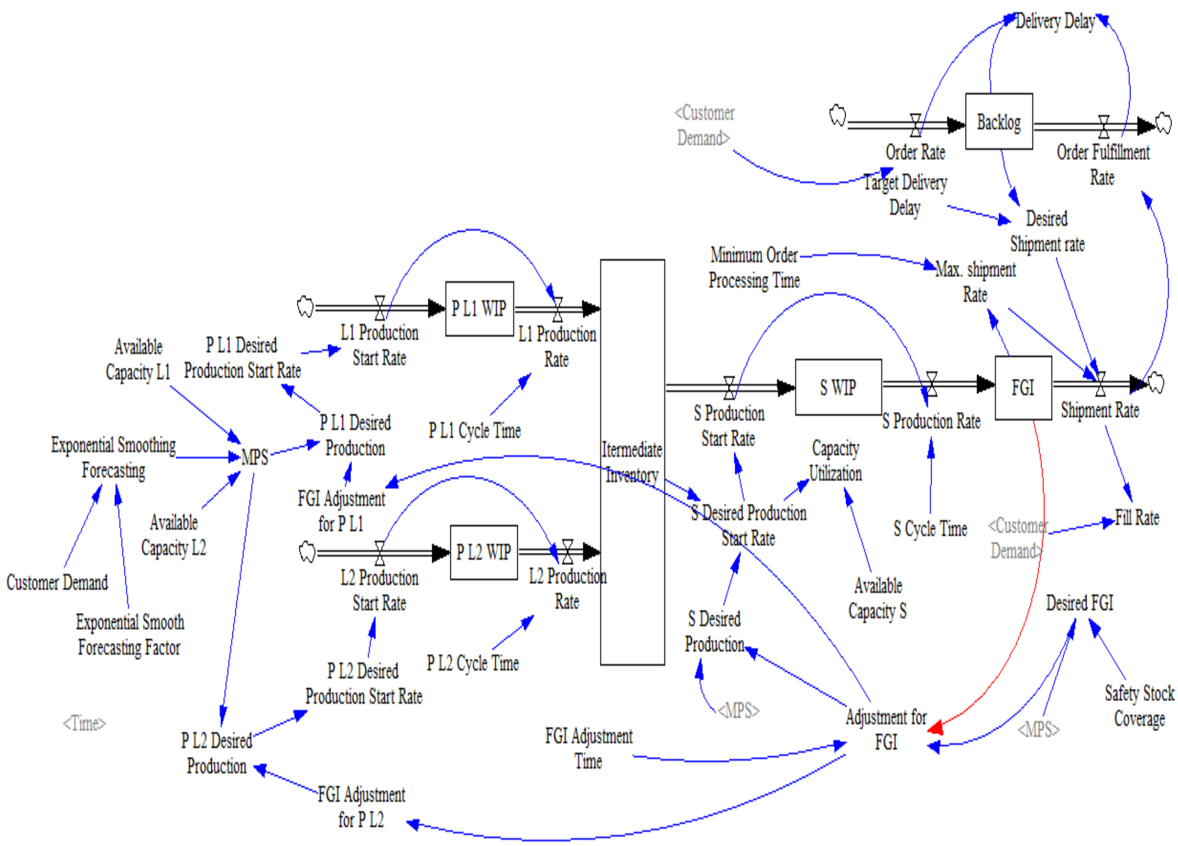

Figure 6. 3: SFD for Pure-Push Model

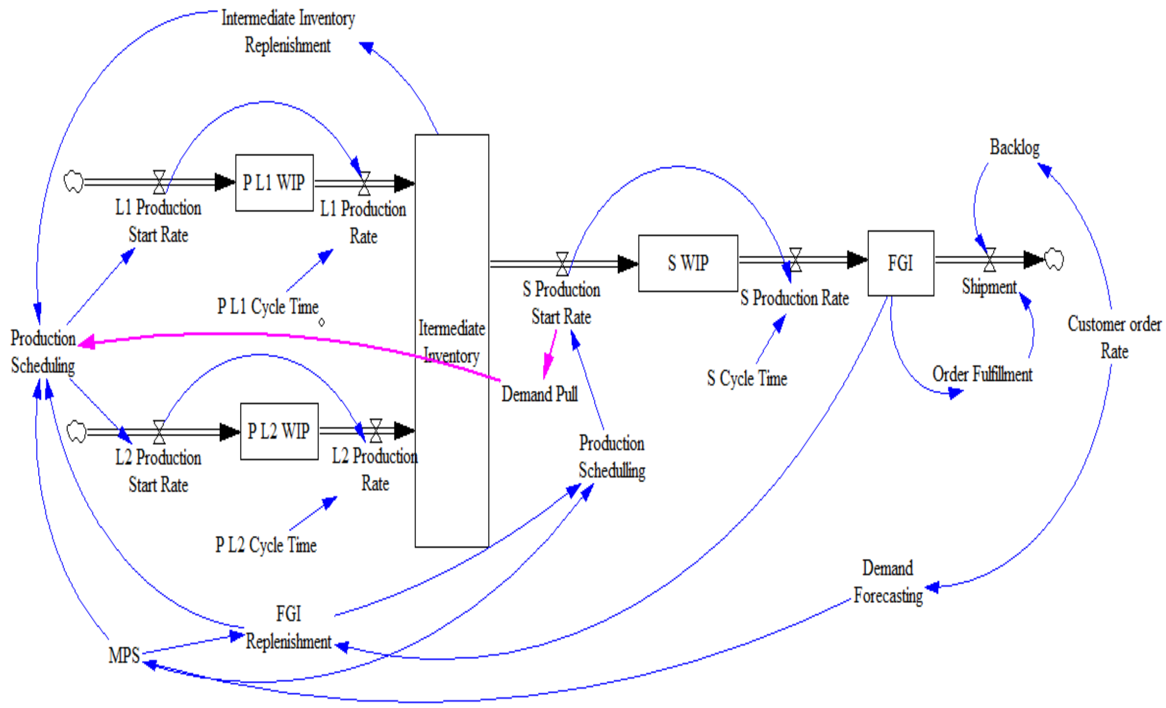

Figure 6. 4: Push-Pull Scenario

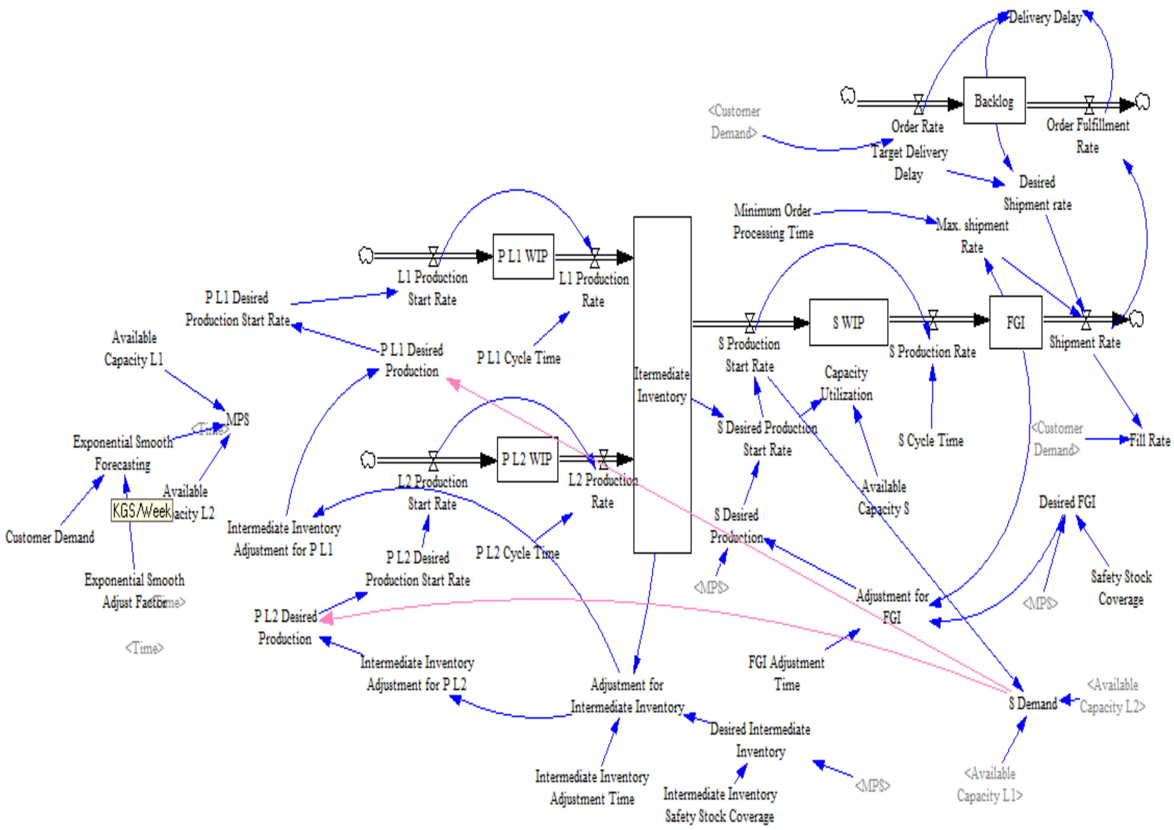

Figure 6. 5: SFD for Push-Pull Model

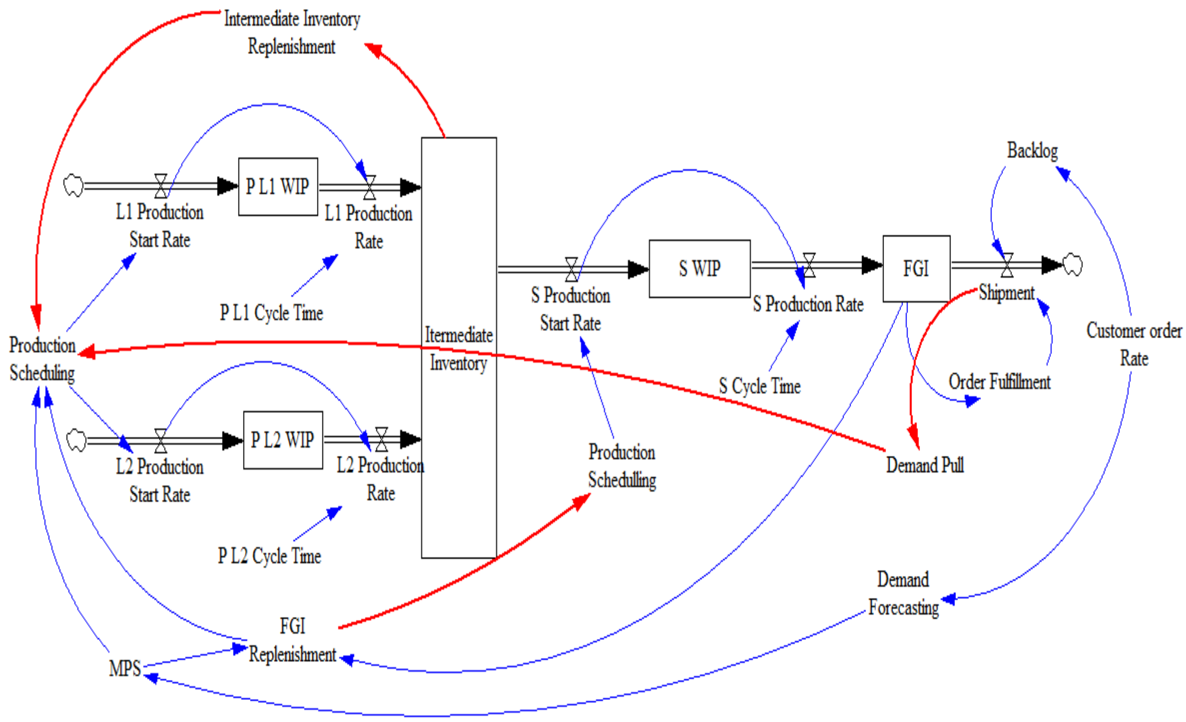

Figure 6. 6: Pure-Pull Scenario

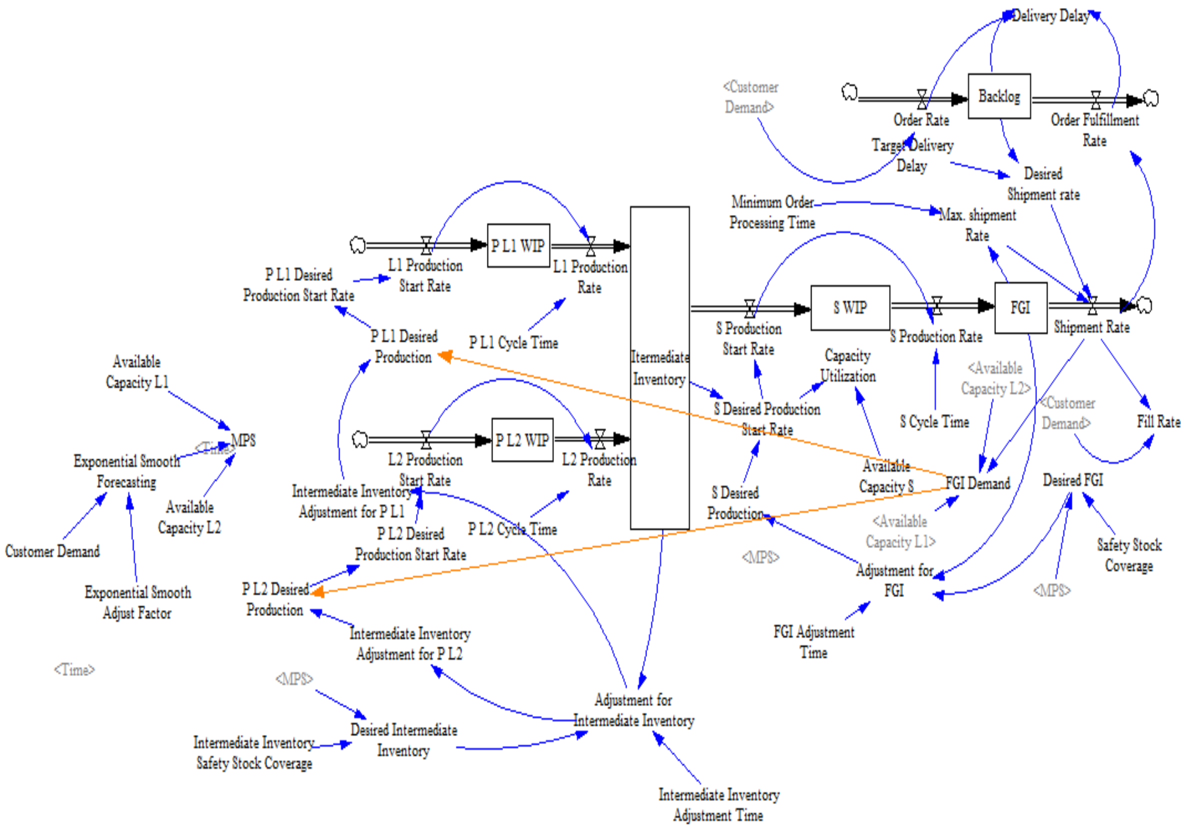

Figure 6. 7: SFD for Pure-Pull Model

6.6. Model Equations

The model equations three scenarios are clearly set in this section. Most of the equations are similar in nature and form as in pure push model. However, specific ones to other models are discussed in their respective sections.

Basic Model Assumptions

1. Customer demand is confined to a single type of an end-product with normal distribution.
2. Aggregation of several activities into a single deterministic delay.
3. Customer orders which cannot be filled immediately are not lost, but will accumulate in a backlog of unfilled orders.
4. The raw material inventory is supplied from an external source and there are no constraints in getting raw materials.

6.6.1. Scenario 1: Pure-Push Model

In this strategy, the feedback is sent from the MPS to the desired production. This means that depending on the MPS, the production is pushed downstream. Hence subsequent lines will have their own decisions when to release to the next levels. The cigarette brands are manufactured according to MPS and pushed down the manufacturing system.

The demand forecast is modelled as a first-order exponential smooth of actual orders - in practice obtained from the aggregation of orders which is updated over a period of one month, the frequency with which marketing updates their forecasts. The customer demand (CD) is collected from the factory in 2013 for 46 weeks. The customer order variable is used to forecast the future customer demand in the variable name of exponential smoothing forecasting using first order exponential smoothing method. The formula employed for forecastings using exponential smooth is:

$$Y_{t+1} = Y_t + \alpha(X_t - Y_t) \quad (1)$$

$$\alpha = 1/ESAF \quad (2)$$

Where, Y_{t+1}=forecasting demand for period $t+1$

X_t=real value of demand during period t

α=smoothing coefficient which is 0.5 for this particular model

ESAF=Exponential Smooth Adjust Factor

