Development of a Comprehensive Supply Chain Performance Measurement System: A Case Study in the Grocery Retail Industry

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Submitted to the Engineering Systems Division in Partial Fulfillment of the Requirements for the Degree of

Master of Engineering in Logistics

at the

Massachusetts Institute of Technology

June 2004

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Abstract

While companies are looking for a single solution or a set of metrics that they can apply to measure their supply chain performance, it is clear that such a single solution does not exist. An effective supply chain performance measurement system has to align with a company's own supply chain processes. This thesis, based on the research of several established performance measurement models including the Balanced Scorecard and the SCOR Model, provides a framework for companies to build their supply chain performance measurement systems in-house.

This thesis recommends a roadmap consisting of eight steps for companies to follow in the design and implementation phases of establishing a supply chain measurement system. The result is a set of 21 performance metrics is proposed that can be used by a company in the grocery retail industry to measure the efficiency of its supply chain. This metric set is well balanced because it encompasses six different criteria: comprehensive, causally oriented, vertically integrated, horizontally integrated, internally comparable, and useful. In conclusion, it is critical for companies from different industries to custom-tailor their own set of performance metrics, based on a careful evaluation of their individual business processes and supply chain performance objectives, that will allow management to do a better job utilizing existing capital resources and planning for strategic change and business development.

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Acknowledgements

First of all, I would like to thank Dr. Chris Caplice, my thesis advisor. He has shared his insights and provided valuable guidance through the process of thesis creation. I truly appreciate his effort and encouragement.

I would also like to thank Mike Griswold from the supermarket chain. His support and help in sharing immense industry knowledge and information enriched this thesis. Without his commitment and time, this thesis would not be as practical as it is now.

Thanks to the professors and fellow classmates in the MLOG program. They have made my learning experience at MIT enjoyable and invaluable. Special thanks go to Mr. Larry Lapide, Research Director at MIT's Center for Transportation and Logistics, who provided me with much needed initial guidance which turned into a road map that I was able to easily follow.

Finally, and most importantly, I would like to thank my parents and my family who have supported me with their love and patience throughout my education as well as every stage in my life.

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Chapter 1. Introduction

Performance measurement is not a new topic. Although performance measurement in supply chains may appear to be a relatively recent phenomenon, performance measurement in the business world can be traced to the eighteenth century. Philosopher Jeremy Bentham recognized more than 200 years ago the power of public accountability. He wrote: "The more strictly we are watched, the better we behave." (Jeremy Bentham, quoted in Hood et al. 1999) Bentham foresaw as far back as the eighteenth century the power that managers exercise today: using a performance system that combines quantitative figures along with public disclosure helps companies focus on their goals and perform better.

The earlier era of performance measurement management in the industrial supply chain was focused on production. In operations such as automobile production, there are plentiful tangible processes that can be precisely measured and monitored. However, in the modern economy, companies are not mass production driven anymore but knowledge-oriented production driven. In this environment, companies focus more on intangible processes in the supply chain functions, such as customer service. As a result, different performance measurement metrics have thrived in the past decades. Companies are also starting to pay attention to develop an entire performance measurement system instead of individual metrics in measuring supply chain performance.

While the trends and philosophies described previously are applied to all industries, their effects on particular sectors are various. One particular sector is the grocery retailing industry, which is the focus of this thesis. The grocery retailing industry must deal with certain characteristics that make their industry unique. One of these characteristics is the low margin, high volume nature of the business. Since the products are almost non-differentiable among competitors, low product price and high availability on shelves are the main competing points. As a result, supply chain strategies are developed to streamline delivery processes and maintain the lowest cost possible. When this type of approach is used, it becomes necessary to have a balanced supply chain measurement system to monitor the tradeoffs between customer service and carrying cost.

Objective

This thesis is a case study of building a supply chain performance measurement system in a grocery retail company. It provides a step-by-step working guide of developing and implementing a supply chain performance measurement system in the company. The research is based on real data from a regional supermarket chain, and interviews with supply chain professionals within the company. The thesis aims to provide a new and easy-to-implement methodology/solution for supply chain metric selecting and performance measurement system modeling by studying performance measurement models developed in the past decades, including TQM, the Balanced Scorecard, and the Supply Chain Operations Reference Model (SCOR Model).

Chapter 2. Literature Review

In this chapter, performance measurement models currently in practice are reviewed, including TQM (Total Quality Management), the Balanced Scorecard, and the SCOR (Supply Chain Operational Reference) Model. In addition, several researchers' views on supply chain performance measurement are introduced and briefly discussed.

2.1 Why metrics?

You cannnot improve what you cannot measure. Measuring performance is the first step for managers to improve any decision-making process in a company. Without understanding the current performance, there is no baseline for managers to set up an improvement plan; in other words, a company is flying blind.

For each decision-making process in a company, managers should consider these three questions:

1. What is the company doing?

2. How well is the company doing?

3. How can the company demonstrate to others how well it is doing?

The answer to the first question should be the company's or department's strategy, as well as all the processes and activities done to support the strategy. Answering the other questions requires managers to define metrics, collect information/data, and analyze the data. Metrics must be developed based on the priorities of the company's strategy, which

provides the key business drivers and criteria for metrics that managers most desire to watch. Processes are then designed to collect information (such as surveys) relevant to these metrics and quantigy it for storage, display, and analysis. Managers then examine the outcomes and track the results to provide feedback and guide the company.

In sum, the value of metrics is in their ability to:

- Define the present status of the organization from many perspectives for decision-makers
- Provide feedback about processes to guide improvements on a continuous basis
- Identify trends in performance over time as the metrics are tracked
- Allow the company to align its strategic activities to the strategic plan
- Provide accountability and incentives based on real data, not anecdotes and subjective judgements
- Allow managers to identify best practices in the organization and expand their usage elsewhere
- Permit benchmarking of process performance in comparison with outside organizations

2.2 Why is supply chain performance measurement important?

According to Chibba and Horte (2003), several recent studies (Mason-Jones and Towill (1998), Gunasekaran, Patel, and Tirtiroglu (2001), Simatupang, Wright, and Sridharan (2002), and Tan, Lyman, and Wisner (2002)) indicate that the improvements in an organization's supply chain can provide considerable benefits to organizations. Fadel and

Narayanan (1997) claim that streamlining operations of a supply chain leads to process efficiencies that translate into cost savings, better products, and improved customer service.

A number of researchers (Gunasekaran et al. (2001), Hoek (2001), Landeghem and Persoons (2001), Otto and Kotzab (2001)) have tried to outline how to measure the efficiency of the integrated supply chain. According to PRTM Consulting Management[1], "cross-industry studies show that integrated supply-chain management typically yields the following results:

- 25–50% reduction in total supply chain costs
- 25–60% reduction in inventory-holding
- 25–80% increase in forecast accuracy
- 30–50% improvement in order-fulfillment cycle time"

2.3 What should be considered when developing a supply chain performance measurement system?

Traditionally, companies have measured their performance primarily based on financial accounting principles. However, in the past decades, researchers have recognized the weaknesses and vagueness of previous management approaches and have identified several criteria to consider when developing a supply chain performance measurement system. The suggested criteria from these studies are summarized in Table 1.

[1] http://www.prtm.com/

Table 1 - Summary of Researchers' Views in Supply Chain Measurement Criteria

Hausman (2002)	Reimer (1997)	Caplice & Sheffi (1995)
Service	Quality	Customer Satisfaction
Assets	Cost	Financial Result
Speed	Speed	Internal Process Efficiency

Lambert and Pohlen (2001) define a framework for developing metrics which consists of seven steps: 1) map the supply chain, 2) analyze each link, 3) develop profit and loss statements, 4) realign supply chain processes, 5) align non-financial measures with P&Ls, 6) compare across firms, and 7) replicate. They conclude that many measures identified as supply chain metrics are actually measures of internal logistics operations. Furthermore, they observe that most of the literature has focused on analyzing and categorizing performance measurement systems but little research has been devoted to supply chain performance measures. They also suggest that research is needed to determine what should be measured, when, and why.

Hausman (2002) suggests that companies must focus on two dimensions of performance (multi-functional and cross-enterprise) to ensure supply chain integration. He argues that the overall performance of factories could actually decrease despite the positive results of their cost-related performance measure. Likewise, companies that have outstanding improvements in their own operational performance do not necessarily increase the end-consumers' satisfactions due to the overall poor performance of the supply chain. Therefore, businesses need to migrate from single-dimensional measures to multi-

dimensional ones, and from a single-enterprise focus to a cross-enterprise focus. Businesses that use multi-dimensional performance measures should recognize that not all dimensions are equally important, and some tradeoffs are necessary. According to Hausman, supply chains need to perform on three key dimensions: Service, Assets, and Speed.

Reimer (1997) proposes that the primary purpose of measurements is to change behavior and the secondary purpose is to determine the condition of the system that is being monitored. To predict how a changed behavior will alter a company's system response, a thorough understanding of the system dynamics is required and measurements are a way to check on the health of the system. He identifies three main types of goals for metrics: Cost, Quality, and Speed. He argues that there is a dynamic tension between these vertices; therefore, multiple metrics are needed in order to ensure balance within the business process. He also suggests management's responsibilities with metric selection and use as follow: 1) ensure the metric is actionable; 2) ensure the metric meets proper criterion; 3) communicate the metric results; 4) delineate ownership of data collection and analysis; and 5) take proper behavioral actions with out of control data points.

Caplice and Sheffi (1995) suggest that performance metrics should be selected and maintained as a system, so metrics can complement and support each other and provide the decision makers with a well balanced picture of the logistics process. They argue that, however, in practice, performance measurement systems are often not formally managed or evaluated. To address this issue, they further propose a set of evaluation criteria for supply chain performance measurement systems, which I will discuss in detail in the

following chapter (Chapter 3 Methodology). They also note that while there are a large number of potential performance dimensions, the three most basic ones are Customer Satisfaction, Internal Process Efficiency, and Financial Results. They suggest management include other dimensions if they are relevant to a company's long-term performance.

2.4 What performance measurement models are currently in practice?

Over the last decade, a variety of measurement approaches have been developed, including:

- The Balanced Scorecard
- The TQM (Total Quality Management)
- The SCOR Model (Supply Chain Operational Reference Model)

2.4.1 The Balanced Scorecard[2]

The Balanced Scorecard was developed in the early 1990's by Drs. Robert Kaplan and David Norton. The Balanced Scorecard approach provides a clear prescription as to what companies should measure in order to 'balance' the financial perspective. The Balanced Scorecard is not only a measurement system but also a management system that enables organizations to clarify their vision and strategy and translate them into action. It provides feedback around both the internal business processes and external outcomes in order to continuously improve strategic performance and results.

[2] The Balanced Scorecard Institute
http://www.balancedscorecard.org/

Kaplan and Norton (1996) describe the balanced scorecard as follows:

> "The balanced scorecard retains traditional financial measures. But financial measures tell the story of past events, an adequate story for industrial age companies for which investments in long-term capabilities and customer relationships were not critical for success. These financial measures are inadequate, however, for guiding and evaluating the journey that information age companies must make to create future value through investment in customers, suppliers, employees, processes, technology, and innovation."

The Balanced Scorecard suggests that managers view the organization from four perspectives, and develop metrics, collect data and analyze it relative to each of these perspectives:

- The Financial Perspective
- The Customer Perspective
- The Business Process Perspective
- The Learning and Growth Perspective

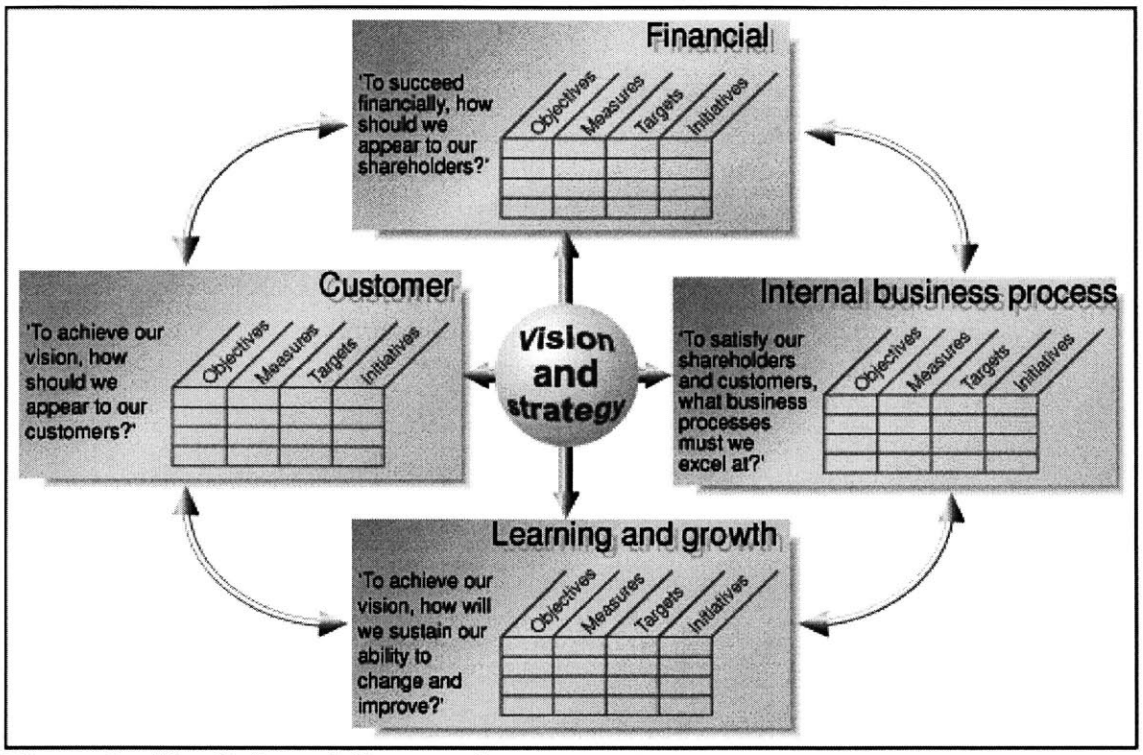


Figure 1 – The Balanced Scorecard
Source: http://www.cscresearchservices.com/foundation/library/iscont/RP04.ASP

- The Financial Perspective: *What financial steps are necessary to ensure the execution of the company strategy?*

Kaplan and Norton do not disregard the traditional need for financial data. But the point is that the current emphasis on financials leads to an "unbalanced" situation with regard to other perspectives. Some examples of metrics in this perspective are: Manufacturing Costs, Warehousing Costs, and Transportation Costs.

- The Customer Perspective: *Who are the company's targeted customers, and what is the company's value proposition in serving them?*

Customers are the source of company revenue. If customers are not satisfied, they will eventually find other suppliers to meet their needs. Therefore, poor performance from this

perspective is a leading indicator of the company's future decline, even though the current financial picture may look good. Some examples of metrics from this perspective are: Fill Rate, Backorder Levels, and On-Time Delivery.

- The Internal Process Perspective: *To satisfy customers and shareholders, at what processes must the company excel?*

Metrics based on this perspective allow the managers to know how well their business is running, and whether its products and services conform to customer requirements. Unlike other performance systems that tend to focus on the incremental improvement of current organizational processes, Balanced Scorecard focuses on strategy and the interaction among objectives and measures, leading to the possible development of entirely new processes to drive customer and sharehoulder value. Some examples of metrics in this perspective are: Adherence-To-Plan and Forecast Error.

- The Employee Learning and Growth Perspective: *What capabilities and tools do employees require to help them execute company strategy?*

This perspective includes employee training and corporate cultural attitudes related to both individual and corporate self-improvement. Kaplan and Norton (1996) emphasize that "learning" is more than "training"; it also includes things like mentors and tutors within the organization, as well as that ease of communication among workers that allows them to readily get help on a problem when it is needed. In any case, learning and growth are the essential foundation for success of any knowledge-worker organization. Some examples of metrics in this perspective are: In house Training Hours, APICS Membership/ Certification.

2.4.2 Total Quality Management (TQM)

TQM is a philosophy, a set of guiding principles, and actions which compel an entire organation to excellence and efficiency in personal and corporate activities. It is the application of quantitative methods, technical tools, and management techniques to improve all the processes within an organiztion and continously exceed customer needs.

According to Besterfield (Besterfield et al., 2003), TQM requires six basic concepts:

1. A committed and involved management to provide long-term top-to-bottom organizational support
2. An unwavering focus on the customer, both internally and externally
3. Effective invovement and utilization of the entire work force
4. Continuous improvement of the business and production process
5. Treating suppliers as partners
6. Establish performance measures for the processes

Garvin (1988) identified eight dimensions of quality. The table below shows these eight dimensions with their meanings and explanations. These dimensions are somewat independent; therefore, a product or service can be excellent in one dimension and average or poor in another.

Table 2 - Eight Dimensions of Quality

Dimensions	Meaning and Example
Performance	Primary operating characteristics of a product or service, such as the service speed in the fast food industry.
Features	Secondary characteristics, added features that supplement the

	product's/service's basic functioning. One example is free drinks on a plane flight.
Conformance	The degree to which a product's/service's design and operating characteristics meet pre-established standards. One common measure is the frequency of repairs under warranty.
Reliability	Consistency of performance over time. Among the most common measures of reliability are the mean time of first failure, the mean time between failures, and the failure rate per unit time.
Durability	Product useful life, including repair. One example is estimated product lives for refrigerators.
Serviceability	Resolution of problems and complaints: the speed, courtesy, competence, and ease of repair. One example is the timeliness with which service appointments are kept.
Aesthetics	Sensory characteristics: how a product looks, feels, sounds, tastes, or smells.
Perceived quality	Past performance and other intangibles, such as images, advertising, brand names. Reputation is one of the primary contributors to perceived quality.

2.4.3 The SCOR (Supply Chain Operations Reference) Model [3]

Developed by the Supply-Chain Council (SCC), the Supply Chain Operations Reference-model (SCOR) segregates key supply-chain management processes and matches their process elements against best practices and benchmarking performance data, providing users with a framework for understanding where they need to make improvements. The SCOR-model builds on the concepts of business process reengineering, benchmarking, and process measurement by integrating their techniques into a cross-functional framework that addresses management issues at the enterprise rather than at the

[3] Supply-Chain Council Inc. http://www.supply-chain.org

functional level. The SCOR-model itself contains several sections and is organized around the five primary management processes of Plan, Source, Make, Deliver, and Return (shown in Figure 2).

