

# What About Measuring Supply Chain Performance?

Most consultants' recipes for affecting business change and behavior in an organization use ingredients for measuring ongoing performance. Many feel that continuous improvement in an organization relies on "measuring, measuring, and measuring again." Once a company's road map for change is laid out, it can develop a set of performance metrics or key performance indicators (KPIs) to ensure that it knows when it is meeting its objectives. Such organizations should choose a limited number of metrics and align executive to management-level measures; we offer suggestions for setting performance targets or internal or external benchmarks, and include advice on how to start measuring supply chain performance.

The current interest in performance measurements has led to a variety of supporting adages or clichés in the industry, such as:

- "Anything measured improves."
- "What you measure is what you get."
- "Anything measured gets done."
- "You can't manage what you do not measure."

These are not new business ideas, but there are a few new twists. Using measurements to support manufacturing operations has its roots back to the late 19th and early 20th centuries with ideas espoused by Frederick W. Taylor, the father of applying scientific methods to running business. His ideas for time and motion studies of operations were successfully used to scientifically manage production lines and warehouse operations. These ideas, however, led to exaggerated business processes that transitioned into "running a business by the stopwatch" with employers treating human employees as if they were highly reliable, predictable machines to be monitored and controlled. Over time, the workplace's view of performance measurement became more humane and these exaggerated types of monitor and control methods fell out of favor, replaced by a focus on a measuring a business' performance rather than that of the individual.

Throughout the last decade, companies have expended significant amounts of time and effort to re-engineer their supply chains through busi-

ness process change and technology focused on implementing integrated Supply Chain Management (SCM) principles. While substantial financial and human resources have been spent on doing this, there has been little sign of realized benefits. While consultants are recommending supply chain measurement, they generally lack formal approaches to it. In addition, while SCM software providers are selling solutions that enable companies to drastically improve their supply chain performance, these same vendors do not adequately provide tools needed to measure these improvements. In this report, AMR Research discusses supply chain performance measurement and the results of research conducted to address the following questions:

- Why is performance measurement important?
- What general approaches are available to measure supply chains?
- What advice can be followed when selecting performance measures?
- What methods are available for setting performance targets?
- What are application vendors doing to support supply chain performance measurement?
- How should a company get started?

## Why Is Performance Measurement Important?

Measurement is important, as it affects behavior that impacts supply chain performance. As such,

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performance measurement provides the means by which a company can assess whether its supply chain has improved or degraded. The importance of using measures to help ensure that a supply chain is performing well can be illustrated by the following anecdotal story:

Tom is driving on a long trip in a car that has a broken speedometer and a broken gas gauge. He has been traveling for several hours, keeping track of the time and looking at his odometer to determine how fast he is going. He is sure that he has been obeying the speed limits – when he is stopped by a patrolman and given a speeding ticket. Slowing down, he drives for two more hours keeping track of the time and his odometer, but once again is stopped by a patrolman and given another speeding ticket. During the remainder of the trip Tom slows down to a speed that he now believes will avoid getting another speeding ticket. He drives for one more hour when the car stops all of a sudden. He ran out of gas!

Not a very good trip for Tom, primarily because he was missing some very important key measurement devices in his car – the speedometer and the gas gauge. Unlike Tom, most people would be extremely reluctant to drive this car. In a similar way, however, there are many companies that run their supply chains without a good set of measurements in place. Like Tom, the only way they are able to find out if they are meeting their supply chain goals is after the fact, by diagnosing poor financial results, or when they lose an important customer – events similar to Tom's speeding tickets.

There are several lessons on the importance of measuring supply chain performance to be learned from this story:

- Measurements are important to directly controlling behavior and indirectly to performance – the speedometer reading impacts how hard or soft Tom pushes on the gas pedal.
- A few key measurements will go a long way toward keeping a company on track towards achieving its supply chain improvement objectives – like those on a speedometer and a gas gauge.
- Seemingly relevant, but cumbersome, measurements are of little use, and are possibly a hindrance, in helping to improve supply chain performance – like the odometer in the car.
- Picking the wrong measures and leaving out important ones could lead to supply chain performance degradation – like running out of gas.
- Driving a supply chain based only on after-the-fact measures, like losing an important customer or having poor financial performance is not very effective – the way getting speeding tickets and running out of gas is an expensive way to drive a car.

### What General Approaches Are Available To Measure Supply Chains?

Traditionally, companies have tracked performance based largely on financial accounting principles, many which date back to the ancient Egyptians and Phoenicians. Financial accounting measures are certainly important in assessing whether or not operational changes are improving the financial health of an enterprise, but insufficient to measure supply chain performance for the following reasons:

- The measures tend to be historically oriented and not focused on providing a forward-looking perspective.
- The measures do not relate to important strategic, non-financial performance, like customer service/loyalty and product quality.
- The measures do not directly tie to operational effectiveness and efficiency.