Exponential smoothing forecasting (ESF) is the outcome of the demand forecasting on which production scheduling is done. Production scheduling is done using MPS variable to plan the necessary materials and processes for the downstream processes. MPS is then used as an input to Desired Production (DP) in both primary and secondary manufacturing area and Desired Finished Goods Inventory (DFGI) in the finished goods inventory area. Hence this scenario makes the process push downstream. In this case, however, the push systems are relaxed to contain some information feedback from FGI. This is actually against the concept of push production in which products are pushed downwards without the consent of the status of downstream facilities. However, this is rarely seen in practical scenarios as it can cause congestions and overcrowding of inventories.

Hence,

$$MPS = \begin{cases} AC_p, \ \text{ESF} \geq \text{AC}_\text{p} \\ \text{ESF, Or else} \end{cases} \tag{3}$$

Where, AC_p = Available capacity for the primary manufacturing.

Equation (3) tells us that the order is released based up on ESF and the available capacity. In the primary manufacturing section, there are two production lines, the tobacco leaf and tobacco stem lines. In the tobacco leaf line the capacity of the line is denoted by Available Capacity L1 (L1AC) and for the tobacco stem lines, it is named as Available Capacity L2 (L2AC). The MPS is seen here as a master mind in generating production releases. The production schedule in the form of desired production according to MPS is also receive information from replenishment in the form of inventory adjustment for both intermediate and finished goods inventories. It can be seen that information feedback from both MPS and FGI adjustment are used to calculate the desired production. Hence, in the primary manufacturing area for both lines,

$$DP_t = MPS_t + FGIA_t \tag{4}$$

Where, $FGIA_t$=Finished Goods Inventory Adjustment at time t

FGIA in both lines in the primary is adjusted by adjustment for finished goods inventory variable which is found through feedback by FGI and Desired FGI variables.

Hence,

$$FGIA_t = (DFGI_t - FGI_t)/FGIAT \tag{5}$$

Where, $DFGI_t$ =desired finished goods inventory at time t

FGI_t= finished goods inventory at time t

FGIAT = finished goods inventory adjustment time, which represents the time period over which the manufacturing plant seeks to bring the inventory with the finished products in balance with the desired inventory level, and is given in units of weeks.

FGIAT plays an important role in the replenishment of the products through a designed desired finished goods inventory variable which is in turn initiated by SSC and MPS. Hence,

$$DFGI_t = MPS_t * SSC_t \qquad (6)$$

Where, SSC_t = The safety stock coverage in time *t*, which represents the time period over which the company would like to maintain a safety stock coverage, excess to the order processing time, in order to meet any variations in customer demand.