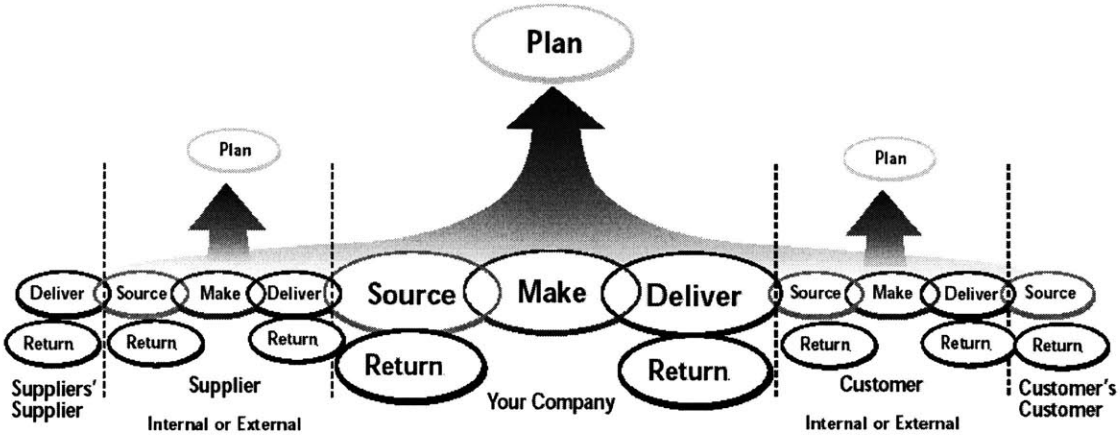


Figure 2 - SCOR is organized around five major management processes.
Source: Supply-Chain Operations Reference-model (SCOR) 6.0 Introduction

While the SCOR-model can span to all customer interactions, all physical material transactions from supplier's supplier to customer's customer, and all market interactions, it does not attempt to describe every business process or activity. Moreover, the SCOR-model does not address the following functions such as sales and marketing, research and development, and some elements of post-delivery customer support.

As shown in Figure 3 in the following page, the SCOR-model is designed and maintained to support supply chains of various levels of complexity that extend across multiple industries. The Supply Chain Council has focused on three process levels (Top level, Configuration Level, and Process Element Level) and does not attempt to prescribe how a particular company should conduct its business or change its systems and information flows.

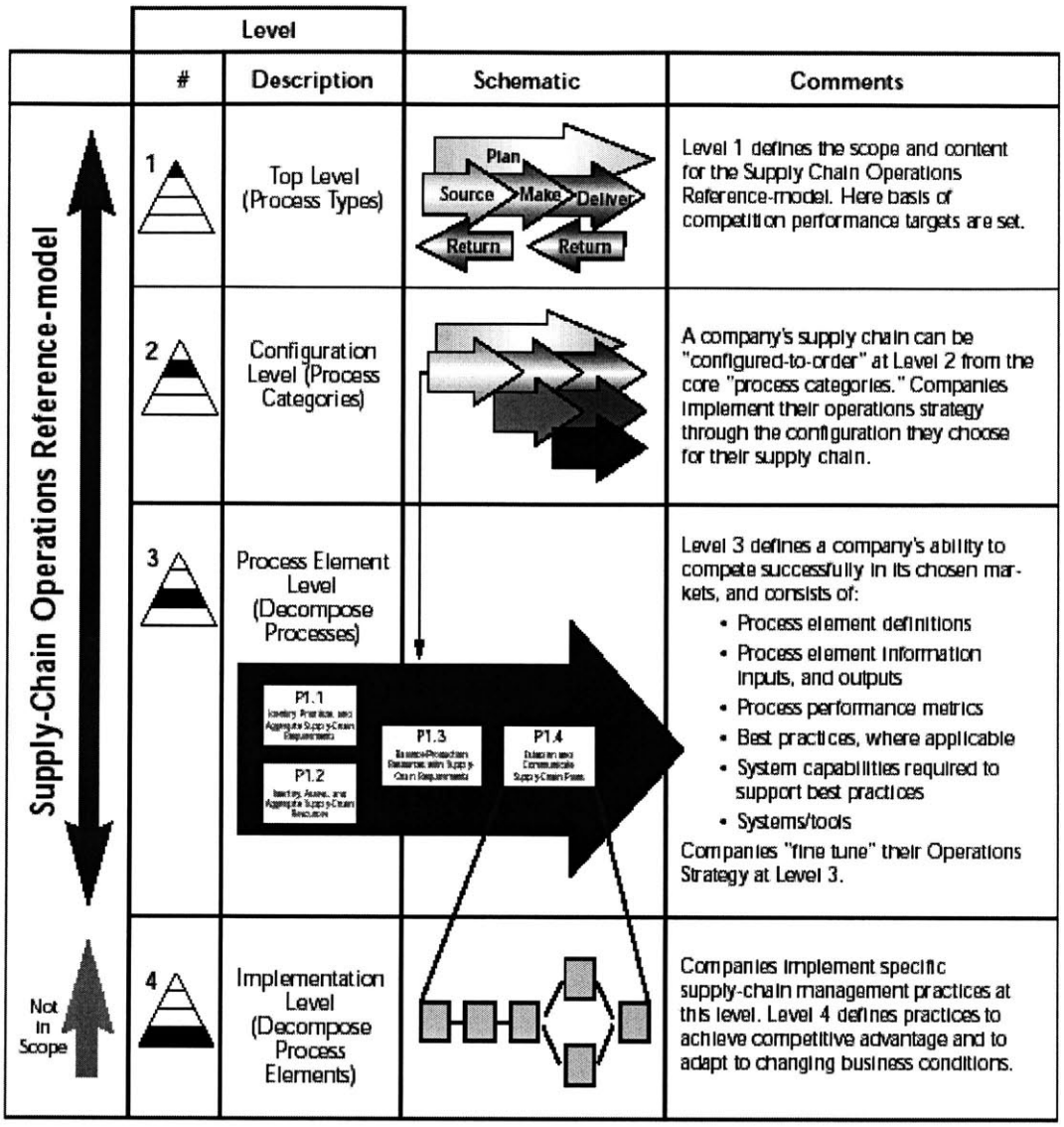


Figure 3 - SCOR is a hierarchical model with specific boundaries in regard to scope.
Source: Supply-Chain Operations Reference-model (SCOR) 6.0 Introduction

Finally, it is important to understand that the SCOR-model describes processes rather than functions. To further elaborate on the matter, the SCOR-model focuses on the activities involved, not the employees who or business elements that perform the activities. It is essential to note that the SCOR-model by itself is not and should not be utilized as a substitute for developing a comprehensive company strategy. Rather than

that, the SCOR-model should be perceived as a gauge to ensure that a company's long-term strategy is in alignment with its end objectives.

Chapter 3. Methodology

An effective supply chain measurement system must consider overall supply chain goals and use a balanced set of supply chain metrics. The balanced set of supply chain metrics should be classified on a strategic, tactical, and operational level, and should include both financial and non-financial measures as well. The current measurement models such as the Balanced Scorecard and the SCOR-model all support these ideas. However, in the grocery retail industry, because of the unique nature of the industry, a new supply chain performance measurement model is needed. Simply adopting one of the current performance measurement models won't be effective. The reasons will be discussed in this chapter. In this chapter, the methodology of building a new supply chain performance measurement model for the grocery retail industry will also be presented.

3.1 Why is it not suitable to adopt an existing performance measurement model in the grocery retail industry?

3.1.1 The SCOR-model

The SCOR-model involves more than sixty process steps and more than two hundred metrics. While the Supply Chain Council indicates that the model can be used in almost every industry, any supply chain from a simple supply chain network to a very complex one, the SCOR-model is not easy to implement. In order to use the SCOR-model effectively, managers need to examine and understand their companies' specific supply chain processes. Simply following all the processes and metrics listed in the SCOR-model will not work for most companies, including those in the grocery retail industry for

the following reasons. First, the SCOR-model was originally designed mainly for the manufacturing industry, and so a large portion of the model is focused on three processes, "Make" (production), "Build-to-Order Product Source," and "Deliver," which are not part of the grocery retail industry supply chain. Second, even after eliminating the metrics in the "Make" section, there are still about 150 metrics in the SCOR-model, much more than the ideal number of metrics that can be tracked and reported efficiently by companies. Third, in addition to the processes in the "Make" section, which can be totally eliminated when adopting the SCOR-model in supply chain performance measurement systems of the grocery retail industry, the processes identified in the "Plan," "Source," "Deliver," and "Return" sections in the SCOR-model are also different from the processes in the grocery retail supply chain.

Therefore, to implement the SCOR-model concept for supply chain performance measurement systems in the grocery retail industry, it is necessary to, first, totally eliminate the "Make" section in the SCOR-model (as shown in Figure 4). Second, a grocery retailer's supply chain processes must be represented in a process map by "Plan," "Source," "Deliver," and "Return" and then these processes must be compared with those in the SCOR-model. Third, for the similar processes, it is necessary to further examine the metrics of the SCOR-model under those processes to see if they are applicable for the particular grocery retailer's situation (as shown in Figure 5).

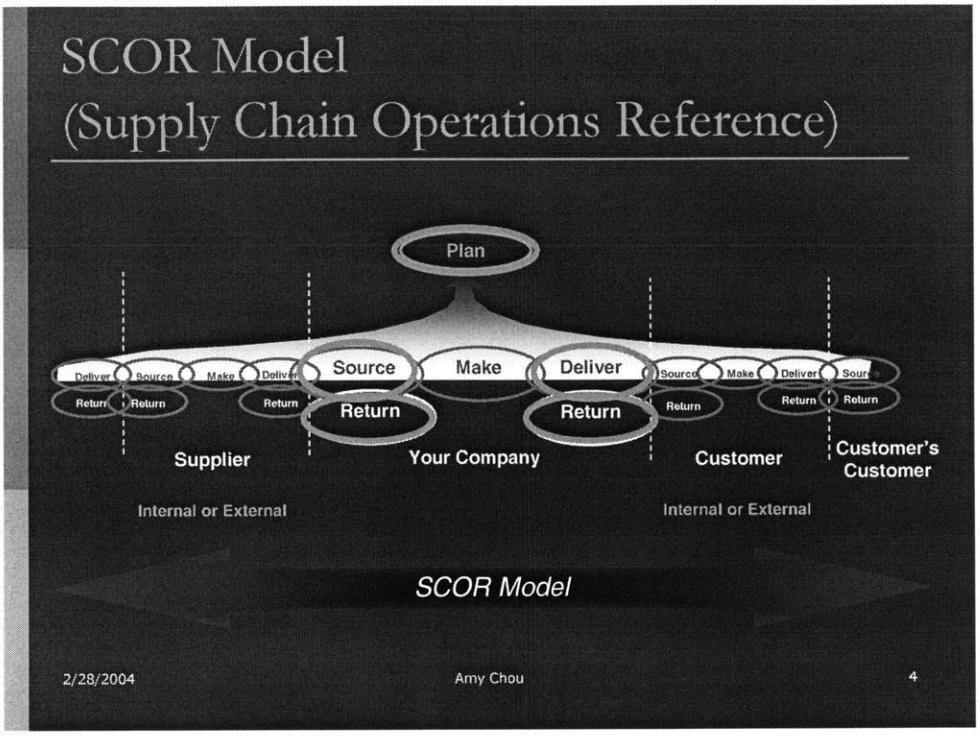


Figure 4 – Choose the process categories using in the Grocery Retail Industry
Source: It is a modified diagram from Supply-Chain Operations Reference-model (SCOR) 6.0

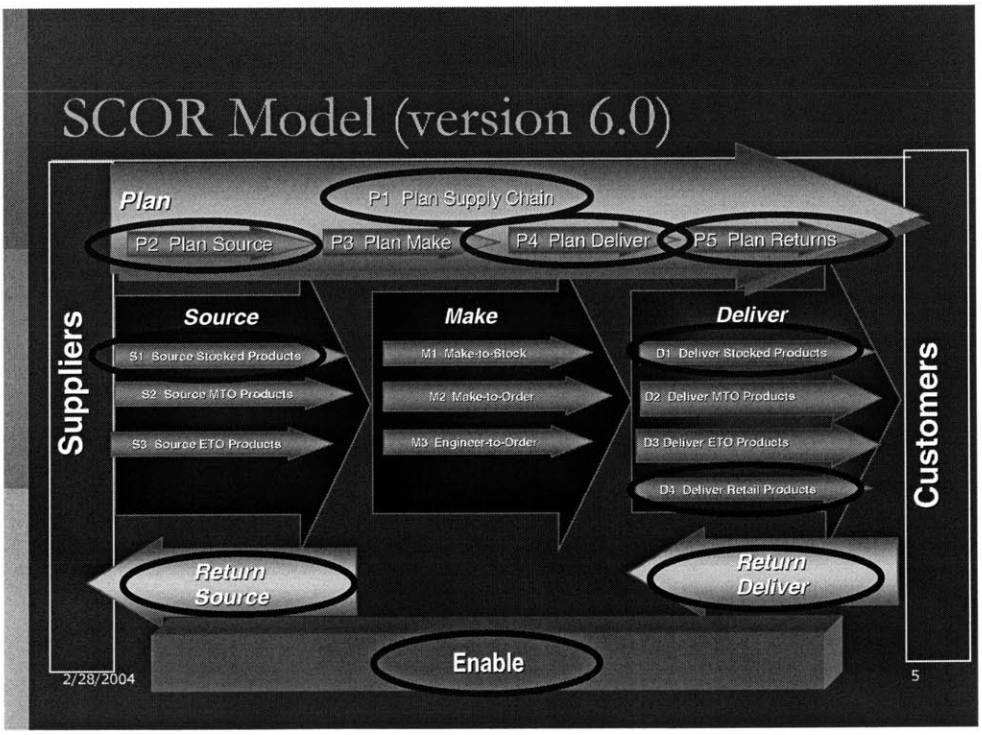


Figure 5 – Choose the processes using in the Grocery Retail Industry
Source: It is a modified diagram from Supply-Chain Operations Reference-model (SCOR) 6.0

3.1.2 Balanced Scorecard

While the Balanced Scorecard approach was not specifically designed for the supply chain, it does provide good guidance for designing the core measures in supply chain performance measurement systems. The central idea is to focus on key metrics that have real meaning to the company. No one wants to get lost in a sea of numbers that don't really mean anything. The Balanced Scorecard approach helps a company to select metrics aligned with its objectives. In Chapter 2 (Literature Review), I have summarized the measurement dimensions among different research; here I add the suggested dimensions from the three measurement models in Chapter 2 and group the dimensions with similar definitions. The result is shown in Table 3. Based on the comparison, three groups were identified as key dimensions for supply chain performance measurement in the grocery retail industry. These dimensions are Customer Service, Operation Efficiency, and Cost/Assets.

- Customer Service (Supply Chain Delivery Reliability): "The performance of the supply chain in delivering: the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer." (SCOR-model 6.0)[4] (e.g. Delivery Performance, Fill Rates, Perfect Order Fulfillment, etc.)

- Operation Efficiency (Supply Chain Responsiveness and Flexibility): "The velocity at which a supply chain provides products to the customer." (e.g. Order Fulfillment Lead Times) "The agility of a supply chain in responding to

[4] The definitions of dimensions in the Supply-Chain Operations Reference-model (SCOR) 6.0

marketplace changes to gain or maintain competitive advantage." (e.g. Supply Chain Response Time, Production Flexibility)

- Costs/Asset (Supply Chain Costs and Asset Management Efficiency): "The costs associated with operating the supply chain." (e.g. Cost of Good Sold, Total Supply Chain Management Costs, Value-Added Productivity, Warranty/Returns Processing Costs, etc). "The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital." (e.g. Cash-to-Cash Cycle Time, Inventory Days of Supply, Asset Turns, etc.)

Table 3 - Suggested Dimensions of Performance Measurement System from Different Researches and Models

Grocery Retail Industry	SCOR-model	Balanced Scorecard	TQM	Hausman (2002)	Reimer (1997)	Caplice & Sheffi (1995)
Customer Service	Reliability	Customer	Reliability		Quality	Customer Satisfaction
Customer Service	Flexibility		Serviceability	Service		
Cost/Assets	Cost	Financial Result	Features		Cost	Financial Result
Cost/Assets	Assets			Assets		
Operation Efficiency	Responsiveness	Internal Process	Perormance	Speed	Speed	Internal Process Efficiency
		Training				
			Durability			
			Conformance			
			Aesthetics			
			Percieved Quality			

3.1.3 TQM

The most radical difference between traditional and "total quality" thinking is the shift from a product to a process orientation. TQM demands a focus on processes that create output rather than the output itself. To develop a new supply chain performance measurement model for the grocery retail industry, I will also focus on a company's specific processes.

3.2 Six criteria for evaluating a supply chain measurement system

As I mentioned in Chapter 2, Caplice and Shaffi (1995) have proposed a set of evaluation criteria for supply chain performance measurement systems. The new model for the grocery retail industry will be applied to these criteria to make sure it is a good system. According to Caplice and Shaffi, a good metric system has to meet the following criteria:

Table 4 – Caplice and Shaffi's Six Evaluation Criteria

Criterion	Description
Comprehensive	The measurement system captures all relevant constituencies and stakeholders for the process.
Causally Oriented	The measurement system tracks those activities and indicators that influence future, as well as current, performance.
Vertically Integrated	The measurement system translates the overall firm strategy to all decision makers within the organization and is connected t the proper reward system.

Horizontally Integrated	The measurement system includes all pertinent activities, functions, and departments along the process.
Internally Comparable	The measurement system recognizes and allows for trade-offs between the different dimensions of performance.
Useful	The measurement system is readily understandable by the decision makers and provides a guide for action to be taken.