In response to some of these deficiencies in

traditional accounting methods for measuring supply chain performance, a variety of measurement approaches have been developed, including the following:

- The Balanced Scorecard
- The Supply Chain Council's SCOR Model
- The Logistics Scoreboard
- Activity-Based Costing (ABC)
- Economic Value Analysis (EVA)
- Balanced Scorecards

The Balanced Scorecard recommends the use of executive information systems (EIS) that track a limited number of balanced metrics that are closely aligned to strategic objectives. The approach was initially developed by Robert S. Kaplan and David P. Norton and was discussed in an article, titled "The Balanced Scorecard – Measures That Drive Performance," published in the *Harvard Business Review*, January-February 1992. While not specifically developed for supply chain performance measurement, Balanced Scorecard principles provide excellent guidance to follow when doing it. The approach would recommend that a small number of balanced supply chain measures be tracked based on four perspectives:

- Financial perspective (e.g., cost of manufacturing and cost of warehousing)
- Customer perspective (e.g., on-time delivery and order fill rate)
- Internal business perspective (e.g., manufacturing adherence-to-plan and forecast errors)
- Innovative and learning perspective (e.g., APICS-certified employees and new product development cycle time)

An industry has grown around the Balanced Scorecard approach with a variety of firms that provide consulting and solutions for implementing performance measurement, such as:

- Renaissance Worldwide, Inc. (Newton, MA) got its start doing this Balanced Scorecard consulting and grew to be one of the 30 largest consulting firms.
- Gentia Software Inc. (Boston, MA) markets a software application, Gentia's Renaissance Balanced Scorecard that

W<sup>2</sup>

#### Weblink

For more on performance indicators:

[reiter.ASCET.com](mailto:reiter.ASCET.com)

For more on VMIs, see:

[anthony.ASCET.com](mailto:anthony.ASCET.com)

[moore.ASCET.com](mailto:moore.ASCET.com)

For more on value added, see:

[peters.ASCET.com](mailto:peters.ASCET.com)

[srivastava.ASCET.com](mailto:srivastava.ASCET.com)

For more on forecasting, see:

[wayman.ASCET.com](mailto:wayman.ASCET.com)

[quinn-c.ASCET.com](mailto:quinn-c.ASCET.com)

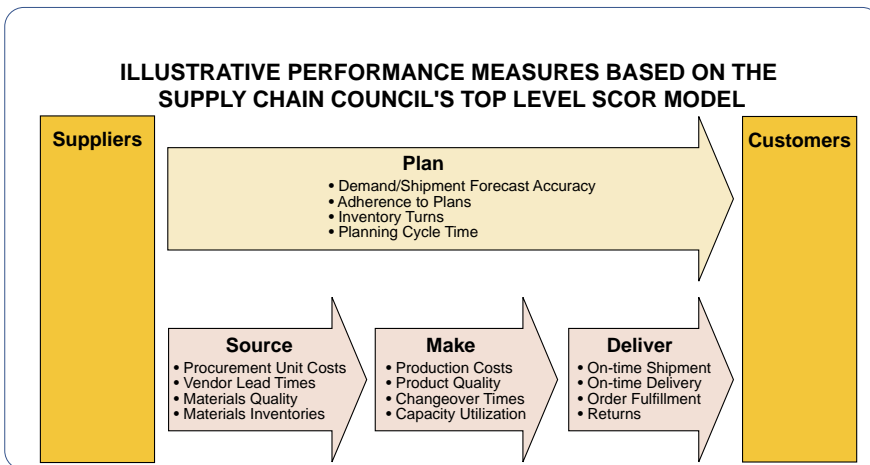


Figure 1.0 Illustrative performance measures

incorporates Renaissance Worldwide's performance measurement approach.

- Corvu Corp. (Edina, MI) sells a Balanced Scorecard System software application that provides interactive scorecard functionality.

#### Supply Chain Council's SCOR Model

The Supply Chain Council's SCOR Model provides guidance on the types of metrics one might use to get a balanced approach towards measuring the performance of one's overall supply chain. The SCOR Model approach advocates a set of supply chain performance measures comprised of a combination of:

- Cycle time metrics (e.g., production cycle time and cash-to-cash cycle)
- Cost metrics (e.g., cost per shipment and cost per warehouse pick)
- Service/quality metrics (on-time shipments and defective products)
- Asset metrics (e.g., inventories)

In contrast to the Balanced Scorecard, which is focused on executive enterprise-level measurement, the SCOR Model approach directly addresses the needs of supply chain management with balanced measurements. Figure 1.0 depicts an illustrative set of supply chain measures balanced among the SCOR Model's top-level processes.

#### The Logistics Scoreboard

Another approach to measuring supply

chain performance was developed by Logistics Resources International Inc. (Atlanta, GA), a consulting firm specializing primarily in the logistical (i.e., warehousing and transportation) aspects of a supply chain. The company recommends the use of an integrated set of performance measures falling into the following general categories:

- Logistics financial performance measures (e.g., expenses and return on assets)
- Logistics productivity measures (e.g., orders shipped per hour and transport container utilization)
- Logistics quality measures (e.g., inventory accuracy and shipment damage)
- Logistics cycle time measures (e.g., in-transit time and order entry time)

Logistics Resources sells a spreadsheet-based, educational tool called The Logistics Scoreboard that companies can use to pilot their supply chain performance measurement processes and to customize for ongoing use. The tool and a monograph (Logistics Performance, Cost, and Value Measures that documents the tool and its use) are distributed by The Penton Institute (Cleveland, OH). In contrast to the other approaches discussed, The Logistics Scoreboard is prescriptive and actually recommends the use of a specific set of supply chain performance measures. These measures, however, are skewed toward logistics, having limited focus on measuring the production and procurement activities within a supply chain.