PDP variable initiates the start of production for both lines in the primary manufacturing areas through the variable Production Start Rate (PPSR) scheduled based on Desired Production Start Rate (PDPSR).

PPSR is a non negative (PPSR>0) variable that initiates further pushing of production process for both production lines. This is represented in Vensim® as:

PPSR= MAX(0, PDPSR) (7)

Where, PDP=desired production in the primary manufacturing

PPSR=production start rate in the primary manufacturing

PDPSR=desired production start rate in the primary manufacturing

The Primary Production Rate (PPR) executes production on both lines constrained in by MPS in the primary manufacturing. This is done during delay of time represented by cycle time (CT) for both lines which represents the average delay time of the production process for the products from start till completions of the product. Hence, this can be represented as:

PPR =DELAY3(PPSR, PL1CT) (8)

PPR =DELAY3(PPSR, PL2CT) (9)

Where, PL1CT= manufacturing cycle time for line 1 in the primary manufacturing

PL2CT= manufacturing cycle time for line 2 in the primary manufacturing

This means that production is done on during cycle time. Up on succession on production, some of the work left is captured under work-in-process (WIP) variable. It is obvious that WIP is the difference between PSR and PR here. It is a level variable and represented as follows in the program:

$$\mathrm{PWIP_t} = \int_0^t (\mathrm{PPSR_t} - \mathrm{PPR_t}) + PWIP_0 \quad (10)$$

Where, $PWIP_t$= WIP in the primary manufacturing of both lines for time t

$PWIP_0$= Initial WIP in the primary manufacturing of both lines

The products from the respective lines in the primary manufacturing is temporarily stored in the form of intermediate inventory necessary for the secondary production stages based on MPS. This point is assumed where the mixing of both processed tobacco leaf and tobacco stem will perform. After the proper mixing of these items, in the secondary manufacturing, the proper making and packaging of the cigarette from the rag is performed.

Since, the cigarette rag is the mixture of the leaf and stem of tobacco in the proper ratio, the intermediate inventory (IINV) is the difference between input and output of the process.

Hence,

$$\mathrm{IINV_t} = \int_0^t \left(PL1PR_t + PL2PR_t - SPR_t\right) + IINV_0 \quad (11)$$

Where, $IINV_t$=intermediate inventory at time t

$IINV_0$ =initial intermediate inventory

$PL1PR_t$ =production rate of line 1 in primary manufacturing area at time *t*

$PL2PR_t$= production rate of line 2 in primary manufacturing area at time *t*

SPR_t= production rate of the secondary manufacturing area at time *t*

Through MPS and feedback from FGI in the form of adjustment for FGI variable, the scheduling of production called by desired production initiates production start rate in the secondary production. Hence,

$$SDP_t = MPS_t + FGIA_t \quad (12)$$

Where, SDP_t=desired production in secondary manufacturing line at time t

Finished goods inventory adjustment is found using equation (5) with modified units. The scheduled products along with intermediate inventory initiates desired production start rate (SDPSR) in th secondary manufacturing area. SDPSR is initiated with the minimum value between the SDP and IINV and can be captured as follows:

$$SDPSR_t = MIN\ (SDP_t, IINV_t) \quad (13)$$

The SDPSR variable totally initiates the production in the form of production start rate in the secondary manufacturing line (SPSR) variable which is a non negative (SPSR>0) variable similar to in the primary manufacturing.

$$SPSR_t = MAX(0, SDPSR_t) \quad (14)$$

SDPSR variable again depends up on the maximum capacity of the line available capacity in this case. The SDPSR variable can infer as to find how much capacity utilized in the form of capacity utilization (CU) variable. This variable depends on the maximum (available) capacity in the line. Hence,

$$CU_t = \frac{SDSR_t}{AC_s} * 100 \quad (15)$$

Where, AC_s=available capacity in the secondary production line

The production in the secondary production line is further undergone in the line so that some WIP is prevailed. The WIP in the line is given as:

$$SWIP_t = \int_0^t (SPSR_t - SPR_t) + SWIP_0 \quad (16)$$

Where, $SWIP_t$= WIP in the secondary manufacturing for time t

$SWIP_0$= Initial WIP in the secondary manufacturing line

Now, the production rate which is dictated by manufacturing cycle time in the secondary manufacturing is given by:

SPR_t =DELAY3 ($SPSR_t$, SCT) (17)

Where, SCT = manufacturing cycle time in the secondary manufacturing which is similar to the definitions given in the primary manufacturing.

The difference between production rate and shipment rate is stored in the store in the form of FGI. Hence,

$$FGI_t = \int_0^t (SPR_t - SR_t) + FGI_0 \quad (18)$$

Where, FGI_t= finished goods inventory at time t

FGI_0= initial FGI

SR_t=shipment rate

Based on the planned values the products are shipped to the customers which is captured through shipment rate (SR) variable. The value of shipments depend on the desired shipment rate (DSR) and maximum shipment rate (MSR) which is given as:

$$SR_t = MIN\ (DSR_t, MSR_t) \tag{19}$$

Equation (18) tells us that the products are shipped to customers with the availability of the minimum of DSR (which is the planned shipment including backlogs) and MSR (the maximum possible shipment). Here comes what is the genuine meaning of push production which is not based on customer order rather pushed by MPS and in some instants coupled with feedback from FGI. Hence, the fill rate (FR) which shows whether customer satisfaction from this system canbe found as:

$$FR_t = (SR_t / COR_t) * 100 \tag{20}$$

The other assumption mentioned before in this work was the backlog. According to this assumption the immediate customer orders not fulfilled from the FGI is allowed backordered so that orders can be met in later times. Hence, the backlog (BL) variable captures the amount of the orders backlogged during the time periods. Hence,

$$BL_t = \int_0^t (OR_t - OFR_t) + BL_0 \tag{21}$$

Where, BL_t= backlog in period time t

Bl_0=initial backlog

OFR_t=order fulfilment rate at time t

OR_t=order rate at time t

Literally order rate is equal to CD_t in this particular application. Another important performance variable to track how much customer orders are met from the available inventory is order fulfilment rate (OFR) which is equal to the shipment rate in this case. Any company can design its own target delivery delay as a delay is a natural phenomenon.

The total actual delay in the ordering process is assumed here as delivery delay where as the target delivery delay is set by the company prior to delivery processes to get the desired shipment. The actual delivery delay (DD) is given as:

$$DD_t = BL_t / OFR_t \tag{22}$$

The desired shipment rate (DSR) dictated by the target delivery delay (TDD) absorbing backlog is given as:

$DSR_t = BL_t/TDD$ (23)

Availability of FGI in the stock determines the maximum shipment rate (MSR) in the systemwith in minimum order processing time. Hence MSR will never less or equal to zero as some FGI must be available to ship to the customers within this time range. MSR at any time t is given as:

$MSR_t = MAX\ (0, FGI_t/MOPT)$ (24)

Where, MOPT= The minimum order processing time, which denotes the minimum time required by the company to process and ship a customer order.

Besides, those specific measures to pure push model, there are some performance measures defined in the same way for all other SCs.

The first measure is capacity utilization (μ) which is defined as the ratio of desired production start rate to the available capacity in this case. Hence,

$$\mu_t = \left(\frac{DPSR_t}{AC_t}\right) * 100 \qquad (25)$$

In the same way, the fill rate (f_r) for the finished product is defined as the ratio of shipment rate to customer order rate. Hence,

$$f_r = \left(\frac{SR_t}{COR_t}\right) * 100 \qquad (26)$$

6.6.2. Scenario 2: Push-Pull Model

Originally, the whole SC process is forecast driven because the average cycle time from the raw material storage and component storage manufacturer II to departure of the finished products to the customer is longer than the requested delivery time. Practically, this system may cause high variability of the production cycle times and as a result high safety stocks are kept somewhere in the supply line to alienate variability. In such cases, Jammernegg and Reiner [2007] commentthat part of the manufacturing process is needed to change from push to pull that may reduce the variability. This calls push-pull strategy in action. In the case taken for this study, if the cigarettes are available in FGI, orders can be filled immediately. Therefore, incoming customer orders “pull” the available cigarette from FGI. In turn, replenishment of FGI shipped to customers “pulls” products from WIP. If the products are not available in FGI, backlogged orders “pull” parts directly from the WIP inventory. Since the parts have to be made, filling orders from WIP increases the delivery delay experienced by customers and reduces the flow of shipments below customer orders as WIP and assembly capacity limit shipments. In actual scenario, every SCS is a hybrid between the push and pull. For example, a pure push-based system still stops at the retail store where it has to wait for a customer to "pull" a product off of the shelves. However, this is the case where ISC is concerned. In this scenario, the manufacturing of the product in secondary lines is based on demand-pull strategy where the production start rate in secondary line determine what is to be produced on the upstream production lines. In this scenario, MPS is no longer acting as a demand signal for the desired production variable of the production lines in primary production. Instead, this signal originates from the downstream production lines in secondary production and through the S Demand variable.