Source: Caplice and Sheffi, (1995), pp. 63

Chapter 4. Working Guide for Developing and Implementing the Supply Chain Measurement System at ABC Supermarket

4.1 Company Background

ABC Supermarket (for the reasons of confidentiality, the real name of the company will not be used) is a large grocery chain in New England. It operates more than 200 stores and has nearly 30,000 employees in Maine, Massachusetts, New Hampshire, Rhode Island, Connecticut, and Vermont. ABC Supermarket supports its stores from its two distribution centers and one cross-dock facility, and from its supplier XYZ Wholesaler's (for the reasons of confidentiality, the real name of the company will not be used) four distribution centers. The SWOT analysis of ABC Supermarket supply chain functions is summarized as follow:

Table 5 – SWOT Analysis of ABC Supermarket's Supply Chain

Strengths	ABC Supermarket has its own DCs, cross-dock facility, and transportation company. Supply chain decisions are mainly made in the headquarters, which makes ABC's supply chain system a centralized one. The centralized supply chain system is easy to control, more flexible, and easy to optimize.
Weaknesses	ABC Supermarket is not utilizing to its full capacity its centralized supply chain network. There is no single supply chain optimization model, and operation decisions are not made by optimal solution for

	ABC's whole supply chain.
Opportunities	High-level management at ABC Supermarket has realized the current supply chain issues and is willing to make necessary changes within the company to make the supply chain system work more effectively and efficiently.
Threats	The new supply chain solution might involve process reengineering and operation-level re-organization. ABC Supermarket might experience resistance from operation-level managers and/or staff members during the implementation stages.

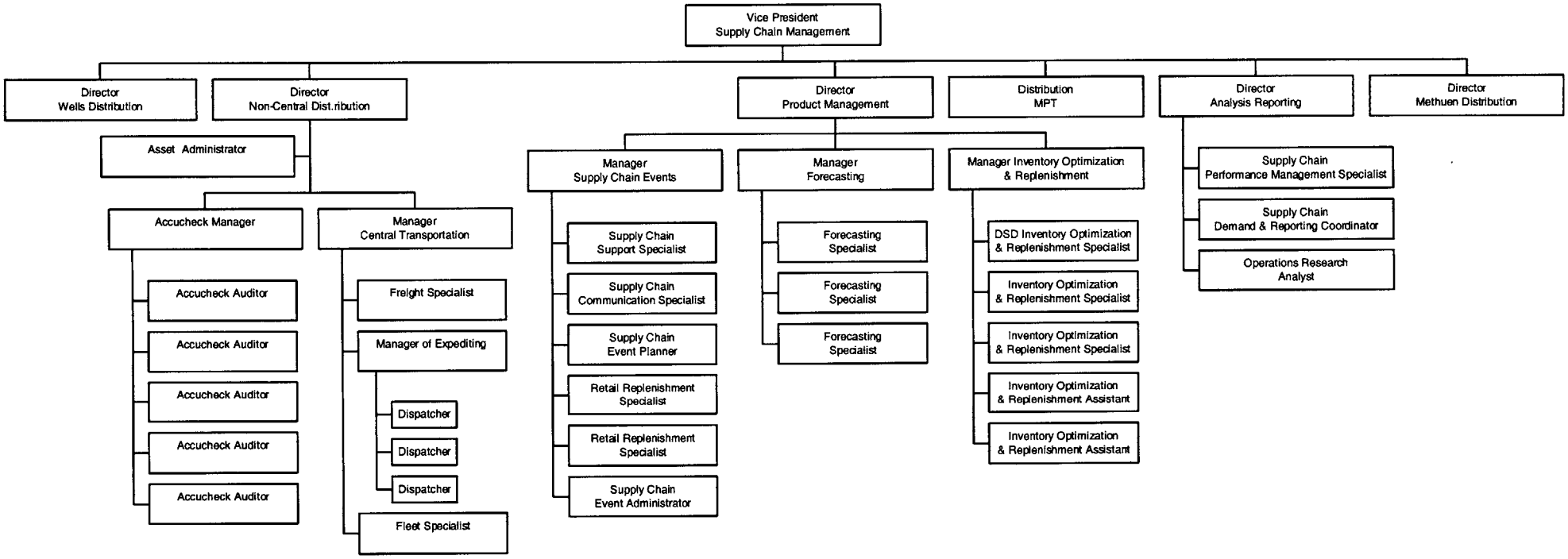


Figure 6 - ABC Supermarket's Supply Chain Organization Chart

4.2 Steps of developing a customized supply chain performance measurement system at ABC Supermarket

The development plan involves the following eight steps:

1. Identify current metrics and the measurement system in the company
2. Draw supply chain process maps of the company
3. Diagnose the company's current performance measurement system
4. Suggest high-level metrics
5. Suggest activity-related metrics
6. Find resources for metrics targets (e.g. benchmarking)
7. Prepare metric dictionary
8. Report results

4.2.1 Identify current metrics and the measurement system in the company

The first step is to understand the existing metric system at ABC Supermarket. ABC Supermarket does not really have a system for supply chain performance measurement. It does use some metrics, however, here and there in the supply chain processes, to measure performance in certain supply chain functions. In order to capture all the metrics ABC uses, I conducted interviews with managers and staff members who work in different supply chain functions at ABC, including employees in the headquarters, distribution centers, cross-dock facility, and store operations. The worksheet that I used to gather metrics information during the interviews is shown in Table 6. The interview results are summarized in Table 7. In Table 7, I grouped the metrics by supply chain functions:

Transportation, Inbound Delivery, Distribution Center, Outbound Delivery, and Store Operations.

Table 6 – The Worksheet for Gathering Metric Information in Interviews

Measure					Performance		
Name of Measure	Data Required for Calculation	Frequency of Measurement	Responsibility for Measuring	Purpose of the Measure	Current Goal	Current Performance	Future Goal

Source: Keebler et al. (1999), pp.129

Table 7 - ABC Supermarket's Current Metrics

	Measure					Performance		
Processes	**Name of Measure**	**Data Required for Calculation**	**Frequency of Measurement**	**Responsibility for Measuring**	**Purpose of the Measure**	**Current Goal**	**Current Performance**	**Future Goal**
Transportation	Transportation Cost per Mile	Total transportation cost (including driver salary, truck maintenance, gasoline, and toll) divided by total traveling mileage (not including backhaul)	Monthly	Financial Analyst	For comparison with corporate budget	Keep under budget	$1.75/mile	Every year's budget (or best in class)
	Transportation Cost per Case	Total transportation cost divided by total number of cases shipped	Monthly	Financial Analyst	For comparison with corporate budget	Keep under budget	N/A	Every year's budget (or best in class)
	Transportation Cost per Cube	Total transportation cost divided by total cubes shipped	Monthly		To see if trucks are efficiently utilized	N/A	N/A	N/A
	XYZ Wholesaler Transportation Cost per Mile	Total transportation cost (charged by XYZ) divided by total traveling mileage	Monthly	Financial Analyst	For comparison with corporate budget; if over budget, ABC Supermarket can relocate some deliveries to CWP	Keep under budget	N/A	Every year's budget (or best in class)
	XYZ Wholesaler Transportation Cost per Case	Total transportation cost (charged by XYZ) divided by total number of cases shipped	Monthly	Financial Analyst	For comparison with corporate budget; if over budget, ABC Supermarket can relocate some deliveries to CWP	Keep under budget	N/A	Every year's budget (or best in class)
Inbound Delivery	On-time Delivery (ABC, vendor and other carriers)	% of total number of deliveries on time (within the scheduled date assigned by vendor) to total number of deliveries in the period	Weekly	Freight Specialist	The main criterion of carrier ranking	N/A	94% (ABC); 89% (vendors)	95% within scheduled shipping windows
	Receiving Inspection	The case difference between (and % of) actual goods received (piece count) and ordered	Randomly inspect (sample size: ?); weekly published	Internal Audit Team	For charging back XYZ Wholesaler and vendors; also for vendor performance measurement	N/A	N/A	N/A

Outbound Delivery	On-time, Early, and Late Delivery (by product category)	% of number of deliveries on time/early/late (within the whipping windows to the total number of deliveries in the period	Weekly	Outbound Transportation Manager	For performance monitoring; currently not fully used by management	N/A	N/A	N/A
	Cube Utilization (ABC)	Actual cube divided by maximum cube		Outbound Transportation Manager	To see if trucks are efficiently utilized	N/A	74.2%; 80.4%; 71.8%; 53.2%	N/A
Distribution Center	Operation Cost per Case	Total operation cost (warehouse fixed cost plus productive labor cost) divided by total number of cases shipped	Monthly	Financial Analyst	For comparison with corporate budget	Keep under budget	N/A	Every year's budget (or best in class??)
	XYZ Wholesaler Operation Cost per Case	?	Monthly	Financial Analyst	For comparison with corporate budget	N/A	N/A	Every year's budget
	Inventory Weeks of Supply	Inventory quantity (cases) divided by average weekly demand (by SKU level)	Weekly	Purchasing	For re-order decision	Keep 2 to 2 1/2 weeks of inventory	N/A	N/A
	Service Level	Total number of cases shipped divided by total number of cases ordered	Weekly	Purchasing	For performance monitoring and future improvement	95% for non-promotion items and 100% for promotion items	95% for non-promotion and 99% for promotion	N/A
	Cases Shipped per Hour	Total cases shipped divided by total payroll and overtime hours	Weekly	MPT manager for distribution	For comparison with corporate budget	N/A	N/A	Every year's budget
Store Operation	Availability (Out-of-Stock)	The number of items that are out of stocks in every given day (the average of 3 or 4 days' records in 200 stores)	Weekly	Store Manager	Each store has to identify the reason for each out of stock	Less than 350 items in every given day	N/A	N/A
	Forecast Accuracy	The % difference between sales forecast and actual point-of-sale data	Weekly		To identify items that are forecasting more or less than average weekly movement	60%	N/A	N/A

ABC Supermarket's current metric system separates the Transportation function from Inbound Delivery and Outbound Delivery functions. The reason is mainly the data collection issue. For example, ABC's transportation department tracks the total mileage of total trips made within a month, but does not track mileage for inbound delivery only or outbound deliver only.

4.2.2 Draw supply chain process maps of the company

a. By the SCOR-model definition (processes)
    i. Level one/Top Level (Process Type) – defines the scope and content from the SCOR-model (which types to choice from the five main process types: Plan, Source, Delivery, Return)
    ii. Level two/Process Element Level (decompose Processes) – defines the core sub-process categories.
b. By supply chain functions – Headquarters, DC, Transportation, Store Operation, and Return
c. Combine processes and functions

I broke down ABC's supply chain network into Source (S), Deliver (D), and Return (R) processes, and separate each sub-process (e.g. S1, S2… etc) into different functions - Headquarters, For Hire/Third Party Transportation, DC/X-dock, Private Transportation, and Store Operations. The process maps are shown in the following pages. For each sub-process identified in the maps, I will discuss in more details in the later section.