The S Demand variable follows a similar heuristics as the MPS for calculating how the demand should be distributed among the two production lines in the primary production. The equation for S demand is given as:

$$Sdemand_t = \begin{cases} AC_p ; PPSR_t \geq AC_p \\ PPSR_t ; Othersise \end{cases} \tag{27}$$

Where, $Sdemand_t$=the demand pull at secondary production at time *t*

AC_p = the available capacity for the primary production lines

Ideally the desired production variables in primary production do not follow the MPS (as shown in equation (4)), but only start production if it is required for downstream production lines or if the safety stock of the interim inventory is too low. Hence, the following equation for the desired production in push-pull scenario can capture the situation:

$$PDP_t = Sdemand_t + IIA_t \tag{28}$$

$$IIA_t = (DII_t - II_t) / IIAT \tag{29}$$

$$DII_t = MPS_t * IISCC_t \tag{30}$$

Where,

IIA_t= intermediate inventory adjustment at time *t*

DII_t= desired intermediate inventory at time *t*

IIAT= Intermediate inventory adjustment time

$IISCC_t$= Intermediate inventory safety stock coverage at time *t*

6.6.3. Scenario 3: Pure-Pull Model

In this particular model, the production of the upstream facilities is dictated by the status of the downstream facility. This means that the demand-pull signal for the production lines in the primary production area originates after the FGI, where the shipment rate, i.e., output of FGI, defines the FGI Demand variable that constitutes what should be manufactured, depending on the product and quantity that has been shipped. To be clear with the model, this scenario implements the replenishment of both inventories, i.e., the intermediate inventory and FGI, and from where the demand-pull signal originates and targets the same variables in the simulation. Hence, the desired production in the secondary process (SDP) is found from the feedback of adjustment from FGI. Therefore, SDP at any time t is given by:

$$SDP_t = FGI_t \tag{31}$$

Since, the desired production in primary process for both lines (PDP) initiated by both inventory adjustment from intermediate and FGI, it can be written as:

$$PDP_t = FGIdemand_t + IIA_t \tag{32}$$

Finally, the value for the FGI demand is:

$$FGIdemand_t = \begin{cases} AC_P; AC_p \geq SR_t \\ SR_t; otherwise \end{cases} \tag{33}$$

It may be noted that equations (28) - (30) are valid for the pure-pull case too.

6.7. Model Validating and Testing

Based on Gordon [1978], Forrester and Senge [1980], Barlas [2000] and Vlachos [2007], the model validation and test in SD by a point-by-point match between the model behaviour and the real behaviour as occurs in engineering systems is neither possible nor as important as it is in classical forecasting modelling. However, they argue that structural validity and behaviour validating are commonly used with decreasing importance. The authors also contend that there are two structural validation and conclude that indirect structural tests of extreme condition and behaviour sensitivity tests are widely used since both involves quantitative data used to communicate. Extreme conditions and behaviour sensitivity tests are used in this study. Besides the shapes of the curves for different types of inventories scaled is replicated to the models developed by Lertpattarapong [2002] and Ramamoorthy [2005].

6.8. Results and Discussions

The model is simulated using the following model parameters:

[TDD, FGISSC, IISSC, MOPT, FGIAT, IIAT, PL1CT, PL2CT, SCT] = [96, 16, 16, 16, 16, 16, 1.5, 1.5, 3] hours

[L1AC, L2AC, AC_S,] = [10, 10, 15.28] KGS/Minutes.

The outputs from the simulation are different performance metrics for ISC which are shown consecutively. It is difficult to find the replicate model comparing with other works as the parameters and model problems varies. However, the trends of some of the performances of the pure push model can be compared by producing similar initial and constant values. It can be seen that using the initial conditions as in the model testing and validation case, the trend similar in form with the extreme condition in which most of the parameters are set to zero. Hence it is guaranteed to compare the performance of the ISC metrics for those scenarios as a possible policy recommendation. Regarding this initial conditions, the system was first simulated under normal conditions, with customer demand were assumed to follow normal distributions. The results obtained by modelling the system under these initial conditions are used as a replica and benchmark for comparing the system's performance under a different strategies and scenarios considered.

Before simulating the results the replications are tested using different test results. Then the forecasted demand using exponential smoothing method is shown, which is a part in production scheduling is. Figure 6.8 shows the comparison between actual customer demand and forecasted demand for period of 46 weeks. The actual customer demand is collected for 2013 but it is fitted to normal distribution curve to reduce noises in the model. To further decrease cycles in customer demand, exponential smoothing method is employed with a trial and error smoothening constant of 0.5. After initial conditions and replication of the model are tested, the model is experimented using the following scenarios for each production strategies. This is because customer demand is exogenous and is expected to influence the SC metrics of ISC in varying degrees. Hence, different effects of CD need to be studied. After iterating the SSC with different values, it is found that the SSC=0.5 is just optimal for this initial conditions for all strategies. The initial condition is therefore customer demand is normally distributed and the SSC is 0.5 weeks. Hence this phenomenon is the benchmark against the varying conditions of the customer demand in different production strategies.

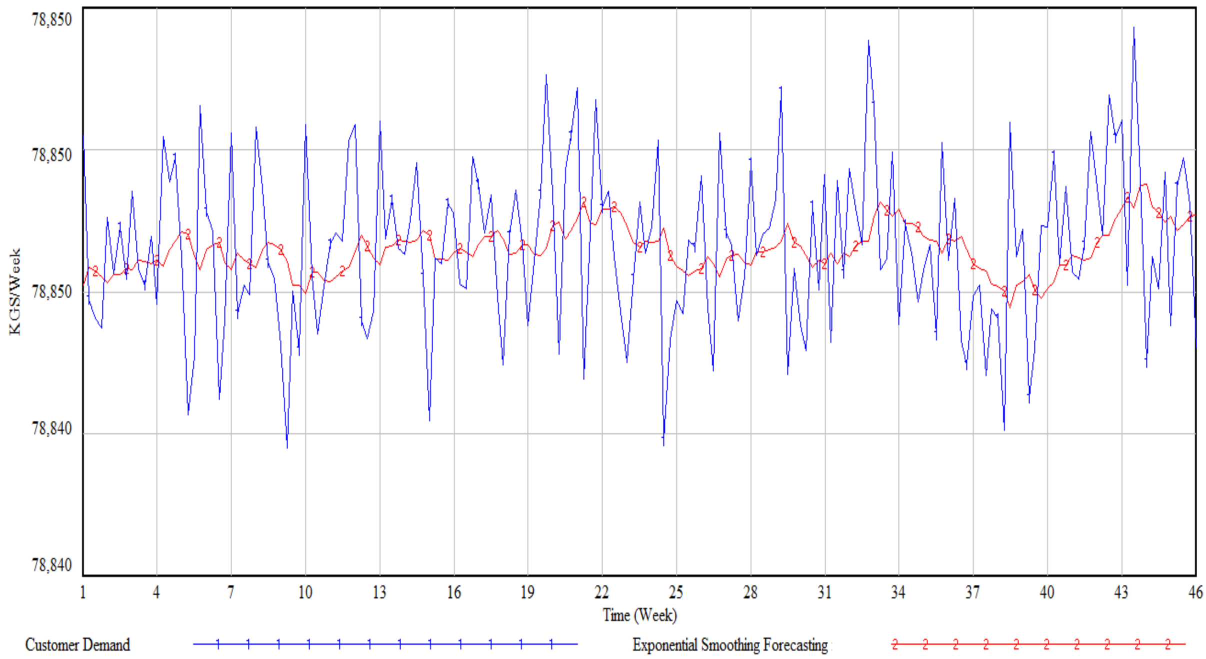

Figure 6. 8: Comparison of Actual Customer Demand with Forecasted Demand

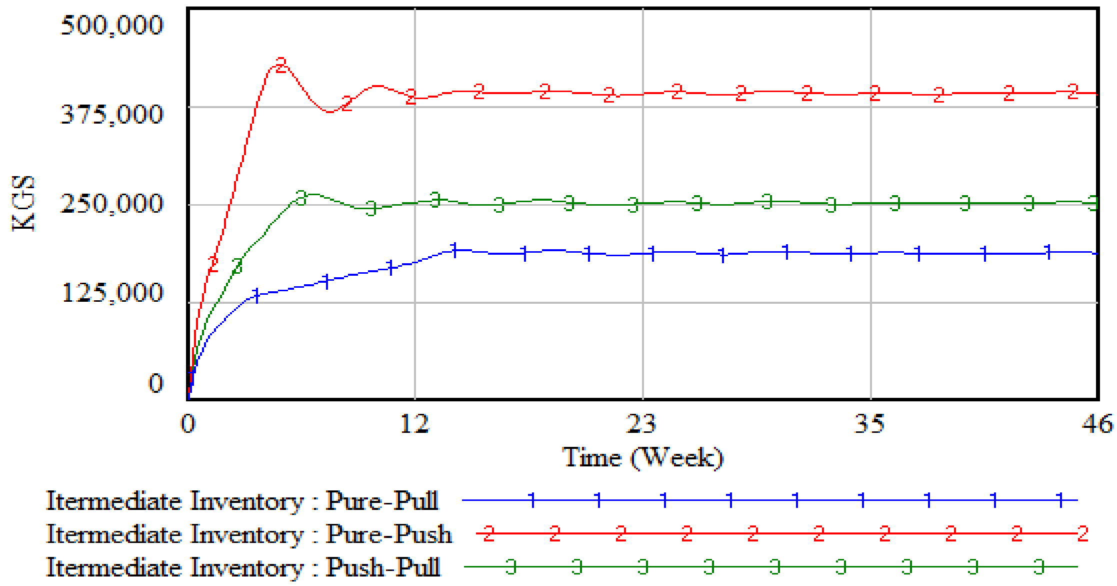

Figure 6. 9: Comparisons of Strategies Based on Intermediate Inventory

Visualizing and controlling WIPs and intermediate inventories is the most important task in the ISC as the major activities involves the flow of materials within the chain. After proper materials are planned through MPS, work flows in the ISC can be controlled through managing inventories. The practical inventory in the case company was the accumulations of inventories in the chain which is termed as intermediate inventory in this case. As can be seen form Figure 6.9, there is a considerable accumulation of the inventory for the three scenarios. From the figure it can be concluded that large amount of inventories in the pure-push strategy which validated the theory behind the push strategy so far given by Hopp [2003]. In contrary, Pure-pull strategy performs well with small size of the inventory without sacrificing the fill rate. Hence, the pure-pull is the optimal strategy for the company in terms of intermediate inventory. The same is true with the WIP of the primary and secondary manufacturing lines.