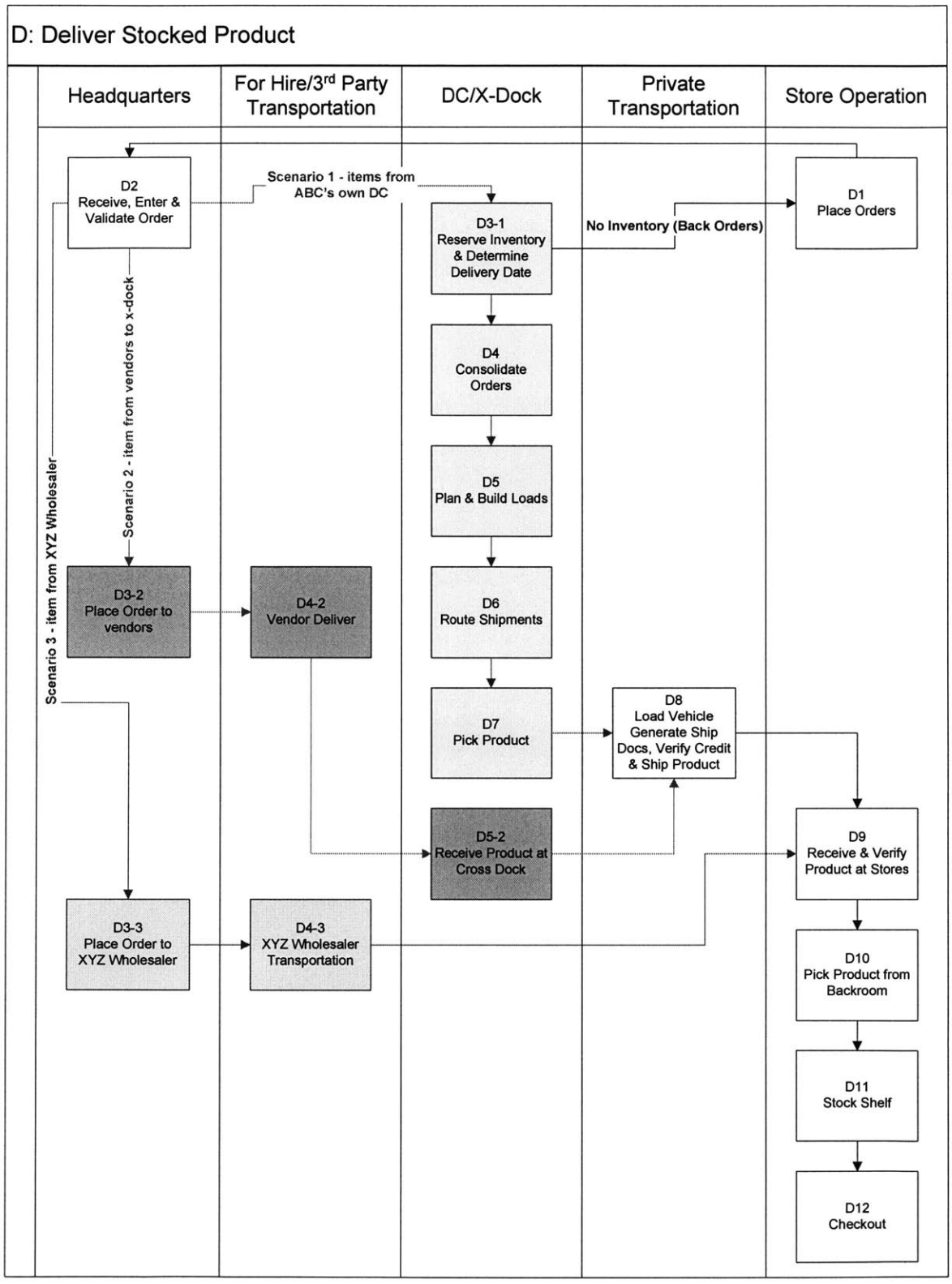


Figure 7 – ABC Supermarket's Delivery Process and Sup-Processes

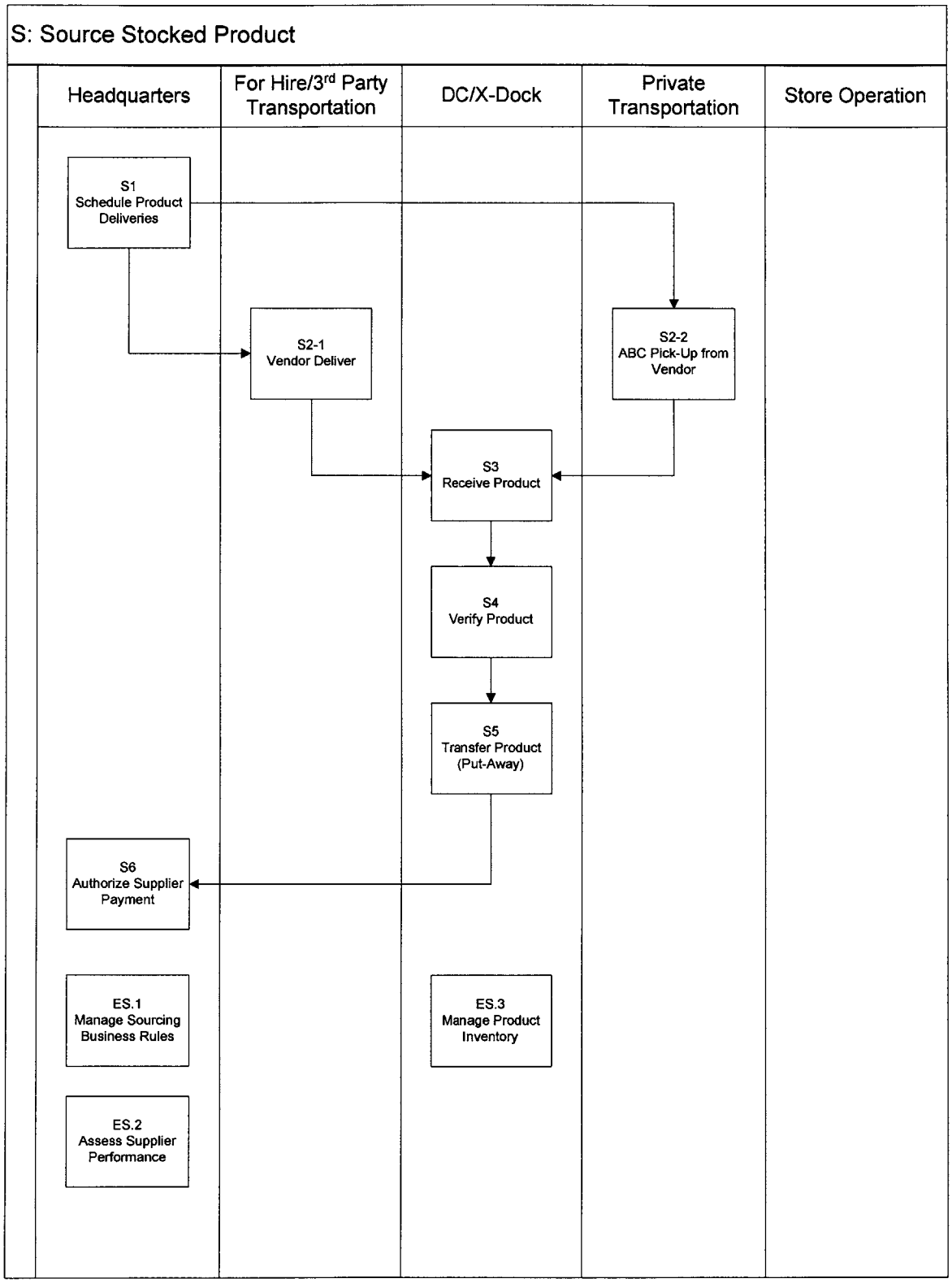


Figure 8 - ABC Supermarket's Sourcing Process and Sub-Processes

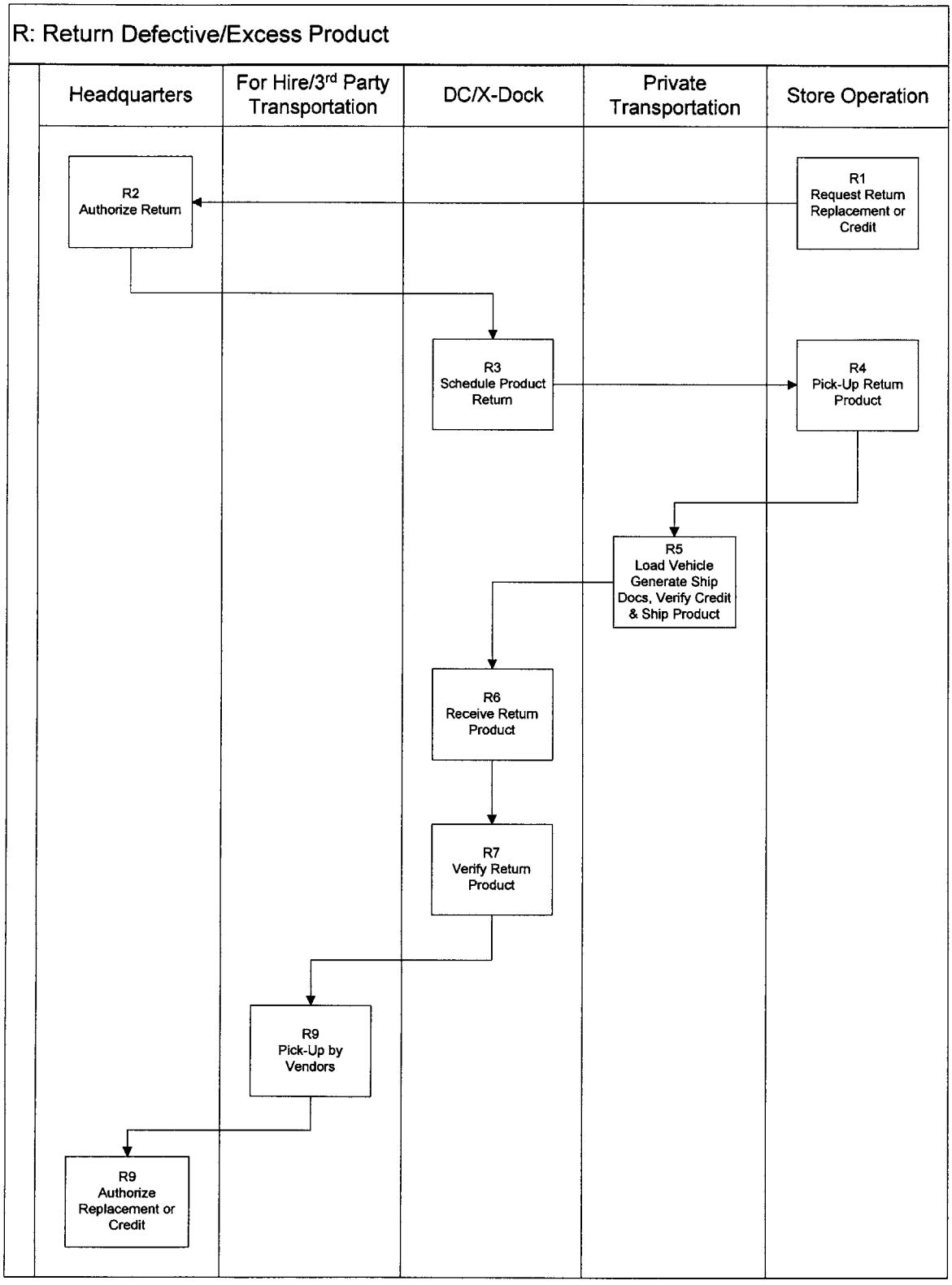


Figure 9 - ABC Supermarket's Return Process and Sub-Processes

4.2.3 Diagnose ABC Supermarket's current performance measurement system

The main strength of ABC's current measurement system is that it is comprehensive in scope, as three distinct dimensions of performance are captured. The current system is also horizontally integrated across supply chain functions. However, the primary weakness of the system is that the system is not as causally oriented and vertically integrated as it potentially could be. The summary of the evaluation is shown in the table below:

Table 8 - Summary of Evaluation of ABC's Current Measurement System

Criterion	Description
Comprehensive	Three dimensions: Customer Service, Operation Efficiency, and Cost/Assets. ABC's current metrics capture all the three dimensions but are not well balanced. The details are addressed in the following section.
Causally Oriented	Whether this system is causally oriented depends on the processes. For example, in transportation, there is no metric measuring the root cause of higher transportation costs (e.g. empty miles, optimal traveling distance, etc). However, in store operation, the forecast accuracy might be the root cause of bad performance, i.e. out-of-stock.
Vertically Integrated	Again, this criterion depends on the processes. In Distribution Center function, the system measures cases

	shipped per hour, which is directly applicable to lower levels of organization management.
Horizontally Integrated	The system is horizontally integrated in that most of the metrics are expandable along the supply chain.
Internally Comparable	While recognized as being interrelated, there is no formal way to trade off performance along the different dimensions.
Useful	The system is action oriented and is very understandable.

4.2.3.1 Comprehensive Analysis

As discussed in Chapter 3.2.2, I have already identified the dimensions that ABC Supermarket will use for the new measurement system. These dimensions are Customer Service, Operation Efficiency, and Cost/Assets. Here, we re-examine the current metrics and assign each metric under the responsive dimensions. The result is summarized in Table 10 in the following pages and the comprehensive analysis for a balanced system is shown in Table 9 below.

Table 9 - Comprehensive Analysis of ABC Supermarket's Current Metric System

	Customer Service	Operation Efficiency	Cost/ Assets	Total	Percentage
Transportation	0	5	0	**5**	**28%**
Inbound Delivery	1	0	1	**2**	**11%**
Distribution Center	2	1	4	**7**	**39%**
Outbound Delivery	1	1	0	**2**	**11%**
Store Operation	1	1	0	**2**	**11%**
Total	**5**	**8**	**5**	**18**	**100%**
Percentage	**28%**	**44%**	**28%**	**100%**	

As shown in Table 9, in ABC's current eighteen supply chain metrics, there are 5 (28%), 8 (44%), and 5 (28%) metrics in the Customer Service, Operation Efficiency, and Cost/Assets category, respectively. It seems that ABC's current metric system captures all the three dimensions quite evenly, slightly more in the Operation Efficiency dimension. However, if examining in more detail (by breaking down into function level), we will find that the metric system under each function is not as balanced. For example, under Transportation function, all metrics that ABC Supermarket measures are from the Operation Efficiency perspective. There are no metrics from the Customer Service perspective or the Cost/Assets perspective. Similar situations happen in the Inbound Delivery, Outbound Delivery, and Store Operations functions; there is always a certain dimension that ABC doesn't measure under a particular function. (See Table 11 in the end of this section.)

Table 10 - ABC Supermarket current metrics marked with dimension

		Measure					Performance		
Dimension	**Processes**	**Name of Measure**	**Data Required for Calculation**	**Frequency of Measurement**	**Responsibility for Measuring**	**Purpose of the Measure**	**Current Goal**	**Current Performance**	**Future Goal**
OE	**Transportation**	Transportation Cost per Mile	Total transportation cost (including driver salary, truck maintenance, gasoline, and toll) divided by total traveling mileage (not including backhaul)	Monthly	Financial Analyst	For comparison with corporate budget	Keep under budget	$1.75/mile	Every year's budget (or best in class??)
OE		Transportation Cost per Case	Total transportation cost divided by total number of cases shipped	Monthly	Financial Analyst	For comparison with corporate budget	Keep under budget	N/A	Every year's budget (or best in class??)
OE		Transportation Cost per Cube	Total transportation cost divided by total cubes shipped	Monthly	N/A	To see if trucks are efficiently utilized	N/A	N/A	N/A
OE		XYZ Wholesaler Transportation Cost per Mile	Total transportation cost (charged by XYZ Wholesaler) divided by total traveling mileage	Monthly	Financial Analyst	For comparison with corporate budget; if over budget, ABC Supermarket can relocate some deliveries to CWP	Keep under budget	N/A	Every year's budget (or best in class??)
OE		XYZ Wholesaler Transportation Cost per Case	Total transportation cost (charged by XYZ Wholesaler) divided by total number of cases shipped	Monthly	Financial Analyst	For comparison with corporate budget; if over budget, ABC Supermarket can relocate some deliveries to CWP	Keep under budget	N/A	Every year's budget (or best in class??)

CS	**Inbound Delivery**	On-time Delivery (ABC, vendor and other carriers)	% of total number of deliveries on time (within the scheduled date assigned by vendor) to total number of deliveries in the period	Weekly	Freight Specialist	The main criterion of carrier ranking	N/A	94% (ABC); 89% (vendors)	95% within scheduled shipping windows
F		Receiving Inspection	The case difference between (and % of) actual goods received (piece count) and ordered	Randomly inspect (sample size); weekly published	Internal Audit Team	For charging back XYZ Wholesaler and vendors; also for vendor performance measurement	N/A	N/A	N/A
CS	**Outbound Delivery**	On-time, Early, and Late Delivery (by product category)	% of number of deliveries on time/early/late (within the whipping windows to the total number of deliveries in the period	Weekly	Outbound Trans Manager	For performance monitoring; currently not fully used by management	N/A	N/A	N/A
OE		Cube Utilization (ABC)	Actual cube divided by maximum cube	N/A	Outbound Trans Manager	To see if trucks are efficiently utilized	N/A	74.2%; 80.4%; 71.8%; 53.2%	N/A
F	**Distribution Center**	Operation Cost per Case	Total operation cost (warehouse fixed cost plus productive labor cost) divided by total number of cases shipped	Monthly	Financial Analyst	For comparison with corporate budget	Keep under budget	N/A	Every year's budget (or best in class??)
F		XYZ Wholesaler Operation Cost per Case	N/A	Monthly	Financial Analyst	For comparison with corporate budget	N/A	N/A	Every year's budget
F		Inventory Weeks of Supply	Inventory quantity (cases) divided by average weekly demand (by SKU level)	Weekly	Purchasing	For re-order decision	Keep 2 to 2 1/2 weeks of inventory	N/A	N/A

CS		Service Level (Fill Rate)	Total number of cases shipped divided by total number of cases ordered	Weekly	Purchasing	For performance monitoring and future improvement	95% for non-promotion items and 100% for promotion items	95% for non-promotion and 99% for promotion	N/A
OE		Cases Shipped per Hour	Total cases shipped divided by total payroll and overtime hours	Weekly	Tony (MPT manager for distribution)	For comparison with corporate budget	N/A	N/A	Every year's budget
F		Inventory Accuracy	The % of the actual total cases divided by the cases in the system	Physical count 3-day a circle	warehouse people	To maintain accurate information to support better buying/shipping decisions	98%	95%	100%?
CS		Pick-and-Pack Accuracy	The % of the actual pick-and-pack cases divided by the PO cases		warehouse people				
CS	**Store Operation**	Availability (Out-of-Stock)	The number of items that are out of stocks in every given day (the average of 3 or 4 days' records in 200 stores)	Weekly	Store Manager	Each store has to identify the reason for each out of stock	Less than 350 items in every given day	N/A	N/A
OE		Forecast Accuracy	The % difference between sales forecast and actual point-of-sale data	Weekly	N/A	To identify items that are forecasting more or less than average weekly movement	60%	N/A	N/A

Table 11 - Comprehensive Analysis (Part 2) of ABC's Current Metric System

		Customer Service	Operation Efficiency	Cost/Assets
Transportation	Transportation Cost per Mile		X	
	Transportation Cost per Case		X	
	Transportation Cost per Cube		X	
	XYZ Wholesaler Transportation Cost per Mile		X	
	XYZ Wholesaler Transportation Cost per Case		X	
In-bound	On-time Delivery (CWP, vendor and other carriers)	X		
	Receiving Inspection			X
Distribution Centers	Operation Cost per Case			X
	XYZ Wholesaler Operation Cost per Case			X
	Inventory Weeks of Supply			X
	Service Level (Fill Rate)	X		
	Cases Shipped per Hour		x	
	Inventory Accuracy			X
	Pick-and-Pack Accuracy	X		
Out-bound	On-time, Early, and Late Delivery (by product category)	X		
	Cube Utilization (CWP)		x	
Store Opera-tion	Availability (Out-of-Stock)	X		
	Forecast Accuracy		x	

4.2.3.2 Causally Oriented Analysis

ABC's current supply chain performance system is causally oriented since it tracks root causes of performance, not just end results. The Causally Oriented Analysis for ABC Supermarket is presented by Cause & Effect Diagrams shown in the next page.

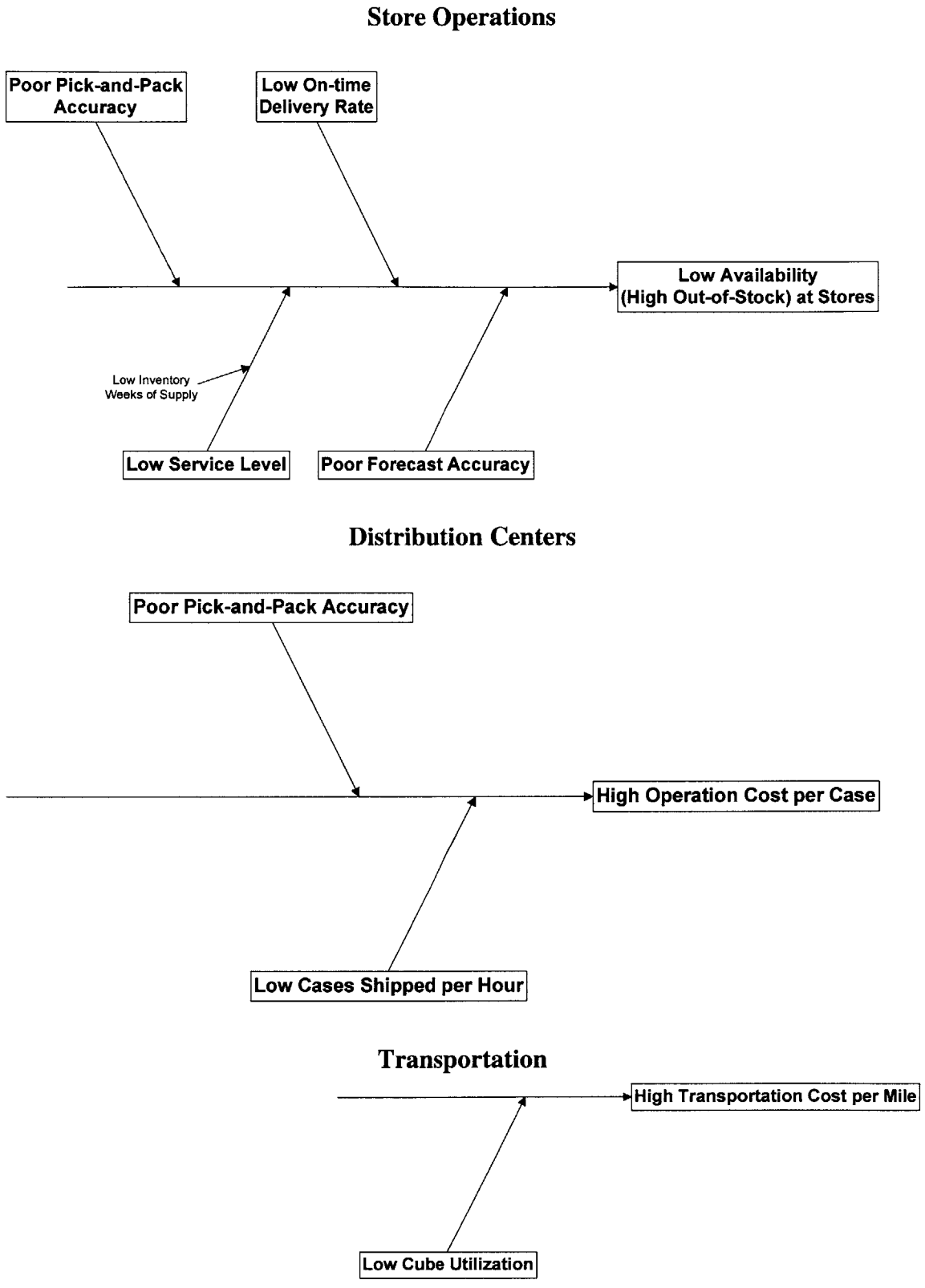


Figure 10 - Causally Oriented Analysis (Cause & Effect Diagrams)

The Cause & Effect diagram is a tool for discovering all the possible causes for a particular effect, usually some troublesome aspect of product or service quality, or an effect related to internal processes such as "high operation cost per case". The major purpose of the Cause & Effect Diagram is to provide an immediate identification of major causes for the effect by generating a comprehensive list of possible causes. In short, preparing a Cause & Effect Diagram will lead to greater understanding of the problem. In order to evaluate whether ABC's current supply chain system is causally oriented, I used Cause & Effect Diagrams to capture the relationship among the metrics in the system. Three Cause & Effect Diagrams have been identified; they are Store Operations, Distribution Centers, and Transportation.

In the Transportation Cause & Effect Diagram, it can be seen that there are not enough metrics measuring the root cause of higher transportation costs (e.g. empty miles, optimal traveling distance, etc). However, in Store Operations, the system captures several possible root causes for high out-of stock rate, including poor forecast accuracy, low service level, poor pick and pack accuracy, and low on-time delivery rate.

4.2.3.3 Vertically Integrated Analysis

ABC's system is partially vertically integrated. As shown in the table below, some functions such as Distribution Center align lower level performance measurement systems with firm-wide objectives. The system measures cases shipped per hour, a lower-level measurement, which affects the higher-level objectives such as low operation cost per case.

Table 12 – Vertically Integrated Analysis

		Top Level Metrics	Activity Level Metrics
Transportation	Transportation Cost per Mile	X	
	Transportation Cost per Case	X	
	Transportation Cost per Cube		x
	XYZ Wholesaler Transportation Cost per Mile		x
	XYZ Wholesaler Transportation Cost per Case		x
In-bound	On-time Delivery (CWP, vendor and other carriers)		x
	Receiving Inspection		x
Distribution Centers	Operation Cost per Case	x	
	XYZ Wholesaler Operation Cost per Case		x
	Inventory Weeks of Supply		x
	Service Level (Fill Rate)	X	
	Cases Shipped per Hour		x
	Inventory Accuracy		x
	Pick-and-Pack Accuracy		x
Out-bound	On-time, Early, and Late Delivery (by product category)		x
	Cube Utilization (CWP)		x
Store Operation	Availability (Out-of-Stock)		x
	Forecast Accuracy		x

4.2.3.4 Horizontally Integrated Analysis

ABC's system is horizontally integrated in that most of the metrics are expandable along the supply chain. It includes all pertinent activities, functions, and departments along the process.

4.2.3.5 Internally Comparable Analysis

While ABC's system is recognized as being interrelated, there is no formal way to trade off performance along the different dimensions. For example, there is no information about how increasing on-time deliveries affects transportation cost per case shipped.

4.2.3.6 Useful Analysis

The system is action-oriented and is very easy to understand. The metrics are directly related to activity performance, encouraging the company to keep tracking them continuously, unlike an overly complex system that will probably end up being ignored or discarded after a relatively short period of time.

4.2.4 Suggest a High-Level New Metric Set for ABC Supermarket

After consider ABC's unique industry situation, I suggest the following twenty one high-level metrics:

Table 13 - Suggested Supply Chain Metrics

Performance Dimensions	Metric	Description	Formula
Customer Service	Fill Rate (in "SKUs' or "cases"; at DC level)	The amount of cases shipped on the initial shipment verses the amount of cases ordered	$SKUFillRate = \frac{\#ofSKUShippedinInitialShipment}{Total\#ofSKUOrdered}$
	Back Order (in "SKU's", "cases" or in "value"; at "Store", "Distribution Center", or "Total Company" level.)	An unfilled customer order. A backorder is demand (immediate or past due) against an item whose current stock level is insufficient to satisfy demand.	$BackOrder = \#ofSKUPast\,\text{Re}\,questDeliveryDate$ or $\#ofCasePast\,\text{Re}\,questDeliveryDate$ or $\$ofItemPast\,\text{Re}\,questDeliveryDate$
	Order Fulfillment Cycle Time (for each order or each line item)	The average actual lead times consistently achieved, from Customer Signature/ Authorization to Order Receipt, Order Receipt to Order Entry Complete, Order Entry Complete to Order Ready for Shipment, Order Ready for Shipment to Customer Receipt of Order, and Customer Receipt of Order to Installation Complete.	$OrderFulfillmentCycle = \frac{\sum_1^n[(ActualDeliveryDt)-(OrderEntryDt)]}{n}$ n=number of orders
	On-time Delivery	The number of delivery made on-time divided by the total number of shipments in a period.	$OnTimeDelivery = \frac{\#ofDeliveryMadeOnTime}{Total\#ofShipments}$

Operation Efficiency	Receiving Cycle Time	All time associated with unloading, receiving, inspecting, and placing incoming materials into inventory and processing payment to the supplier including recording exceptions, moving incoming materials to storage location, and inputting data into inventory systems.	$\text{Re}\,ceivingCycleTime = \frac{\sum_1^n [(ActualArrivingTime) - (InvEntryTime)]}{n}$ n=number of orders
	On-Time Delivery (Case Count)	The amount of cases shipped on-time verses the amount of cases ordered.	$OnTimeCaseDelivery = \frac{\#ofCasesShippedOnTime}{Total\#ofCasesOrdered}$
	Supply Chain Cycle Time	The total time it would take to satisfy a customer order if all inventory levels were zero. It is calculated by adding up the longest lead times in each stage of the cycle.	$SupplyChainCycleTime = \text{Re}\,ceivingCycleTime + OrderFulfillmentCycleTime$
	Freight Cost Per Unit (case) Shipped	Total freight costs divided by number of units (case) shipped per period.	$FreightCostPerUnit = \frac{TotalFreightCosts}{Total\#ofCasesShipped}$
	Warehouse Operation Cost per Unit (case) Shipped	Total warehouse costs (including warehouse occupancy cost and wages) divided by the number of units (case) shipped per period.	$WarehouseCostPerUnit = \frac{TotalWarehouseCosts}{Total\#ofCasesShipped}$
	Percent of Truckload Capacity Utilized	The total cubes shipped divided by the theoretical maximum.	$\%OfTruckloadCapacityUtilized = \frac{TotalCubesShipped}{TotalMaximumCapacity}$
	Actual Transit Time/Distance vs. Budget Transit Time/Distance	Measured by the number of days (or hours)/miles, from the time a shipment leaves the facility to the time it arrives at the store location, against a standard transit time/distance quoted by the carrier for each traffic lane.	$TransitBudgetPerformance = \frac{TotalActualTransitTime}{TotalBudgetTransitTime}$

	Pick and Pack Accuracy	Total number of accurate cases shipped divided by the total # of cases shipped.	$Pick\ \&\ PackAccuracy = \frac{Total\#ofAccurateCases}{Total\#ofCasesShipped}$
	Case Shipped per Hour	Total cases shipped in a period of time divided by the total manhours in that period of time.	$CaseShippedPerHour = \frac{Total\#ofCasesShipped}{TotalManhours}$
Cost and Assets	Total Supply Chain Management Costs as percentage of Revenue	The aggregation of the following cost elements: Create Customer Order Costs Order Entry and Maintenance Costs Contract/Program and Channel Management Costs Order Fulfillment Costs Distribution Costs Transportation Costs Installation Costs	$\%TotalSCMCostsof\ \mathrm{Re}venue = \frac{TotalSupplyChainManagementCosts}{Total\ \mathrm{Re}venue}$
	Inventory Days of Supply	Gross inventory ÷ (value of transfers/365 days).	$InventoryDaysOfSupply = \frac{GrossInventory}{ValuesOfTransfers/365days}$
	Inventory Accuracy	The amount of on-hand quantity (cases) verses the perpetual inventory quantity (cases), within the following tolerances: A items = plus or minus 1% quantity variance from perpetual balance B items = plus or minus 3% quantity variance from perpetual balance C items = plus or minus 5% quantity variance from perpetual balance	$InventoryAccuracy = \frac{OnHandCases}{InventoryCases}$

	Inbound Freight Costs as percentage of Purchases	Inbound freight costs divided by purchase dollars.	$\%InboundFreightCostOfPurchase = \frac{InboundFreightCosts}{PurchaseCosts}$
	Outbound Freight Costs as percentage of Net Sales	Outbound freight costs divided by net sales.	$\%OutboundFreightCostOfSales = \frac{OutboundFreightCosts}{NetSales}$
	Inventory Turns	The number of times that a company's inventory cycles or turns over per year.	$InventoryTurns = \frac{Rolling12mthCostOfSales}{AverageInventoryLevel(\$)}$
	Shelf Out-of-Stock %	The percentage of SKUs that are stock-out in the store level.	$ShelfOutOfStock\% = \frac{\sum_{1}^{n} \frac{\#ofOutOfStockSKU}{TotalSKUonShelves}}{n}$ n=number of stores
	Warehouse Turnover Rate	The number of employees left the company in a specified period (usually 1 year) divided by the average number of employees during the same period.	$Turnover = \frac{\#ofEmployeesLeft}{Average\#ofEmployees}$

4.2.4.1 Evaluation of the Suggested Metric Set

The suggested metric set congregates the six criteria I mentioned earlier. The metric set is comprehensive, covering three dimensions, as shown in the first box set below (yellow highlight). It is vertically integrated since it tracks top- and second-level processes as shown in the purple-highlight box set. It is horizontally integrated since it captures functions in headquarters, inbound and outbound transportations, distribution centers and cross-dock facility, and store operations (as shown in the green-highlight box set).

The metric set is also causally oriented by capturing metrics in both single-function process and cross-function process. For example, Supply Chain Cycle Time is a metric measuring the overall cross-function supply chain performance. Metrics such as Receiving Cycle Time and Order Fulfillment Cycle that can help management track the root cause of poor Supply Chain Cycle Time performance.

Table 14 - Metrics Set Quick Evaluation

	Customer Service	Efficiency	Cost/Assets	Headquarters	Transp-Inbound	Distribution Centers	Transp-Outbound	Stores	X-Dock	Top Level Metrics	Second Level Metrics	Sourcing	Delivering
Fill Rate	x			x		x				x			x
Back Order	x			x		x				x			x
Order Fulfillment Cycle	x			x		x	x		x	x			x
On-Time Delivery	x				x		x		x		x		x
Receiving Cycle Time		x			x	x				x		x	
On-Time Case Delivery		x		x		x	x		x		x		x
Supply Chain Cycle Time		x		x	x	x	x	x	x	x		x	x
Freight Cost Per Unit Shipped		x		x			x				x		x

Warehouse Costs Per Unit Shipped		x				x					x	x	
Percent of Truckload Capacity Utilized		x		x			x		x		x		x
Pick and Pack Accuracy		x				x			x		x		x
Actual Transit Time/Distance vs. Budge Time/Dist		x					x				x		x
Cases Shipped per Hour		x				x			x		x		x
Total SC Management Costs as % of Revenue			x	x	x	x	x	x	x	x			x
Inventory Days of Supply			x	x		x					x	x	
Inventory Accuracy			x			x					x	x	
Inbound Freight Costs as percentage of Purchases			x		x						x	x	
Outbound Freight Costs as percentage of Net Sales			x				x				x		x
Inventory Turns			x	x						x		x	
Shelf Out-of-Stock %			x					x		x		x	
Warehouse Turnover Rate			x			x					x	x	

4.2.5 Suggest activity-related metrics

Activity-related metrics are more tactical and operational, providing diagnostic information on whether higher-level performance objectives are being met. For the activity-related metrics, we need to, first, identify each sub-process in the supply chain. As reference, we will use the process maps identified in Chapter 4 (4.2.2): "Deliver Stock and Retail Product," "Source Stock Product," and "Return Product". Second, gather the metrics published in the SCOR-model and assign metrics from the similar processes in the SCOR to each of our sub-processes. Third, re-arrange metrics and group by the three performance dimensions we use earlier. The results are as follows[5]:

4.2.5.1 D: Deliver Stock and Retail Product

As presented in the SCOR-model, Deliver Stock Product is "the process of delivering product that is maintained in DC prior to the receipt of a store order." Deliver Retail

[5] The metrics and process definitions are from SCOR-model

Product is "the process used to acquire, merchandise, and sell finished goods at a retail store. A retail store is a physical location that sells products (and services) direct to the consumer using a point of sale process (manual or automated) to collect payment. Merchandising at a store level is the stocking and restocking of products in designated storage locations to generate sales in a retail store." There are twelve sub-processes in ABC Supermarket's Deliver Stock and Retail Product Process:

D1 Place Orders
D2 Receive, Enter & Validate Order
D3-1 Reserve Inventory & Determine Delivery Date
D4 Consolidate Orders
D5 Plan & Build Loads
D6 Route Shipments
D7 Pick Product
D8 Load Vehicle Generate Ship Documents, Verify Credit & Ship Product
D9 Receive & Verify Product at Stores
D10 Pick Product from Backroom
D11 Stock Shelf
D12 Checkout

D3-2 Place Order to Vendors
D4-2 Vendor Deliver
D5-2 Receive Product at Cross Dock

D3-3 Place Order to XYZ Wholesaler
D4-3 XYZ Wholesaler Transportation

Scenario 1 – Items from ABC's own DC

D1 Place Orders

D2 Receive, Enter & Validate Order
Receive orders from the store and enter them into the headquarter order processing system. Orders can be received through phone, fax, or electronic media.

Performance Dimensions	Metric
Customer Service	
Efficiency	Customer Signature/Authorization to Order Receipt Time Order Receipt to Order Entry Complete Time Upside Order Flexibility Downside Order Flexibility

Cost and Assets	Create Customer Order Costs Order Entry and Maintenance Costs

D3-1 Reserve Inventory & Determine Delivery Date

Inventory (both on hand and scheduled) is identified and reserved for specific orders and a delivery date is committed and scheduled.

Performance Dimensions	Metric
Customer Service	Delivery Performance To Customer Commit Date
Efficiency	Order Receipt to Order Entry Complete Time
Cost and Assets	Finished Goods Inventory Days of Supply Order Fulfillment Costs Finished Goods Inventory Carry Cost

D4 Consolidate Orders

The process of analyzing orders to determine the groupings that result in least cost/best service fulfillment and transportation.

Performance Dimensions	Metric
Customer Service	Order Consolidation Profile
Efficiency	Order Entry Complete to Order Ready for Shipment Time
Cost and Assets	Transportation Costs

D5 Plan & Build Loads

Transportation modes are selected and efficient loads are built.

Performance Dimensions	Metric
Customer Service	
Efficiency	Upside Shipment Flexibility Downside Shipment Flexibility
Cost and Assets	Transportation Costs

D6 Route Shipments

Loads are consolidated and routed by mode, lane and location.

Performance Dimensions	Metric
Customer Service	
Efficiency	Order Entry Complete to Order Ready for Shipment Time
Cost and Assets	Transportation Costs

D7 Pick Product

The series of activities including retrieving orders to pick, determining inventory availability, building the pick wave, picking the product, recording the pick and delivering product to shipping in response to an order.

Performance Dimensions	Metric
Customer Service	Fill Rates

Efficiency	Order Entry Complete to Order Ready for Shipment Time Upside Shipment Flexibility Downside Shipment Flexibility
Cost and Assets	Distribution Costs

D8 Load Vehicle, Generate Shipping Documentation, Verify Credit & Ship Product
The series of task including placing product onto vehicles, generating the documentation necessary to meet internal, customer, carrier and government needs, and sending the product to the store.

Performance Dimensions	Metric
Customer Service	Delivery Performance to Customer Commit Date Delivery Performance to Customer Request Date Perfect Order Fulfillment
Efficiency	Order Entry Complete to Order Ready for Shipment Time Upside Shipment Flexibility Downside Shipment Flexibility
Cost and Assets	

D9 Receive & Verify Product at Store Site
The activities such as receiving product, verifying that the order was shipped complete and that the product is of sufficient quality, recording product receipt, determining put-away location, putting away and recording location that a company performs at its own stores. May include quality inspection.

Performance Dimensions	Metric
Customer Service	Perfect Order Fulfillment
Efficiency	Order Ready for Shipment to Customer Receipt of Order Time Upside Delivery Flexibility Downside Delivery Flexibility Dock To Stock Cycle Time Number of restocking events per day Cost efficiency/elasticity of shipping schedules
Cost and Assets	Items stocked per FTE Accuracy of stocking

D10 Generate Stocking Schedule and Pick Product from Backroom
The process of retrieving restocking orders to pick, determining inventory availability, building a pick wave, picking item and quantity from a designated backroom warehouse location, recording the resulting inventory transaction, and delivering the product to point of stock.

Performance Dimensions	Metric
Customer Service	Inventory inaccuracies during pick-process

Efficiency	Time to Pick Minimum Stock Levels Number of restocking events per day Cost efficiency/elasticity of shipping schedules
Cost and Assets	Labor $ per unit—Direct Product Cost (DPC) Items stocked per FTE Accuracy of stocking

D11 Stock Shelf

For restocks, the tasks associated with identifying the item location, stocking the shelf according to merchandise plans, and recording the appropriate inventory transaction. For promotional items and stock repositioning the tasks associated with shelf and point of sale preparation, stock placement, and end of sale activities.

Performance Dimensions	Metric
Customer Service	Requirements fill % In-stock %
Efficiency	Stocking Cycle Time
Cost and Assets	Put-a-way Labor Cost – Includes internal and/or external contract costs In Store Inventory Accuracy

D12 Fill Shipping Cart and Checkout

Typical set of tasks associated with product selection, storage and movement through to checkout. The processes and tasks associated with product checkout including scanning, method of payment, credit application and approval, service agreement, order confirmation, and/or invoice or receipt.

Performance Dimensions	Metric
Customer Service	% Item Location Accuracy Price checks per cashier shift
Efficiency	Rain check %
Cost and Assets	% Shrinkage Checkout labor - % sales

Scenario 2 – Items from vendors to cross-dock facility

D3-2 Place Orders to Vendors

D4-2 Vendor Deliver

D5-2 Receive Product at Cross Dock

The activities such as receiving product, verifying, recording product receipt, determining reload/put-away location, putting away and recording location in the cross-dock facility. May include quality inspection.

Performance Dimensions	Metric
Customer Service	Incoming Material Quality

Efficiency	Dock To Stock Cycle Time Upside Delivery Flexibility Downside Delivery Flexibility
Cost and Assets	Distribution Costs Incoming Material Costs Product Acquisition Costs Finished Goods Inventory Days of Supply Inventory Obsolescence as a % of Total Inventory End-of-Life Inventory

Scenario 3 – Items from XYZ Wholesaler

D3-3 Place Order to XYZ Wholesaler

D4-3 XYZ Wholesaler Transportation

4.2.5.2 S: Source Stocked Product

As presented in the SCOR-model, Source Stocked Product is "process of the procurement, delivery, receipt and transfer of raw material items, subassemblies, product and or services". There are nine sub-processes in ABC Supermarket's Source Stocked Product Process:

S1 Schedule Product Deliveries
S2-1 Vendor Deliver
S2-2 Pick-Up
S3 Receive Product
S4 Verify Product
S5 Transfer Product
S6 Authorize Supplier Payment
ES1 Manage Sourcing Business Rules
ES2 Assess Supplier Performance
ES3 Manage Product Inventory

S1 Schedule Product Deliveries

Scheduling and managing the execution of the individual deliveries of product against an existing contract or purchase order. The requirements for product releases are determined based on the detailed sourcing plan or other types of product pull signals.

Performance Dimensions	Metric
Customer Service	% Schedules Generated within Supplier's Lead Time % Schedules Changed within Supplier's Lead Time
Efficiency	Average Release Cycle of Changes Average Days per Schedule Change

Cost and Assets	Product Management and Planning Costs as a % of Product Acquisitions Costs

S2-1 Vendor Deliver

S2-2 Pick-Up

S3 Receive Product

The process and associated activities of receiving product to contract requirements.

Performance Dimensions	Metric
Customer Service	% Orders/ lines received damage free % Orders/ lines received complete % Orders/ lines received on-time to demand requirement % Orders/ lines received with correct shipping documents
Efficiency	Receiving Cycle Time % Receipts Received without Item and Quantity Verification
Cost and Assets	Receiving costs as a % of Product Acquisition Costs

S4 Verify Product

The process and actions required determining product conformance to requirements and criteria.

Performance Dimensions	Metric
Customer Service	% Orders / line received defect free
Efficiency	Verification Cycle Time % Receipts Received Without Quality Verification
Cost and Assets	Verification costs as a % of Product Acquisition Costs

S5 Transfer Product

The transfer of accepted product to the appropriate stocking location within the supply chain. This includes all of the activities associated with repackaging, staging, transferring and stocking product.