For the optimal size of inventories, the comparison between the WIPs is shown in the Figure 6.10. From the figure, it is seen that the significance of the WIPs in both lines are insignificant for the three strategies but those FGI and intermediate inventories are significant. This causes the overstock of intermediate inventories that leads to congestion. So, the capacity of the secondary lines should be expanded to handle these stocks. Besides, the safety stock needed to be flat or minimum.

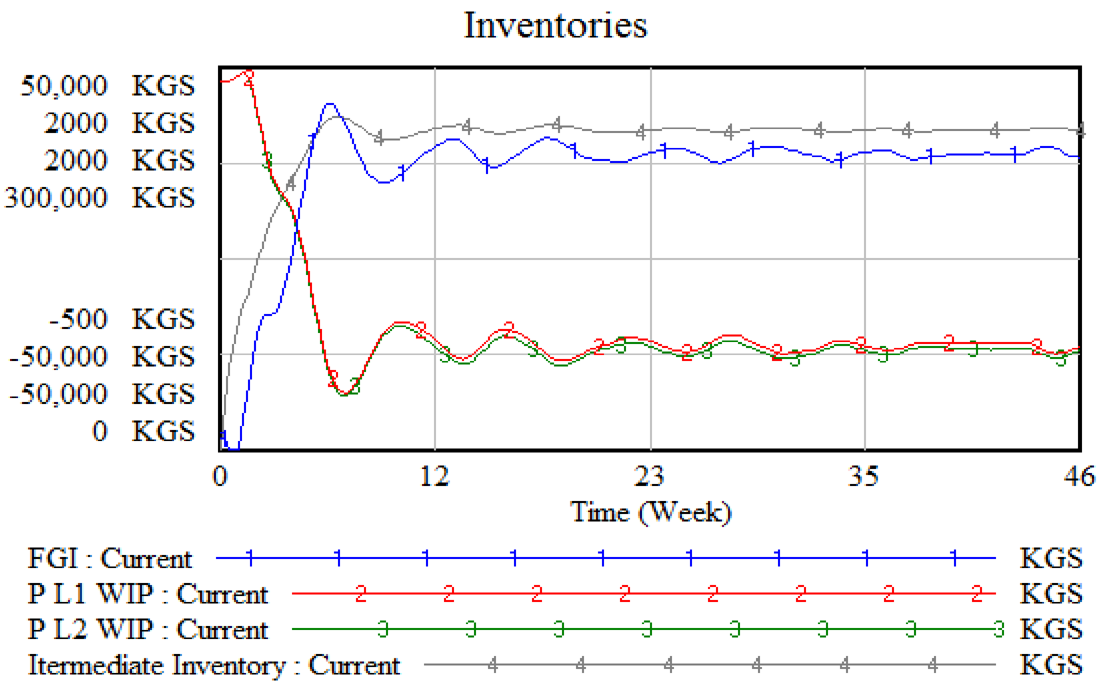

Figure 6. 10: WIPs at Optimal Safety Stock Level

The crucial inventory for the whole line is FGI. FGI dictates towards the filling of orders for each strategies. From Figure 6.11, it is shown that FGI is accumulated more in pure push agian supports the existing theory. However, the pure-pull stsrategy performed well under FGI metrics but is clearly in the risk zone for sacrificing the fill rate.

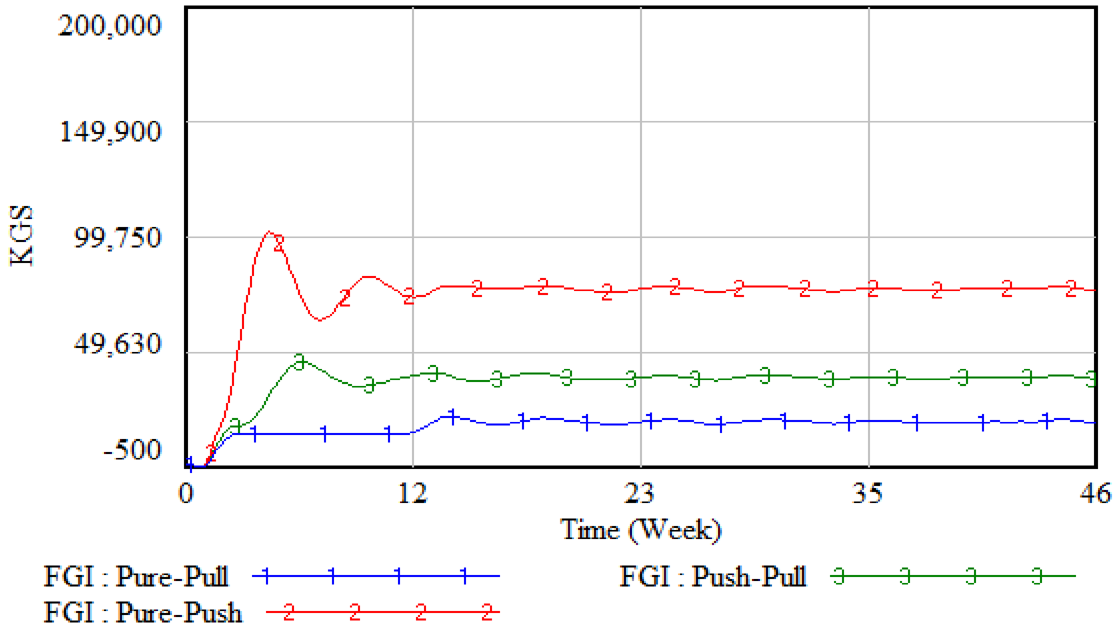

Figure 6. 11: FGI Comparison against Production Strategies

The average delivery delay found from the simulation shows that there is a trend of decreasing till the 4th week and then maintaining nearer to One week delivery delay. The sudden increase of the delivery delay in the first week is caused by the initial assumption of the model with limited order fulfilment in the first week. As can be seen from Figure 6.12, the push-pull model converges before the rest and said to be the optimal model regarding delivery delay metrics. In reality, however, this is supposed to be large but is less than the target delivery delay set by the company.

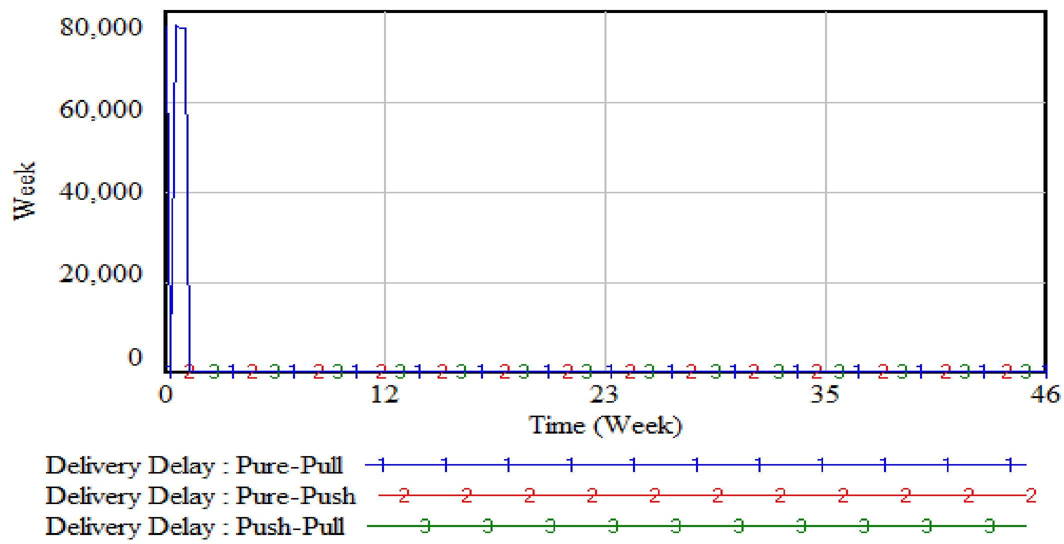

Figure 6. 12: Delivery Delay among Production Strategies

The other ISC metrics which has a direct relationship with the rest of metrics is capacity utilization. This is the line capacity which can show how efficient the flow of materials allowed to satisfy all parties in the lines. The capacity utilizations especially in the secondary production lines for the three strategies are shown in Figure 6.13. From the figure, it can be inferred that there is cyclical pattern in pure-pull strategy to adjust the production to the available capacity. The affinity of this scenario towords inventory adjustment makes the model ideal. However, the rest models show satble capacity utilization with the most stable pattern is shown from pure-push model.