Performance Dimensions	Metric
Customer Service	% Product transferred damage free % Product transferred complete % Product transferred on-time to demand requirement % Product transferred without transaction errors
Efficiency	Transfer Cycle Time Time and Cost Reduction related to Expediting the Transfer Process.
Cost and Assets	Transfer & Product storage costs as a % of Product Acquisition Costs Inventory DOS

S6 Authorize Supplier Payment

The process of authorizing payments and paying suppliers for product or services. This process includes invoice collection, invoice matching and the issuance of checks.

Performance Dimensions	Metric
Customer Service	% Invoices processed without issues and/or errors
Efficiency	Payment Cycle Time % Invoice Receipts and Payments Generated via EDI
Cost and Assets	Cost per invoice.

ES.1 Manage Sourcing Business Rules

The process of defining requirements and establishing, maintaining and enforcing decision support criteria, in alignment with business strategy and objectives. The business strategy defines the criteria for sourcing business rules that are translated into guidelines and policies for conducting business within the company. Sourcing business rules include: supplier selection and negotiation processes, fulfillment and delivery performance and relationship definition for specific levels of collaboration and partnership.

Performance Dimensions	Metric
Customer Service	% Agreements Negotiated without error/change % Orders placed without error The Degree & Frequency of Conformance to Business Rules that is achieved
Efficiency	End to End Cycle Time for Business Processes RP-PO Cycle Time Approval Cycle Time Policy Documentation & Approval Cycle Time
Cost and Assets	Cost of Process Documentation, Monitoring and Auditing Business Rules Cost of non-compliance to Business Rules Assets as a % of cost to administer business rules

ES.2 Assess Supplier Performance

The process of measuring actual supplier performance against internal and/or external standards, providing feedback to achieve and maintain the performance required to meet the customers' business and/or competitive needs.

Performance Dimensions	Metric
Customer Service	On-time delivery performance Defective product Performance to requirements in contracts/agreements Frequency of personnel changes and related impacts Supplier Performance Rating Quality Improvement
Efficiency	The degree and frequency of demonstrated flexibility or responsiveness measured against defined criteria

Cost and Assets	Total cost to measure supply base performance as a % of revenue Total cost of nonconformance as a % of revenue Costs related to specific types of non-conformance Assets as a % of Non-conformance Costs

ES.3 Manage Product Inventory
The process of establishing and maintaining physical inventories and inventory information. This includes warehouse management, cycle counting, physical inventories and inventory reconciliation.

Performance Dimensions	Metric
Customer Service	Fill Rate (% filled of an order)
Efficiency	Cycle Time required to move product to point of use
Cost and Assets	Inventory carrying cost Days of Supply (DOS) Inventory Value (measured in dollars) Inventory Days of Supply

4.2.5.3 R: Return Excess Product

As presented in the SCOR-model, Return Excess Product is "the process of the return of excess inventory and/or serviceable or obsolete products as defined by the terms and conditions of a customer/supplier contract." There are eight sub-processes in ABC Supermarket's Return Excess Product Process:

R1 Authorize Return
R2 Request Return Replacement or Credit
R3 Schedule Product Return
R4 Load Vehicle, Generate Ship Documents, Verify Credit & Ship Product
R5 Receive Return Product
R6 Verify Return Product
R7 Disposition Return Product
R8 Authorize Replacement or Credit

R1 Request Return Authorization
The process of validating, approving, and recording a Return Product Authorization (RPA) for excess inventory and/or serviceable or obsolete products as defined by the terms and conditions of a customer/supplier contract.

Performance Dimensions	Metric
Customer Service	
Efficiency	

Cost and Assets	Create Return Product Authorization Costs Return Order Entry and Maintenance Costs Value of Return Product

R2 Request Return Replacement or Credit

The process and actions required determining return replacement or credit.

Performance Dimensions	Metric
Customer Service	
Efficiency	
Cost and Assets	

R3 Schedule Product Return

Scheduling and managing the execution of the individual return deliveries of product against an existing RPA.

Performance Dimensions	Metric
Customer Service	
Efficiency	
Cost and Assets	Return Product Management and Planning Costs as a % of Product Return Costs Return Product Days of Supply

R4 Load Vehicle, Generate Ship Documents, Verify Credit & Ship Product

R5 Receive Return Product

The process of recording a physical receipt of Excess product and/or serviceable or obsolete products as defined by the terms and conditions of a customer/supplier contract against an RPA

Performance Dimensions	Metric
Customer Service	
Efficiency	
Cost and Assets	Order Management Costs to Return Product into the Supply Chain RPA Costs Receiving Costs as a % of Product Return Costs DOS of Return Product

R6 Verify Return Product

The process of verifying excess product and/or serviceable or obsolete products as defined by the terms and conditions of a customer/supplier contract as available inventory and disposition excess not usable for sale.

Performance Dimensions	Metric
Customer Service	
Efficiency	

Cost and Assets	Verification Costs as a % of Product Return Costs Excess DOS Obsolete DOS

R7 Disposition Return Product
The process of recovering excess and/or serviceable or obsolete products as defined by the terms and conditions of a customer/supplier contract product as available inventory and disposition excess not usable for sale.

Performance Dimensions	Metric
Customer Service	
Efficiency	
Cost and Assets	

R8 Authorize Replacement or Credit
The process and actions required to authorize deliver of replacement product or credit to customer

Performance Dimensions	Metric
Customer Service	
Efficiency	
Cost and Assets	

4.2.6 Find resources for metrics targets (e.g. benchmarking)

Comparing company performance in key metrics to median and best-in-class companies is the first step toward understanding company performance levels. The next step is to establish targets for all defined metrics using a combination of historical performance and external/internal benchmarks. A timeline for achieving these targets should also be identified for each metric. However, since there is little information about external supply chain performance benchmarks in the grocery retail industry, ABC Supermarket will primarily use its historical data and internal benchmarks to create targets for the metrics. A list of benchmark service providers is provided here for future reference[6]:

[6] Benchmark Sources from Supply Chain Council

Table 15 – Benchmarking Resources

Source	Website URL
Performance Measurement Group	www.pmgbenchmarking.com
Best Practices, LLC	www.benchmarkingreports.com
Penn State SMEAL College of Business - Center for Supply Chain Research (CSCR)	www.smeal.psu.edu/cscr/bench.html
Center for Advanced Purchasing Studies	www.capsresearch.org/
Hackett Best Practices	www.hackettbestpractices.com
Manufacturing Pulsemark	www.rsmmcgladrey.com/Resource_Center/resource_ManufacturingWholesaleDistribution.html
Michigan Manufacturing Technology Center's Performance Benchmarking Service	www.mmtc.org
APQC	www.apqc.org
Industry Week Best Plants	www.industryweek.com/iwinprint/bestplants/
Industry Week Census of Manufacturers	www.industryweek.com/Products/toolkit/
International Customer Service Association	www.icsa.com
Benchmarking Exchange	www.benchnet.com/
International Customer Service Association	www.icsa.com
Electric Utility Procurement and Supply Chain Benchmarking Association	www.euba.com/eupscba.html
SIMTechSingapore, Institute Of Manufacturing Technology	benchmarking.simtech.a-star.edu.sg/scor/

4.2.7 Prepare Metric Dictionary

For each suggested metric in 4.2.4, prepare a metric dictionary as shown below. The metric dictionaries provide a clear definition of each metric for every employee involved in the performance measurement system. The information in each metric dictionary includes Metric Name, Frequency of Measurement, Report To, Data Collector, Description, Formula, Unit Type, Polarity, Require Data and Source, Current Performance, Best-in-Class in the Industry, and Target. This set of dictionary can make sure all employees understand what the company is measuring and keep everyone in the same page.

Table 16 - Metric Dictionary

<table>
<tr><td>Metric Name: Fill Rate (Service Level)</td><td>Frequency of Measurement: Monthly</td></tr>
<tr><td>Report To: Director, Product Management
Director, Distribution Center
Manager, Inventory Replenishment</td><td>Data Collector:
Manager, Inventory Optimization & Replenishment</td></tr>
<tr><td colspan="2">Description: The amount of cases shipped on the initial shipment verses the amount of cases ordered. (at DC level)</td></tr>
<tr><td rowspan="2">Formula:
$\frac{\#ofCasesShippedinInitialshipment}{Total\#ofCasesShipped}$</td><td>Unit Type: Percentage</td></tr>
<tr><td>Current Performance:</td></tr>
<tr><td colspan="2">Polarity: High value is good</td></tr>
<tr><td rowspan="2">Require Data and Source:
Number of cases shipped; number of cases ordered in the month. Data for this measure is available in the system (AWS and Core)</td><td>Best-in-Class in the Industry:</td></tr>
<tr><td>Target:</td></tr>
</table>

<table>
<tr><td>Metric Name: Back Order</td><td>Frequency of Measurement: Weekly</td></tr>
<tr><td>Report To: Director, Product Management
Manager, Inventory Replenishment</td><td>Data Collector:
Store level: Store Manager
DC level: Manager, Distribution Center
Top level: Retail Replenishment Specialist</td></tr>
<tr><td colspan="2">Description: An unfilled customer order. A backorder is demand (immediate or past due) against an item whose current stock level is insufficient to satisfy demand. (in "SKU's", “cases” or in "value"; at “Store”, “Distribution Center”, or “Total Company” level.)</td></tr>
</table>

Formula: *BackOrder* = *#ofSKUPast* Re*questDeliveryDate* *or* *#ofCasePast* Re*questDeliveryDate* *or* *$ofItemPast* Re*questDeliveryDate*	**Unit Type:** number **Current Performance:**
Polarity: Low value is good	
Require Data and Source: # of SKU/# of cases/total value past request delivery date. Data for this measure is provided by each store and DC.	**Best-in-Class in the Industry:** **Target:**

Metric Name: Order Fulfillment Cycle	**Frequency of Measurement:** Monthly
Report To: V.P, Supply Chain Director, Product Management	**Data Collector:** Retail Replenishment Specialist
Description: The average actual lead times consistently achieved, from Store Authorization to Order Receipt, Order Receipt to Order Entry Complete, Order Entry Complete to Order Ready for Shipment, Order Ready for Shipment to Store Receipt of Order.	
Formula: $OrderFulfillmentCycle = \frac{\sum_1^n[(ActualDeliveryDt) - (OrderEntryDt)]}{n}$	**Unit Type:** number (days) **Current Performance:**
Polarity: Low value is good	
Require Data and Source: The order entry date and the actual delivery data for each order during a given month. Data for this measure is in the accounting system.	**Best-in-Class in the Industry:** **Target:**

Metric Name: On-Time Delivery	**Frequency of Measurement:** Weekly
Report To: Director, Non-Central Distribution Manager, Central Transportation	**Data Collector:** Freight Specialist
Description: The number of delivery made on-time divided by the total number of shipments in a period. (from each DC and X-dock)	
Formula:	**Unit Type:** %

$OnTimeDelivery = \frac{\#ofDeliveryMadeOnTime}{Total\#ofShipments}$	**Current Performance:**
Polarity: High value is good	
Require Data and Source: The number of delivery made on time and the total number of shipments. Data for this measure is provided by transportation department.	**Best-in-Class in the Industry:** **Target:**

Metric Name: Receiving Cycle Time	**Frequency of Measurement:** Monthly
Report To: Director, Product Management Director, Distribution Center	**Data Collector:** Manager, Distribution Center
Description: All time associated with unloading, receiving, inspecting, and placing incoming materials into inventory and processing payment to the supplier including recording exceptions, moving incoming materials to storage location, and inputting data into inventory systems. (in each DC)	
Formula: $\text{Re}\,ceivingCycleTime = \frac{\sum_1^n [(ActualArrivingTime) - (InventoryEntryTime)]}{n}$	**Unit Type:** number (hours or days) **Current Performance:**
Polarity: Low value is good	
Require Data and Source: Actual shipment arriving time and inventory data entering time. The data is in the warehouse inventory system.	**Best-in-Class in the Industry:** **Target:**

Metric Name: On-Time Case Delivery	**Frequency of Measurement:** Weekly
Report To: Director, Product Management Director, Non-Central Distribution	**Data Collector:** Manager, Central Transportation
Description: The amount of cases shipped on-time verses the amount of cases ordered	
Formula: $OnTimeCaseDelivery = \frac{\#ofCasesShippedOnTime}{Total\#ofCasesOrdered}$	**Unit Type:** % **Current Performance:**
Polarity: High value is good	
Require Data and Source: Total number of cases shipped before the request date, and total of cases ordered in the given week. Data is available in the warehouse inventory system.	**Best-in-Class in the Industry:** **Target:**

Metric Name: Supply Chain Cycle Time	**Frequency of Measurement:** Monthly
Report To: V.P, Supply Chain Director, Product Management	**Data Collector:** Supply Chain Performance Management Specialist
Description: The total time it would take to satisfy a customer order if all inventory levels were zero. It is calculated by adding up the longest lead times in each stage of the cycle.	
Formula: $SupplyChainCycleTime = ReceivingCycleTime + OrderFulfillmentCycleTime$	**Unit Type:** number (days) **Current Performance:**
Polarity: Low value is good	
Require Data and Source: Receiving Cycle Time and Order Fulfillment Cycle Time.	**Best-in-Class in the Industry:** **Target:**

Metric Name: Warehouse Operation Cost per Unit (case) Shipped	**Frequency of Measurement:** Monthly
Report To: VP, Supply Chain Director, Distribution Center	**Data Collector:** Manager, Distribution Center
Description: Total warehouse costs (including warehouse occupancy cost and wages) divided by the number of units (case) shipped per period. (for each DC)	
Formula: $WarehouseCostPerUnit = \frac{TotalWarehouseCosts}{Total\#ofCasesShipped}$	**Unit Type:** $/case **Current Performance:**
Polarity: Low value is good	
Require Data and Source: Total warehouse costs (from DCs) and total number of cases shipped in the given month.	**Best-in-Class in the Industry:** **Target:**

Metric Name: Freight Cost Per Unit (case) Shipped	**Frequency of Measurement:** Monthly
Report To: VP, Supply Chain Director, Non-Central Distribution Manager Central Transportation	**Data Collector:** Supply Chain Performance Management Specialist
Description: Total freight costs divided by number of units (case) shipped per period.	
Formula: $FreightCostPerUnit = \frac{TotalFreightCosts}{Total\#ofCasesShipped}$	**Unit Type:** $/case **Current Performance:**

Polarity: Low value is good	
Require Data and Source: Total transportation costs (from transportation department) and total number of cases shipped in the given month.	**Best-in-Class in the Industry:** **Target:**

Metric Name: Percent of Truckload Capacity Utilized	**Frequency of Measurement:** Weekly
Report To: V.P, Supply Chain Director, Non-Central Distribution Manager, Central Transportation	**Data Collector:** Freight Specialist
Description: The total pounds shipped divided by the theoretical maximum.	
Formula: $\%OfTruckloadCapacityUtilized = \frac{TotalCubeShipped}{TotalMaximumCapacity}$	**Unit Type:** % **Current Performance:**
Polarity: High value is good	
Require Data and Source: Total cubes shipped and total maximum capacity. Data is provided by transportation department.	**Best-in-Class in the Industry:** **Target:**

Metric Name: Actual Transit Time/Distance vs. Budget Transit Time/Distance	**Frequency of Measurement:** Weekly
Report To: Director, Non-Central Distribution Manager, Central Transportation	**Data Collector:** Freight Specialist
Description: Measured by the number of days (or hours)/miles, from the time a shipment leaves the facility to the time it arrives at the store location, against a standard transit time/distance quoted by the transportation department for each traffic lane.	
Formula: $TransitBudgetPerformance = \frac{TotalActualTransitTime}{TotalBudgetTransitTime}$	**Unit Type:** % **Current Performance:**
Polarity: Low value (below 1) is good	
Require Data and Source: Total actual transit time/distance and the total budget transit/distance for the traffic lanes in a given week.	**Best-in-Class in the Industry:** **Target:**

Metric Name: Pick and Pack Accuracy	**Frequency of Measurement:** Weekly
Report To: V.P, Supply Chain Director, Distribution Center	**Data Collector:** Manager, DC
Description: Total number of accurate cases shipped divided by the total # of cases shipped. (at each DC)	
Formula: $Pick\ \&\ PackAccuracy = \frac{Total\#ofAccurateCases}{Total\#ofCasesShipped}$	**Unit Type:** %
	Current Performance:
Polarity: High value is good	
Require Data and Source: The total number of cases pick & pack accurately, and the total number of cases shipped. Data is provided by each DC.	**Best-in-Class in the Industry:**
	Target:

Metric Name: Case Shipped per Hour	**Frequency of Measurement:** Weekly
Report To: Director, Distribution Center	**Data Collector:** Supply Chain Performance Specialist
Description: Total cases shipped in a period of time divided by the total manhours in that period of time. (at each DC)	
Formula: $CaseShippedPerHour = \frac{Total\#ofCasesShipped}{TotalManhours}$	**Unit Type:** case/hour
	Current Performance:
Polarity: High value is good	
Require Data and Source: The total number of cases shipped and the total manhours in the given week. Data is available in the system.	**Best-in-Class in the Industry:**
	Target:

Metric Name: Total SCM Costs as percentage of Revenue	**Frequency of Measurement:** Monthly
Report To: V.P, Supply Chain	**Data Collector:** Supply Chain Performance Management Specialist
Description: The aggregation of the following cost elements: Create Customer Order Costs Order Entry and Maintenance Costs Contract/Program and Channel Management Costs Order Fulfillment Costs Distribution Costs Transportation Costs Installation Costs	

Formula: $\%TotalSCMCostsof\ \text{Re}venue = \frac{TotalSupplyChainManagementCosts}{Total\ \text{Re}venue}$	**Unit Type:** %
	Current Performance:
Polarity: Low value is good	
Require Data and Source: Data is provided by supply chain and finance departments.	**Best-in-Class in the Industry:**
	Target:

Metric Name: Inventory Days of Supply	**Frequency of Measurement:** Weekly
Report To: Director, Product Management Manager, Inventory Optimization & Replenishment	**Data Collector:** Inventory Optimization & Replenishment Specialist
Description: Gross inventory ÷ (value of transfers/365 days). (at each DC)	
Formula: $InventoryDaysOfSupply = \frac{GrossInventory}{ValuesOfTransfers/365days}$	**Unit Type:** number (days)
	Current Performance:
Polarity:	
Require Data and Source: Data is available in the inventory system.	**Best-in-Class in the Industry:**
	Target:

Metric Name: Inventory Accuracy	**Frequency of Measurement:** Monthly
Report To: Director, Product Management Director, Distribution Center Manager Inventory Optimization & Replenishment	**Data Collector:** Manager, DC
Description: The amount of on-hand quantity (cases) verses the perpetual inventory quantity (cases) at each DC, within the following tolerances: A items = plus or minus 1% quantity variance from perpetual balance B items = plus or minus 3% quantity variance from perpetual balance C items = plus or minus 5% quantity variance from perpetual balance	
Formula: $InventoryAccuracy = \frac{OnHandCases}{InventoryCases}$	**Unit Type:** %
	Current Performance:
Polarity: High value is good	
Require Data and Source: Data is provided by each DC.	**Best-in-Class in the Industry:**
	Target:

Metric Name: Inbound Freight Costs as percentage of Purchases	**Frequency of Measurement:** Monthly
Report To: V.P, Supply Chain Director, Non-Central Distribution	**Data Collector:** Supply Chain Performance Management Specialist
Description: Inbound freight costs divided by purchase dollars.	
Formula: $\%InboundFreightCostOfPurchase = \frac{InboundFreightCosts}{PurchaseCosts}$	**Unit Type:** %
	Current Performance:
Polarity: Low value is good	
Require Data and Source: Data is available at the finance department.	**Best-in-Class in the Industry:**
	Target:

Metric Name: Outbound Freight Costs as percentage of Net Sales	**Frequency of Measurement:** Monthly
Report To: V.P, Supply Chain Director, Non-Central Distribution	**Data Collector:** Supply Chain Performance Management Specialist
Description: Outbound freight costs divided by net sales.	
Formula: $\%OutboundFreightCostOfSales = \frac{OutboundFreightCosts}{NetSales}$	**Unit Type:** %
	Current Performance:
Polarity: Low value is good	
Require Data and Source: Data is available at the finance department.	**Best-in-Class in the Industry:**
	Target:

Metric Name: Inventory Turns	**Frequency of Measurement:** Monthly
Report To: Director, Product Management Manager, Inventory Optimization & Replenishment	**Data Collector:** Inventory Optimization & Replenishment Specialist
Description: The number of times that a company's inventory cycles or turns over per year. (at each DC)	
Formula: $InventoryTurns = \frac{Rolling12mthCostOfSales}{AverageInventoryLevel(\$)}$	**Unit Type:** number
	Current Performance:
Polarity: High value is good	
Require Data and Source:	**Best-in-Class in the Industry:**

Sales data is available at the finance department.	**Target:**

Metric Name: Shelf Out-of-Stock %	**Frequency of Measurement:** Daily
Report To: Director, Product Management Manager, Inventory Optimization & Replenishment	**Data Collector:** Supply Chain Performance Management Specialist
Description: The percentage of SKUs that are out-of-stock at store.	
Formula: $ShelfOutOfStock\% = \frac{\sum_{1}^{n} \frac{\#ofOutOfStockSKU}{TotalSKUonShelves}}{n}$	**Unit Type:** %
	Current Performance:
Polarity: Low value is good	
Require Data and Source: Data is provided by each store.	**Best-in-Class in the Industry:**
	Target:

Metric Name: Warehouse Staff Turnover Rate	**Frequency of Measurement:** Quarterly
Report To: V.P, Supply Chain Director, Distribution Center	**Data Collector:** Manager, DC
Description: The number of employees left in a specified period divided by the average number of employees during the same period. (at each DC)	
Formula: $Turnover = \frac{\#ofEmployeesLeft}{Average\#ofEmployees}$	**Unit Type:** number
	Current Performance:
Polarity: High value is good	
Require Data and Source: Data is provided by each DC.	**Best-in-Class in the Industry:**
	Target:

4.2.8 Report results

The last step of implementing the supply chain performance measurement system is to design a proper report format so company can keep track of performance improvement over time. The report format can be a combination of whatever technology makes sense, such as spreadsheets, database products, or packaged applications. The suggested report format for

ABC Supermarket is based on spreadsheets, and a sample report is provided in the end of this section. The same metric that is reported to different management levels and departments might require different report frequency and format. The following tables give an example of this phenomenon.

Table 17 - Metric Measure and Report Frequency

V.P, Supply Chain

Metrics	Measure Frequency	Report Frequency
Order Fulfillment Cycle	Monthly	Monthly
Receiving Cycle Time	Monthly	Monthly
Supply Chain Cycle Time	Monthly	Monthly
On-Time Case Delivery	Weekly	Monthly
Total SCM Costs as percentage of Revenue	Monthly	Monthly
Inbound Freight Costs as percentage of Purchase	Monthly	Monthly
Outbound Freight Costs as percentage of Net Sales	Monthly	Monthly
Freight Cost Per Unit (case) Shipped	Monthly	Monthly
Warehouse Operation Cost per Unit Shipped	Monthly	Monthly
Pick and Pack Accuracy	Weekly	Monthly
Percent of Truckload Capacity Utilized	Weekly	Monthly
Warehouse Staff Turnover Rate	Quarterly	Quarterly

Director, Product Management

Metrics	Measure Frequency	Report Frequency
Fill Rate	Monthly	Monthly
Back Order	Weekly	Monthly
Order Fulfillment Cycle	Monthly	Monthly
Supply Chain Cycle Time	Monthly	Monthly
Inventory Accuracy	Monthly	Monthly
Inventory Days of Supply	Weekly	Monthly
Inventory Turns	Monthly	Monthly
Shelf Out-of-Stock %	Daily	Weekly

Director, Non-Central Distribution

Metrics	Measure Frequency	Report Frequency
On-Time Delivery	Weekly	Monthly
On-Time Case Delivery	Weekly	Monthly

Freight Cost per unit Shipped	Monthly	Monthly
Percent of Truckload Capacity Utilized	Weekly	Monthly
Actual Transit Time/Distance vs. Budget Time/Dist	Weekly	Monthly
Inbound Freight Costs as percentage of Purchase	Monthly	Monthly
Outbound Freight Costs as percentage of Net Sales	Monthly	Monthly
Freight Cost Per Unit (case) Shipped	Monthly	Monthly

Director, Distribution Center

Metrics	Measure Frequency	Report Frequency
Fill Rate	Monthly	Monthly
Receiving Cycle Time	Monthly	Monthly
Warehouse Operation Cost per Unit Shipped	Monthly	Monthly
Pick and Pack Accuracy	Weekly	Weekly
Case Shipped per Hour	Weekly	Weekly
Inventory Accuracy	Monthly	Monthly
Warehouse Staff Turnover Rate	Quarterly	Quarterly

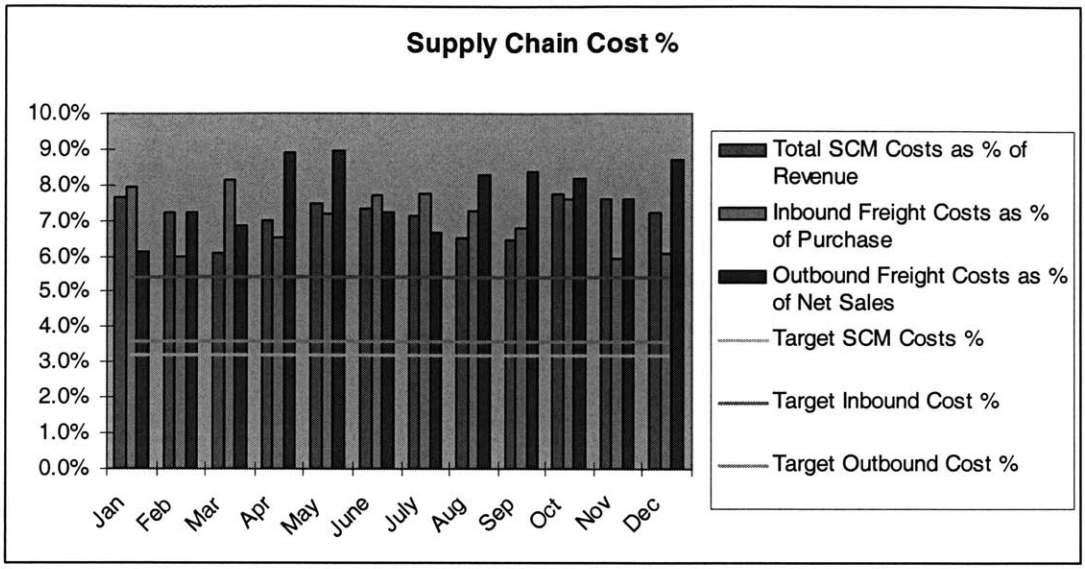
Manager, Inventory Optimization & Replenishment

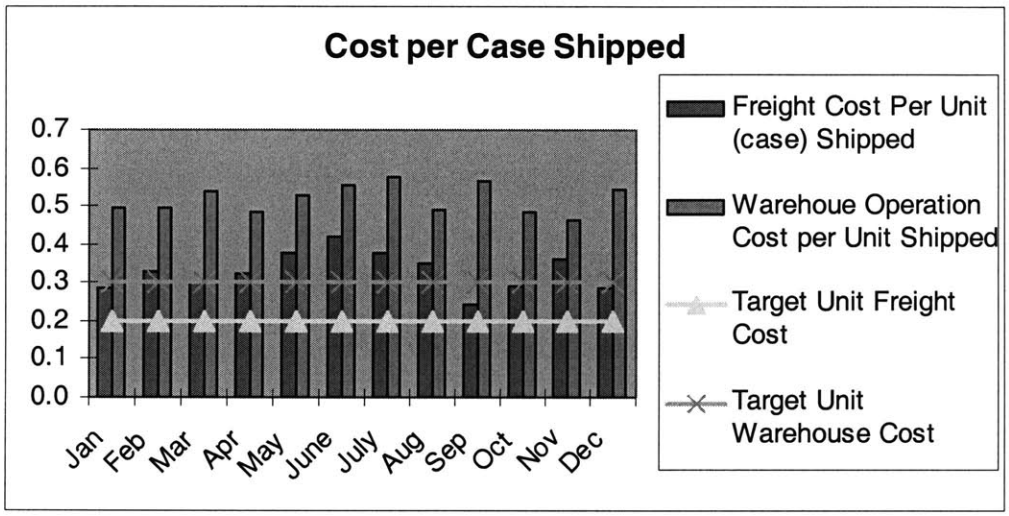
Metrics	Measure Frequency	Report Frequency
Fill Rate	Monthly	Monthly
Back Order	Weekly	Weekly
Inventory Days of Supply	Weekly	Weekly
Inventory Turns	Monthly	Monthly
Inventory Accuracy	Monthly	Monthly
Shelf Out-of-Stock %	Daily	Daily

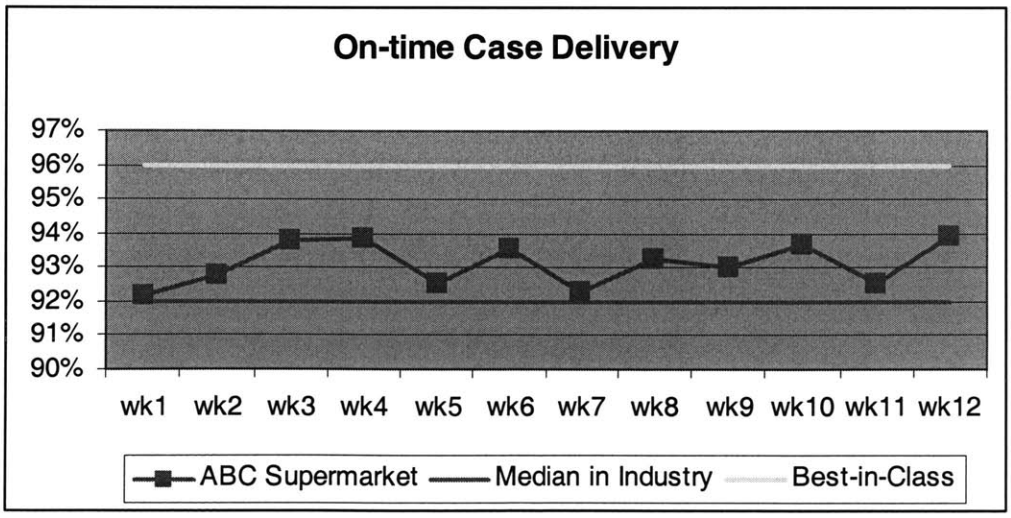
Manager, Central Transportation

Metrics	Measure Frequency	Report Frequency
On-Time Delivery	Weekly	Weekly
Freight Cost per unit Shipped	Monthly	Monthly
Percent of Truckload Capacity Utilized	Weekly	Weekly
Actual Transit Time/Distance vs. Budget Time/Dist	Weekly	Weekly
Freight Cost Per Unit (case) Shipped	Monthly	Monthly

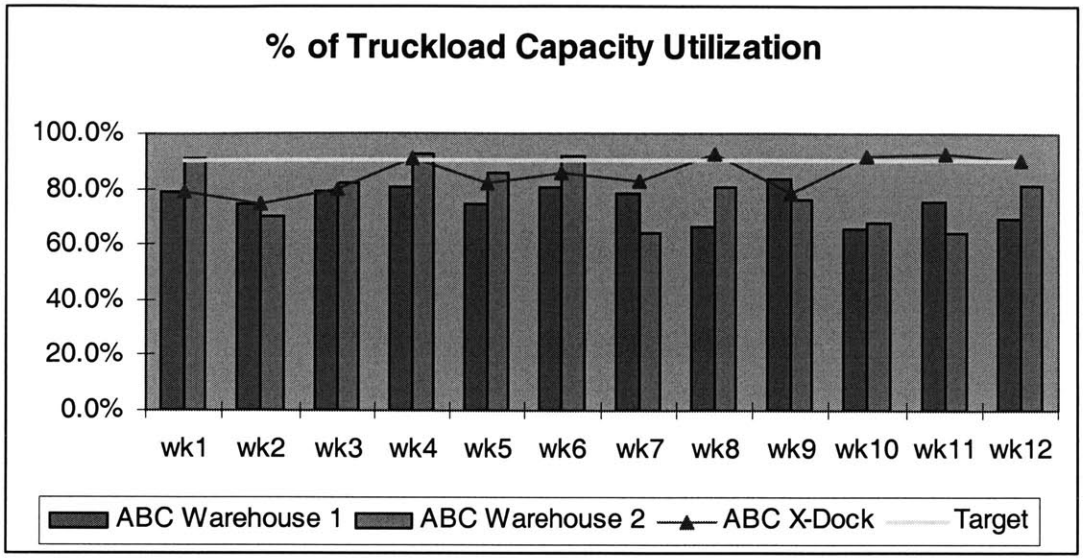
Figure 11 - Report Example for V.P, Supply Chain (Deliver Monthly)[7]

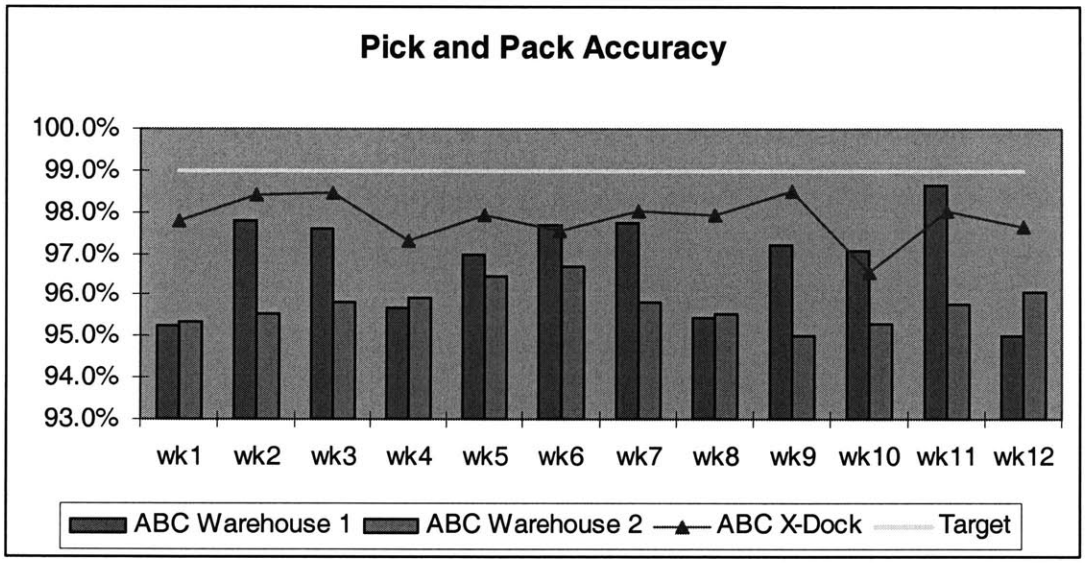


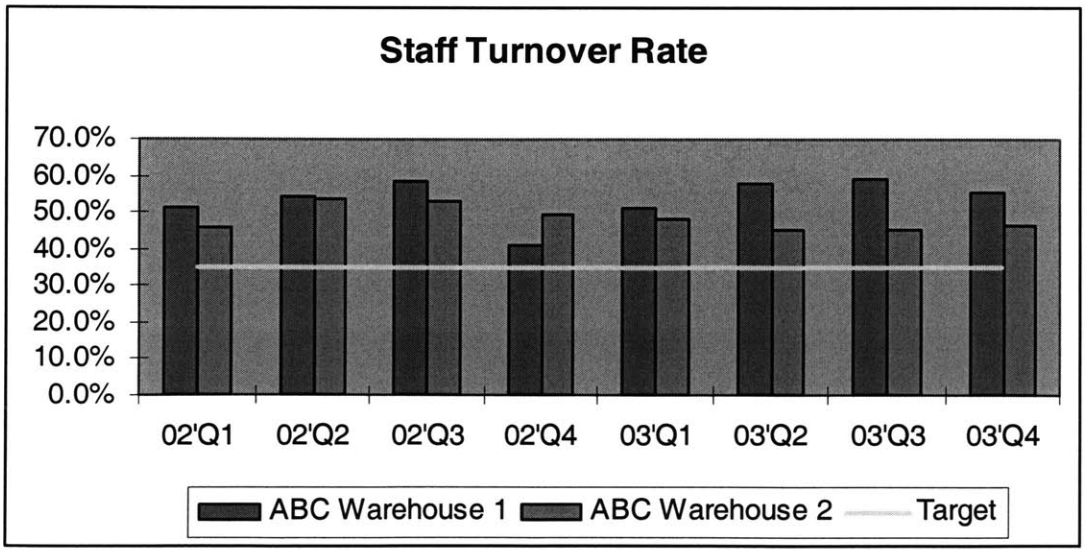


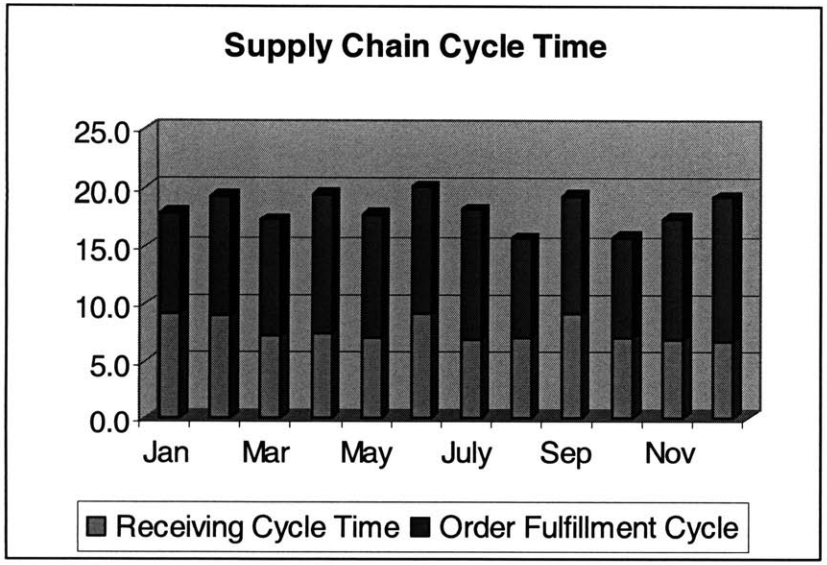


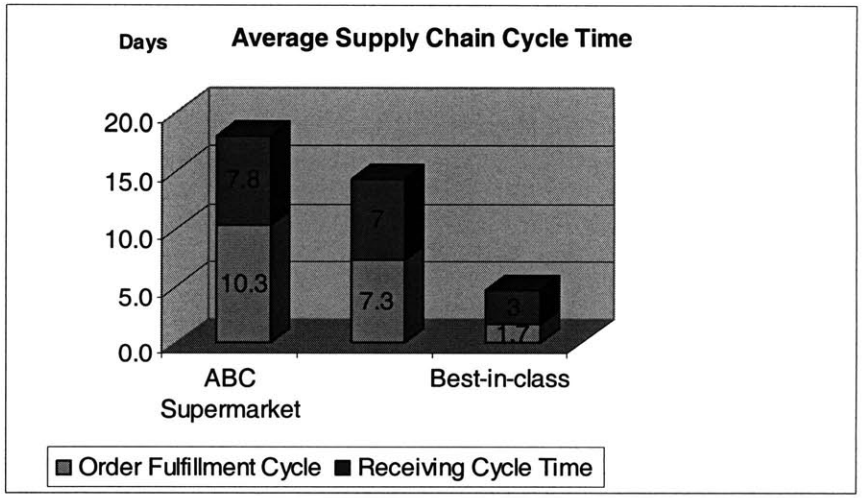
[7] All numbers used here are not based on the real company/industry situation.

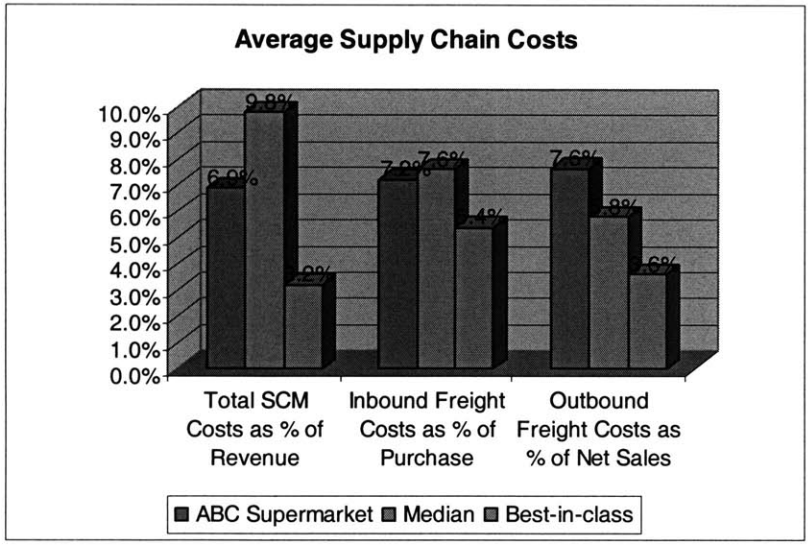

% of Truckload Capacity Utilization
100.0%
80.0%
60.0%
40.0%
20.0%
0.0%
wk1 wk2 wk3 wk4 wk5 wk6 wk7 wk8 wk9 wk10 wk11 wk12
ABC Warehouse 1
ABC Warehouse 2
ABC X-Dock
Target

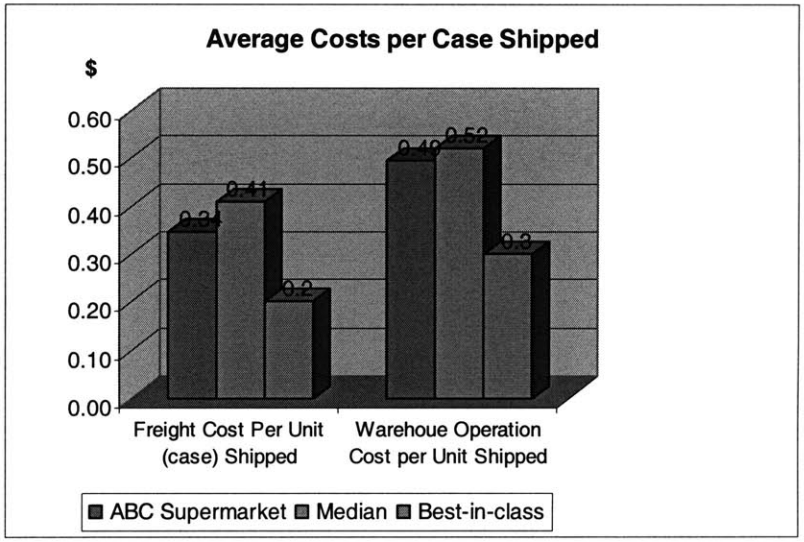

Pick and Pack Accuracy
100.0%
99.0%
98.0%
97.0%
96.0%
95.0%
94.0%
93.0%
wk1 wk2 wk3 wk4 wk5 wk6 wk7 wk8 wk9 wk10 wk11 wk12
ABC Warehouse 1
ABC Warehouse 2
ABC X-Dock
Target

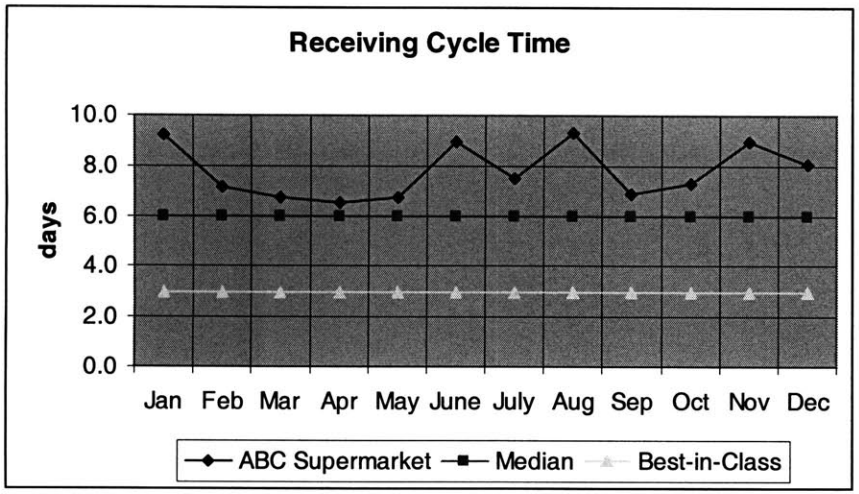

Staff Turnover Rate
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
02'Q1 02'Q2 02'Q3 02'Q4 03'Q1 03'Q2 03'Q3 03'Q4
ABC Warehouse 1
ABC Warehouse 2
Target

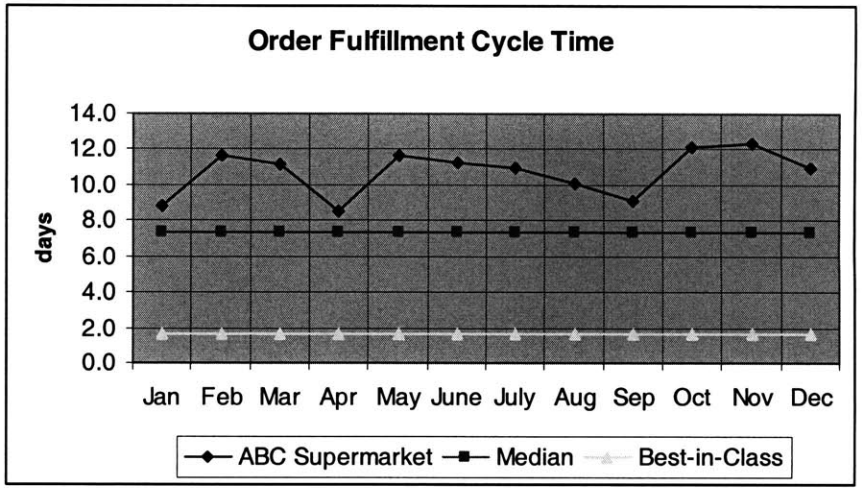

Supply Chain Cycle Time
25.0
20.0
15.0
10.0
5.0
0.0
Jan
Mar
May
July
Sep
Nov
Receiving Cycle Time
Order Fulfillment Cycle

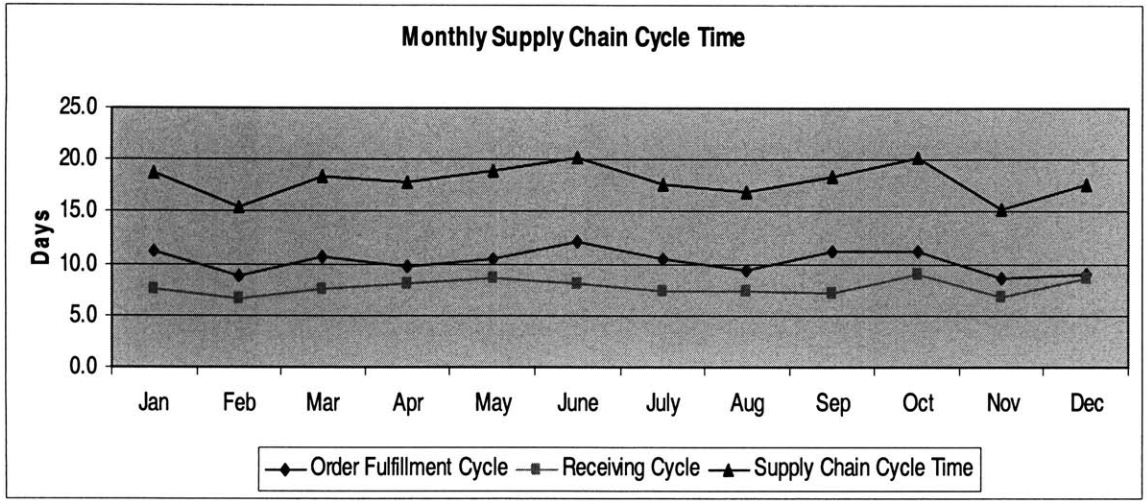

Days
Average Supply Chain Cycle Time
20.0
15.0
10.0
5.0
0.0
7.8
10.3
7
7.3
3
1.7
ABC Supermarket
Best-in-class
Order Fulfillment Cycle
Receiving Cycle Time


Average Supply Chain Costs
10.0%
9.0%
8.0%
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
Total SCM Costs as % of Revenue
Inbound Freight Costs as % of Purchase
Outbound Freight Costs as % of Net Sales
ABC Supermarket
Median
Best-in-class


Average Costs per Case Shipped
$
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0.31
0.41
0.2
0.48
0.52
0.3
Freight Cost Per Unit (case) Shipped
Warehoue Operation Cost per Unit Shipped
ABC Supermarket
Median
Best-in-class


Receiving Cycle Time
10.0
8.0
6.0
4.0
2.0
0.0
days
Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec
ABC Supermarket
Median
Best-in-Class


Order Fulfillment Cycle Time
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
days
Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec
ABC Supermarket
Median
Best-in-Class


Monthly Supply Chain Cycle Time
25.0
20.0
15.0
10.0
5.0
0.0
Days
Jan Feb Mar Apr May June July Aug Sep Oct Nov Dec
Order Fulfillment Cycle
Receiving Cycle
Supply Chain Cycle Time

The formats chosen for the diagrams in the sample report are based on the following principles:

1. Being able to show the trend of the company metric performance (showing the historical data, by week, by quarter, or by month).
2. Being able to compare the company metric performance with the target assigned by the company (showing the target value).
3. Being able to compare the company metric performance with the best-in-class performance in the industry (showing the best-in-class value).

For the metric that is measured separately in the different warehouses, such as Pick & Pack Accuracy and Staff Turnover Rate, all the performance from the different warehouses should be revealed in one diagram, along with the company target, so the management can easily compare each warehouse's performance.

Chapter 5. Conclusion

This research demonstrates that there is no single approach or set of metrics that companies can use to measure supply chain performance. However, approaches discussed herein provide simple guidance for companies developing their own customized supply chain performance measurement systems. Without a clear direction and an appropriately thorough method for building a supply chain performance model, it is easy for companies to get lost in the sea of data. To build a useful and customized supply chain performance measurement system, a company needs to examine its supply chain process carefully and understand the trade-off between different measurement dimensions. A good performance measurement system must be able to provide high-level managers with proper information to support a company's decision-making processes. And, finally, once a metric indicates problems in a particular performance area, the system should be able to provide further information and suggest remedies that would allow management to drill down to the root causes of the defined problems and relieve those pain points.

While this thesis provides a framework that companies can follow and use to get started building their own supply chain performance measurement systems, ongoing supply chain performance measurement requires that the aforementioned eight steps are revisited on a routine basis as supply chain functions or processes change and new initiatives are undertaken. As for any project, the success of implementing a supply chain performance system is contingent on total commitment and dedication by the company's management to achieving a set of well-defined end objectives. The seamless deployment of one such

system will be further facilitated by clear separation of duties and responsibilities in terms of data collection, leadership, and reporting.

Timeliness of the data employed is another critical issue in implementing a successful performance measurement system. The speed of gathering new, relevant data is important in order to only provide the most up-to-date metric information for management's consideration. Furthermore, to achieve maximum utilization of the performance measurement system, it is essential to periodically review the most current data and compare it with industry benchmarks, historical trends, and future targets. Keeping the measurement process aligned to supply chain performance objectives will help management ensure that resources are appropriately applied and desired strategic change is realized. A good performance measurement system, therefore, should provide perceptive diagrams that management can easily monitor the changes of performance in each area.

Bibliography

Besterfield, dale H., Carol Besterfield-Michna, Glen H. Besterfield, and Mary Besterfield-Sacre (2003), *Total Quality Management*, Upper Saddle River, NJ: Person Education, Inc. c2003.

Caplice, Chris and Yossi Sheffi (1995), "A Review and Evaluation of Logistics Performance Measurement Systems." *The International Journal of Logistics Management*, Vol. 6, No.1 (1995), pp. 61-74.

Chibba, Aron and Sven Ake Horte (2003), *Supply Chain Performance – A Meta Analysis,* University of Halmstad.

Fadel, H. and S. Narayanan (1997), Massachusetts Institute of Technology.

Garvin, David A. (1998), *Managing Quality: the Strategic and Competitive Edge*, New York: Free Press; London: Collier Macmillan, c1988.

Gunasekaran, A., Patel, C. and Tirtiroglu, E. (2001), "Performance Measures and Metrics in a Supply Chain Environment." *International Journal of Operations & Production Management,* 14 February 2001, vol. 21, iss. 1-2, pp. 71-87.

Hausman, Warren H., (2002) "Supply Chain Performance Metrics." *The Practice of Supply Chain Management*, June 21, 2002.

van Hoek R.I. (2001) "The Contribution of Performance Measurement to the Expansion of Third Party Logistics Alliances in the Supply Chain." *International Journal of Operations & Production Management*, 14 February 2001, vol. 21, iss. 1, pp. 15-29.

Hood, C., O. James, G. Jones and T. Travers (1999), *Regulation inside Government: Waste-Watchers, Quality Police, and Sleaze-Busters,* Oxford, Oxford University Press.

Kaplan, Robert S. and David P. Norton (1996), *The Balanced Scorecard: Translating Strategy into Action*, Boston, MA: Harvard Business School Press, c1996.

Keebler, James, Karl Manrodt, David Durtsche, and Michael Ledyard (1999), *Keeping Score: Measuring the Business Value of Logistics in the Supply Chain.* Oakbrook, IL: council of Logistics Management, c1999

Lambert, Douglas M. and Terrance L. Pohlen (2001), "Supply Chain Metrics." *The International Journal of Logistics Management*, Vol. 12, No.1 (2001), pp. 1-19.

van Landeghem, R. and K. Persoons (2001), "Benchmarking of Logistical Operations based on a Causal Model." *International Journal of Operations & Production Management*, 14 February 2001, vol. 21, iss. 1-2, pp. 254-267.

Mason-Jones, R. and Denis R Towill (1998), "Time compression in the supply chain: information management is the vital ingredient" *Logistics Information Management*, 1998, Vol. 11, No. 2, pp. 93-104.

Otto, A. and H. Kotzab (2001), Lehrstuhl fur Logistik, Friedrich-Alexander-Universiteät, Nurnberg, pp. 17.

Reimer, Ronald F. (1997), "The Use of Metrics to Manage Proactive Maintenance."

Simatupang, Togar M., Alan C. Wright, and R. Sridharan (2002). "The Knowledge of Coordination for Supply Chain Integration" *Business Process Management Journal*, Vol. 8, No. 3, pp. 289-308.

Tan, K. C., S.B. Lyman, and J. D. Wisner (2002), "Supply Chain Management: a Strategic Perspective." *International Journal of Operations & Production Management*, 8 June 2002, vol. 22, iss. 6, pp. 614-631.