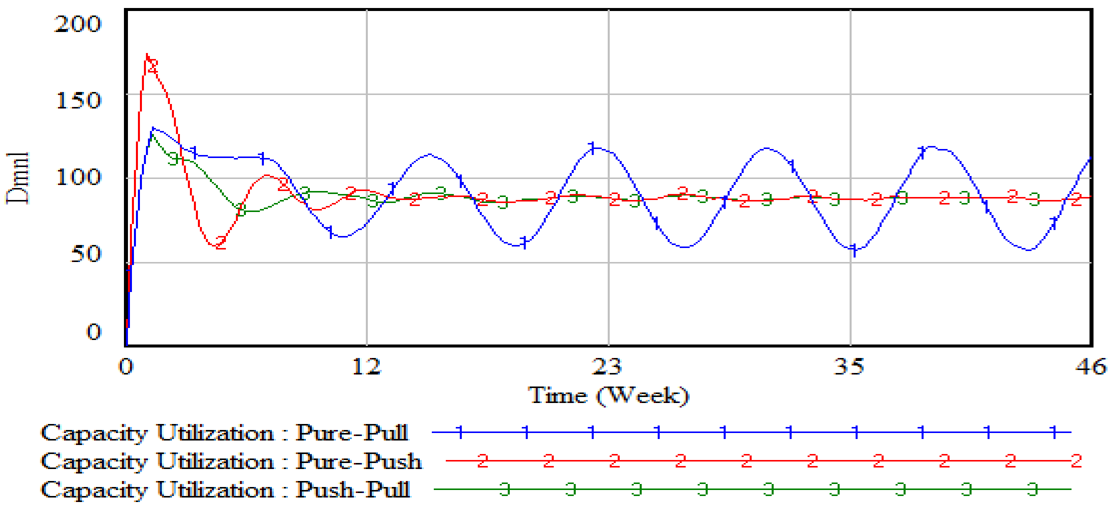

Figure 6. 13: Capacity Utilization for the Production Strategies

The ultimate objective of the model is finding the optimal fill rate amongst strategies. This metric is the final output to the metrics discussed so far. The fill rate is compared among the production strategies in Figure 6.14. From the figure, it can be claimed that the fill rate for all strategies is comparable except the slight advantage of the pure-pull over the rest of the models. This means that with the sacrificing of holding inventory and other capacities, pure-push performs nearer to the other two strategies. This premise can lead us that the pure-push strategy is not the proper strategy for the company in the study. Hence, one can select in between the pure-pull and push-pull strategy in taking care of risks associated in both cases. In the former cases, there is high risk of lost sales and for the latter one, there is high level of inventories in the lines.

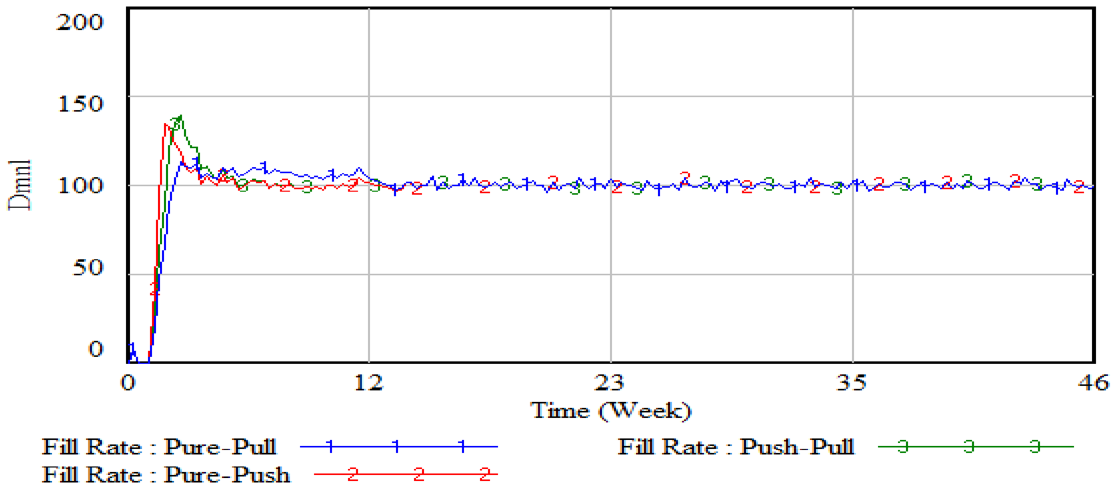

Figure 6. 14: Fill Rate Comparison among Production Strategies

6.9. Conclusions

An ISC is analyzed and modelled using SD and the possible SC measures are formulated to show the change of the measures over the time. It is found that the inventories are accumulated in the system at normal condition. However, it is found that with comparable fill rate, the pure-pull strategy performs more having low inventory levels that is input for efficiency. In the traditional SC of the company, large stocks are accumulated in the manufacturing line.

The delivery delay metrics are well performed under the Push-Pull strategy. It is also concluded that flexibility of capacity is attained in pure-pull strategy. In general, the performance metrics discussed favours the pure-pull strategy in this particular problem. However, the manager has to be curious in selecting the strategy between pure-pull and push-pull because, pure-pull strategy, the system works with small inventories in the lines that may need effective information sharing and the possible risk of lost sales. With minimum information investment, it is possible to decrease the line inventories without sacrificing fill rate in the case of push-pull. This idea will align with the recommendation of Corniani [2008] that cigarette companies are more efficient under push-pull production strategy.

Chapter 7

Conclusions and Scope for Future Work

In this thesis the proper SC strategies and metrics (operational and financial) are identified and tested on Ethiopian manufacturing SCs. The respective metrics for each strategy are matched and the dynamical relationship between the metrics and the improvement strategies are investigated. Accordingly, brief conclusions, contributions of the thesis, limitation of the study and the scope for future work are presented in the following section.

7.1. Conclusions

The main conclusions of this work are presented in 5 major findings from the respective chapters. The findings 1-5 corresponds to Chapter 2-6 respectively.

1. From critical analysis of literature presented in Chapter 2, following are the major findings:
   a. Inventory turnover, revenue growth and total inventory costs are the top common priorities for both academicians and practitioners. Metrics such as new product time to market and responsiveness are the common medium prioritized by both parties. Productivity and net margin metrics are the common low prioritized metrics by the academicians and practitioners.
   b. Researchers put ROA on the most common SCPM, while companies prefer customer satisfaction as the most common SCPM.
   c. Nine SCPM models are found from in literature and in practical world; namely, function based measurements, dimension based measurements, decisional level based measurements, balanced scorecard approach, SCOR model approach, nature of measures,

Theory of Constraints approach, competitive priorities based measurements and performance drivers based measurements.

2. From the work presented in Chapter 3, i.e., linking SC metrics to strategies following are the major findings:
    a. It is found that most of food and beverages, glass, ceramics and plastics, and consumer products use efficient SCs. Most companies in textiles, clothing and leather, and metals and machinery falls into agile category. Most of chemicals and construction companies falls under risk-hedging SCs. The majority of wood, paper and furniture, and transportation equipment comes under responsive SC strategy.
    b. The favorability of particular strategy depends on kind of ownership, position of the company in the SC and size. For instance, private companies favor efficient SCs, manufacturers favor agile SC while small and large companies favor the efficient and responsive SCs respectively.
    c. It is found that there are a subset of metrics unique to each of the supply chain strategies, while few metrics are common to two or more strategies varying the degree.
3. From the comparison of financial performance of Ethiopian companies, presented in Chapter 4, following are the major findings:
    a. ROA, revenue growth, operating margin, profit margin and revenue per employee are identified as the main metrics.
    b. Ethiopian SCs are performing well in revenue growth metric and low in revenue per employee metric.
    c. In general Tobacco and Beverage SCs performs better under the financial metrics against the benchmarks. However, personal care SCs are performing low compared with other industry verticals.
4. From the empirical study of SC operational practices and metrics, presented in Chapter 5, following are the major findings:
    a. With 5% significance level, firms significantly vary in their new product development, flexibility of production process, innovation, the extent of 'made to order' production and production process automation.
    b. It was also discovered that, these five alcohol and liquor firms are significantly differ in all SC performance metrics except in faster delivery service to customer in comparison with their competitors.

5. From the SD modelling of Tobacco SC, presented in Chapter 6, the major findings are:
   a. The inventories are accumulated in the system at normal condition.
   b. Irrespective of the type of strategy, the fill rate became stable after 12 weeks.
   c. In push strategy, large stocks are accumulated in the manufacturing line.
   d. Push-Pull strategy performed well with respect to delivery delay metrics.
   e. Pure-pull strategy happened to be the best strategy with respect to most of the performance metrics.

7.2. Contribution of the Thesis

Identifying the commonly applied SCPM is highly essential. Hence, the thesis contributes by identifying the commonly applied metrics and models by both academicians and practitioners. The thesis also contributes in developing the SCPM framework through which the SCs are measured. Supply chain strategy is directly adopted from Lee [2002] classification. While the research is done on one of the developing countries, it has significant contribution to the SCM academicians and practitioners. It has also advantage for Ethiopian and foreign industries. For Ethiopian industries, it helps to identify SCS to compete effectively and to evaluate how well SC models fit with theoretical findings and suggestions. For foreign industries, it shows the position of Ethiopian manufacturers towards SCM for further collaboration and entry into the country using the industries as partners. Regardless of the difficulty in the interdependence of the SC measures, this work is one of the insightful studies in matching SC measures to the strategies using sufficient samples in the same country.

Supply chain is mainly associated with global sourcing. As western nations opt for cheap raw material and labor in Asia saturates, there is no doubt that they will turn to African countries who have relatively growing economy and better infrastructure like Ethiopia, Kenya, Tanzania, Botswana Nigeria, etc.. The move to low cost country sourcing was made not only to increase competitiveness by cost reduction but also to gain access to low cost country markets. Hence, this study clearly shows to those leading supply chain companies how the supply chain in Ethiopia performs and what are the actual gaps in performance to further collaborate with them. Financial measures are used because managers are practically sensitive to cost or financial measures in order to understand the size and overall efficiency of any supply chain.

The other contribution of the thesis is the investigation of dynamic change of the SCPM over time. The thesis clearly put the dynamic change of the SCPM variables using SD modelling. The dynamic and interdependence nature of the metrics is validated on Tobacco SC. Hence, this research will contribute to the theory of SD in SC metrics and improving SCSs in Ethiopian Tobacco SCs in practice.

7.3. Limitations of the Research

Though the study is one of the first in Ethiopian SCs, it is not without flaws. The research findings from the empirical testing to formulate the theory need to include those wide geographical locations. Since SCM issues are new to the World in general and Ethiopia in particular, the same problem needs to be tested on developed nations as a complement to strengthen the theory. The sample size should be increased for better accuracy in result. The other limitation of the study is the coverage of types of industries. In this study consumer goods and alcoholic and liquor SCs have covered in more detail and the others in lesser intensity. Though the gaps in the performance of the supply chains were studied, the causes of their underperformance were not included. Since different types of industry need different strategyand measures, all industry verticals need to be addressed inclusively. Due to the complex structure of a supply chain, only the metrics of internal supply chain are considered. Finally, due to the short of the budget and time, all industries are not included in this study.

7.4. Scope for Future Work

In this thesis the proper metrics for SC performance have been identified from literature and companies' performance data and tested on different supply chains found in Ethiopia. The work can be extended to investigate the level of impact of these metrics on firm's competitiveness and overall profitability. The SC measures and strategies identified in this research are purely based on the survey from the experts using relative perception approach. Measuring in absolute terms can be considered as a future work. The SD methodology used in this thesis can be extended by including more parties of the SC for better understanding of the interdependencies between the SC partners.

Appendices

Appendix I: Questionnaire-Supply Chain Characteristics for Main Product Line

Variable	Item
ES1	To what extent is it important in the overall SC design to minimize cost
ES2	To what extent is it important is the inventory strategy to minimize inventory throughout the chain
ES3	To what extent is it important in the resource strategy to maintain high average utilization rate in the chain
ES4	To what extent is it important in the lead time strategy to reduce lead time at restricted cost
ES5	To what extent do you agree maintaining long term relationship with suppliers
ES6	To what extent do you agree that your company's supplier selection criterion is based on quality and cost
RS1	To what extent do you agree that maintaining capacity flexibility for demand uncertainty
RS2	To what extent do you agree that keeping excess buffer inventory for demand uncertainty
RS3	To what extent is it important in the lead-time strategy to invest aggressively in ways to reduce lead-time?
RS4	To what extent do you agree that your company's supplier selection criterion is based on flexibility, reliability and quality?
RS5	To what extent do you agree that your company use high level of modular design?
RS6	To what extent is it important in the overall SC design to respond quickly to demand?
RHS1	To what extent do you agree that your company has high level of electronic market that reaches more suppliers?
RHS2	To what extent do you agree that your company shares safety stock with other companies
RHS3	To what extent do you agree that your company pools of inventories and resources?
RHS4	To what extent do you agree that your company make future contracts that lock-in price and delivery?
RHS5	To what extent do you agree that your company maintains capacity flexibility for supply uncertainty?
RHS6	To what extent do you agree that your company has excess buffer inventory for supply uncertainty?
AS1	To what extent do you agree that your company has high level of information accuracy between partners?
AS2	To what extent do you agree that your company keep excess manufacturing capacity?
AS3	To what extent do you agree that your company maintain excess buffer inventory for both raw materials and finished inventories?
AS4	To what extent do you agree that your company has high delivery flexibility?
AS5	To what extent do you agree that your company has high level of new product flexibility?
AS6	To what extent do you agree that your company has high level of responsiveness to volatile markets?

Appendix II: Questionnaire-Supply Chain Performance

Variable	Item
PM1	To what extent your company perform compared with your competitors in terms of average inventory level?
PM2	To what extent your company perform compared with your competitors in terms of backorder or stock-out?
PM3	To what extent your company perform compared with your competitors in terms of capacity utilization?
PM4	To what extent your company perform compared with your competitors in terms of cash to cash cycle time?
PM5	To what extent your company perform compared with your competitors in terms of COGS?
PM6	To what extent your company perform compared with your competitors in terms of customer complaints?
PM7	To what extent your company perform compared with your competitors in terms of customer response time?
PM8	To what extent your company perform compared with your competitors in terms of delivery changes?
PM9	To what extent your company perform compared with your competitors in terms fill rate?
PM10	To what extent your company perform compared with your competitors in terms of forecast accuracy?
PM11	To what extent your company perform compared with your competitors in terms information sharing?
PM12	To what extent your company perform compared with your competitors in terms of information accuracy?
PM13	To what extent your company perform compared with your competitors in terms of inventory turns?
PM14	To what extent your company perform compared with your competitors in terms manufacturing lead time?
PM15	To what extent your company perform compared with your competitors in terms of new product introductions?
PM16	To what extent your company perform compared with your competitors in terms of on time deliveries?
PM17	To what extent your company perform compared with your competitors in terms of product mix?
PM18	To what extent your company perform compared with your competitors in terms of profit?
PM19	To what extent your company perform compared with your competitors in terms of return on assets?
PM20	To what extent your company perform compared with your competitors in terms of return on investments?
PM21	To what extent your company perform compared with your competitors in terms of revenue growth?
PM22	To what extent your company perform compared with your competitors in terms of revenue per employees?
PM23	To what extent your company perform compared with your competitors in terms of safety stock level?
PM24	To what extent your company perform compared with your competitors in terms of total cost of manufacturing?
PM25	To what extent your company perform compared with your competitors in terms of shipping errors?
PM26	To what extent your company perform compared with your competitors in terms of SCM cost?
PM27	To what extent your company perform compared with your competitors in terms of unit cost of manufacturing?
PM28	To what extent your company perform compared with your competitors in terms of value added employee productivity?
PM29	To what extent your company perform compared with your competitors in terms of volume changes?
PM30	To what extent your company perform compared with your competitors in terms of warranty or return processing cost?

Appendix III: Financial Performance Measures for Best Consumer Goods Supply Chains in the World

	Year				
Financial Metrics	**2008**	**2009**	**2010**	**2011**	**2012**
Unilever (millions of pound)					
Revenue	40523	39823	44262	46467	51324
Net Income	5285	3659	4598	4623	4948
No of employees	174000	168000	165000	169000	172000
Total assets	36142	37016	41167	47512	46166
Operating Income	7167	5020	6339	6433	6989
ROA	14.39	10	11.76	10.43	10.56
Revenue Growth	0.84	3.5	4.1	6.5	10.5
Operating Margin	17.69	12.61	14.32	13.84	13.62
profit margin	13.04	9.19	10.39	9.95	9.64
RPE*	0.23289	0.23704	0.26825	0.27495	0.2984
Average RPE	0.17915	0.18234	0.20635	0.2115	0.22953
P&G					
Revenue	77714	75295	77767	81104	83680
Net Income	12075	13436	12736	11797	10756
No of employees	135000	132000	127000	129000	126000
Total assets	143992	134833	128172	138354	132244
Operating Income	15743	15188	15732	15495	13292
ROA	9	9.64	9.68	8.85	7.95
Sales Growth	9.31	-3.11	3.28	4.29	3.18
Operating Margin	20.26	20.17	20.23	19.11	15.88
profit margin	15.54	17.84	16.38	14.55	12.85
RPE	0.57566	0.57042	0.61234	0.62871	0.66413
Colgate Palmolive					
Revenue	15330	15327	15564	16734	17085
Net Income	1957	2291	2203	2431	2472
No. of employees	36600	38100	39200	38600	37700
Total assets	9979	11134	11172	12724	13394
Operating Income	3265	3615	3796	3858	3889
ROA	19.48	21.7	19.75	20.35	18.93
Sales Growth	11.17	-0.02	1.55	7.52	2.1
Operating Margin	21.3	23.59	24.39	23.05	22.76
profit margin	12.77	14.95	14.15	14.53	14.47
RPE	0.41885	0.40228	0.39704	0.43352	0.45318
Kimberly Clark					
Revenue	19415	19115	19746	20846	21063
Net Income	1829	1994	1943	1684	1828
No of employees	58000	57000	57000	56000	53000
Total assets	18089	19209	19864	19373	19873
Operating Income	2547	2825	2773	2442	2686
ROA	10.01	10.69	9.95	8.58	9.32
Sales Growth	6.29	-1.55	3.3	5.57	1.04
Operating Margin	13.12	14.78	14.04	11.71	12.75
profit margin	9.42	10.43	9.84	8.08	8.68
RPE	0.33474	0.33535	0.34642	0.37225	0.39742

RPE (Revenue per employee) in millions of USD   RPE* in millions of Euros

Appendix IV: Financial Performance Measures for FMCG Supply Chains in Ethiopia

ROA Metric Value

Company	Year				
	2008	**2009**	**2010**	**2011**	**2012**
East Africa Companies	3.11	3.43	3.54	4.53	5.68
MOHA Soft Drinks	7.44	8.04	9.86	9.11	8.25
Ethiopian Pulp & Paper SC	4.32	5.09	6.85	7.42	7.56
Zenith Gebs-Eshet	6.44	7.8	7.65	8.47	8.06
Oxford Companies	5.65	5.34	6.08	5.81	7.02
Fafa Food Factory	3.44	4.21	3.54	4.03	4.87
Health Care Foods	4.86	4.95	5.01	5.22	5.54
Kaliti Food Factory	4.74	5.32	5.98	6.05	6.72
K.O.J.J. Food Complex	4.04	4.92	5.12	5.9	5.74
Shewa Bakery	4.98	4.34	5.58	6.03	6.11
Wonji Sugar Factory	3.06	3.34	4.23	4.12	5.46
Awash Wines	6.44	5.67	5.78	6.36	6.45
East African Bottling	7.34	7.58	8.03	8.25	8.44
Great Absynian Water	6.64	6.78	7.13	6.94	7.05
EPHARM	2.26	2.67	2.33	3.12	3.41
Repi Soap Detergents	4.43	4.15	5.35	6.7	6.24
Star Soap and Detergents	4.63	4.47	4.28	3.98	5.23
Mekbeb Cosmotics	6.21	5.78	6.63	6.99	6.54
Dugde Agro Company	8.23	8.86	9.03	9.42	9.22
Yekatit Paper Converting SC	5.52	5.67	6.34	5.18	5.56
MAMCO	4.11	4.85	4.94	5.06	6.14
National Tobacco SC	7.13	8.45	8.89	9.26	9.84
Kokeb Pasta and Macaroni	4.28	4.87	5.21	5.55	6.82
Addis Modjo Edible Factory	8.01	8.25	7.93	8.04	8.37
Hakammaz Confectioneries	3.32	2.95	2.75	3.03	3.94
Standard (benchmark)	**13.22**	**13.01**	**12.79**	**12.05**	**11.69**

Revenue Growth Metric Value

Company	Year				
	2008	**2009**	**2010**	**2011**	**2012**
East Africa Companies	6.49	7.13	8.94	8.86	12
MOHA Soft Drinks	8.08	12	10.56	11.03	12.36
Ethiopian Pulp & Paper SC	5.67	6.63	5.54	8.22	8.71
Zenith Gebs-Eshet	2.43	3.56	4.43	4.9	5.07
Oxford Companies	3.06	3.85	4.04	5.94	6.14
Fafa Food Factory	4.09	4.24	4.65	5.8	7.21
Health Care Foods	3.12	2.99	3.24	3.35	3.69
Kaliti Food Factory	5.67	5.77	6.24	6.8	7.15
K.O.J.J. Food Complex	6.27	6.63	7.12	7.38	7.46
Shewa Bakery	6.11	7.02	7.29	7.78	8.06
Wonji Sugar Factory	7.45	7.61	7.78	8.02	8.13
Awash Wines	7.19	7.37	8.09	8.15	8.64
East African Bottling	8.24	9.04	9.94	10.65	11.12
Great Absynian Water	7.45	7.56	8.03	8.13	8.9
EPHARM	4.44	4.49	4.3	5.17	5.56
Repi Soap Detergents	3.3	4.19	4.47	5.02	5.55
Star Soap and Detergents	3.57	4.04	4.17	4.96	4.63
Mekbeb Cosmotics	7.14	8.56	8.84	9.04	9.92
Dugde Agro Company	5.27	7.36	8.35	9.24	9.97
Yekatit Paper Converting SC	6.03	7.14	8.38	8.87	9.45
MAMCO	6.64	7.18	8.03	8.84	9.08
National Tobacco SC	8.32	9.76	11.04	12.65	12.68
Kokeb Pasta and Macaroni	4.34	5.02	6.16	7.31	7.72
Addis Modjo Edible Factory	10.25	11.02	9.53	10.79	11.48
Hakammaz Confectioneries	4.27	4.96	5.72	5.93	6.33
Standard (benchmark)	**6.9**	**-0.3**	**3.06**	**5.97**	**4.21**

Operating Margin Metric Value

Company	Year				
	2008	**2009**	**2010**	**2011**	**2012**
East Africa Companies	10.34	11.23	9.03	12.56	12.76
MOHA Soft Drinks	7.65	8.6	8.76	8.95	9.25
Ethiopian Pulp & Paper SC	11.45	12.68	11.45	12.78	13.91
Zenith Gebs-Eshet	7.34	9.43	11.09	11.54	11.83
Oxford Companies	8.72	9.74	9.91	11.62	12.69
Fafa Food Factory	7.35	6.71	7.12	8.27	9.68
Health Care Foods	6.59	6.46	6.71	6.85	7.15
Kaliti Food Factory	8.14	8.24	8.71	9.27	9.62
K.O.J.J. Food Complex	8.74	9.1	9.59	9.85	9.93
Shewa Bakery	8.58	9.49	9.76	10.25	10.53
Wonji Sugar Factory	10.46	10.08	10.25	10.49	10.6
Awash Wines	10.31	10.49	11.21	11.27	11.76
East African Bottling	9.08	12.16	13.06	13.77	14.24
Great Absynian Water	10.57	10.68	11.15	11.25	12.02
EPHARM	9.32	7.61	7.42	8.29	8.68
Repi Soap Detergents	6.42	7.31	7.59	8.14	8.67
Star Soap and Detergents	6.69	7.16	7.29	8.08	7.75
Mekbeb Cosmotics	10.26	10.68	11.96	12.16	13.04
Dugde Agro Company	8.39	9.49	11.47	12.36	13.09
Yekatit Paper Converting SC	9.15	8.92	10.11	11.99	12.57
MAMCO	9.76	10.3	11.15	10.75	12.2
National Tobacco SC	11.44	12.88	14.16	15.77	15.8
Kokeb Pasta and Macaroni	7.13	7.81	8.95	10.1	10.51
Addis Modjo Edible Factory	13.04	13.81	12.32	13.58	14.27
Hakammaz Confectioneries	7.06	7.75	8.51	8.42	9.12
Standard (benchmark)	**18.09**	**17.79**	**18.25**	**16.93**	**16.25**

Profit Margin Metric Value

Company	Year				
	2008	**2009**	**2010**	**2011**	**2012**
East Africa Companies	8.83	9.05	9.95	10.55	11.04
MOHA Soft Drinks	6.65	7.45	6.85	7.09	8.04
Ethiopian Pulp & Paper SC	10.75	11.46	11.88	12.08	12.24
Zenith Gebs-Eshet	8.16	9.05	10.49	9.92	10.55
Oxford Companies	9.58	9.57	10.63	9.94	9.85
Fafa Food Factory	7.25	7.4	7.81	8.96	7.93
Health Care Foods	7.28	7.15	7.4	7.51	7.85
Kaliti Food Factory	8.83	8.93	9.4	9.96	10.31
K.O.J.J. Food Complex	9.43	9.79	10.28	9.83	10.62
Shewa Bakery	9.27	10.18	10.45	10.94	9.91
Wonji Sugar Factory	10.61	10.77	10.94	9.92	11.29
Awash Wines	10.35	9.12	11.25	11.31	11.8
East African Bottling	11.29	12.09	12.99	13.7	14.17
Great Absynian Water	10.5	10.61	11.08	11.18	11.95
EPHARM	7.49	6.95	7.35	8.22	8.61
Repi Soap Detergents	7.58	7.24	6.58	8.07	8.6
Star Soap and Detergents	6.62	7.09	7.22	6.68	7.68
Mekbeb Cosmotics	10.19	11.61	11.89	12.09	12.97
Dugde Agro Company	8.71	10.8	11.79	10.36	13.41
Yekatit Paper Converting SC	11.05	10.58	9.91	12.31	11.82
MAMCO	10.08	9.89	11.47	13.03	12.52
National Tobacco SC	11.76	13.2	14.48	16.09	16.12
Kokeb Pasta and Macaroni	7.78	8.46	9.6	10.75	11.16
Addis Modjo Edible Factory	13.69	14.46	12.97	14.23	14.92
Hakammaz Confectioneries	7.71	8.4	9.16	9.37	9.77
Standard (Benchmark)	**15.75**	**16.35**	**16.3**	**14.82**	**14.5**

Revenue per Employee Metric Value

Company	Year				
	2008	2009	2010	2011	2012
East Africa Companies	0.123	0.126	0.135	0.136	0.138
MOHA Soft Drinks	0.01	0.013	0.021	0.022	0.026
Ethiopian Pulp & Paper SC	0.01	0.013	0.016	0.018	0.019
Zenith Gebs-Eshet	0.005	0.007	0.008	0.007	0.009
Oxford Companies	0.01	0.01	0.011	0.022	0.023
Fafa Food Factory	0.011	0.012	0.012	0.012	0.012
Health Care Foods	0.019	0.02	0.021	0.021	0.022
Kaliti Food Factory	0.004	0.005	0.005	0.005	0.005
K.O.J.J. Food Complex	0.009	0.009	0.009	0.01	0.01
Shewa Bakery	0.001	0.002	0.002	0.002	0.002
Wonji Sugar Factory	0.007	0.007	0.006	0.006	0.008
Awash Wines	0.01	0.01	0.01	0.01	0.01
East African Bottling	0.044	0.005	0.045	0.005	0.006
Great Absynian Water	0.009	0.008	0.009	0.009	0.009
EPHARM	9E-04	0.001	0.011	0.01	0.011
Repi Soap Detergents	0.012	0.012	0.013	0.013	0.013
Star Soap and Detergents	0.019	0.02	0.02	0.021	0.021
Mekbeb Cosmotics	0.013	0.013	0.014	0.014	0.014
Dugde Agro Company	0.005	0.006	0.006	0.006	0.006
Yekatit Paper Converting SC	0.003	0.004	0.003	0.003	0.004
MAMCO	0.008	0.008	0.009	0.009	0.01
National Tobacco SC	0.03	0.03	0.03	0.03	0.03
Kokeb Pasta and Macaroni	0.007	0.007	0.007	0.007	0.008
Addis Modjo Edible	0.02	0.02	0.021	0.021	0.02
Hakammaz Confectioneries	0.004	0.004	0.004	0.004	0.005
Standard (Benchmark)	**0.377**	**0.373**	**0.391**	**0.412**	**0.436**

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1. Dagne Birhanu, Krishinanand Lanka and A. Neelakanteswara Rao, Linking supply chain measures with supply chain strategies, International Conference on Performance Measurements, PMA, Edinburgh, 2016.
2. Dagne Birhanu, Krishinanand Lanka and A. Neelakanteswara Rao, Increasing traceability and visibility of the supply chain using system dynamics modelling approach, International Conference on E-Business and Supply Chain Competitiveness, IIT Karagpur, 2016.