#### Activity Based Costing

The Activity-Based Costing (ABC) approach was developed to overcome some of the shortcomings of traditional accounting methods in tying financial measures to operational performance. The method involves breaking down activities into individual tasks or cost drivers, while estimating the resources (i.e., time and costs) needed for each one. Costs are then allocated based on these cost drivers rather than on traditional cost-accounting methods, such as allocating overhead either equally or based on less-relevant cost drivers. This approach allows one to better assess the true productivity and costs of a supply chain process. For example, use of the ABC method can allow companies to more accurately assess the total cost of servicing a specific customer or the cost of marketing a specific product. ABC analysis does not replace traditional financial accounting, but provides a better understanding of supply chain performance by looking at the same numbers in a different way.

ABC methods are useful in conjunction with the measurement approaches already discussed as their use allows one to more accurately measure supply chain process/task productivity and costs by aligning the metrics closer to actual labor, material, and equipment usage.

#### Economic Value-Added

One of the criticisms of traditional accounting is that it focuses on short-term financial results like profits and revenues, providing little insight into the success of an enterprise towards generating long-term value to its shareholders – thus, relatively unrelated to the long-term prosperity of a company. For example, a company can report many profitable quarters, while simultaneously disenfranchising its customer base by not applying adequate resources towards product quality or new product innovation.

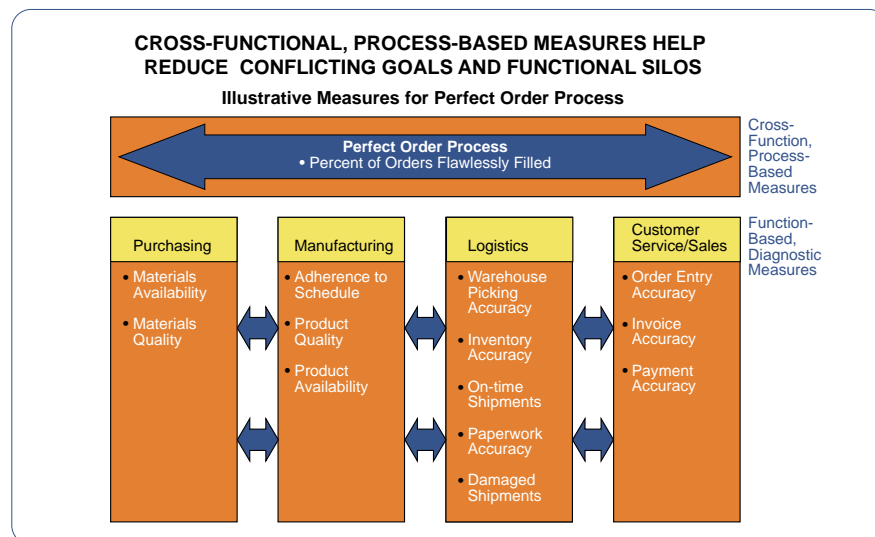
To correct this deficiency in traditional methods, some financial analysts advocate estimating a company's return on capital or economic value-added. These are based on the premise that shareholder value is increased when a company earns more than its cost of capital. One such

measure, EVA, developed by Stern, Stewart & Co., attempts to quantify value created by an enterprise, basing it on operating profits in excess of capital employed (through debt and equity financing). Some companies are starting to use measures like EVA within their executive evaluations. Similarly, these types of metrics can be used to measure an enterprise's value-added contributions within a supply chain. However, while useful for assessing higher-level executive contributions and long-term shareholder value, economic-value-added metrics are less useful for measuring detailed supply chain performance. They can be used, however, as the supply chain metrics within an executive-level performance scorecard, and can be included in the measures recommended as part of The Logistics Scoreboard approach.

### What Advice Can Be Followed When Selecting Measures?

While the approaches described above provide guidance for supply chain measurement, they provide less help in assessing specific metrics to be used. In this regard, a key driving principle, as espoused by the Balanced Scorecard, is that measures should be aligned to strategic objectives. Supply chain strategy, however, differs for every company and depends upon its current competencies and strategic direction. Companies, for example, can generally fall into the following developmental stages that will dictate the types of measures and the degrees to which they will need to focus:

- **Functional Excellence** – a stage in which a company needs to develop excellence within each of its operating units such as the manufacturing, customer service, or logistics departments. Metrics for a company in this stage will need to focus on individual functional departments.
- **Enterprise-Wide Integration** – a stage in which a company needs to develop excellence in its cross-functional processes rather than within its individual functional departments. Metrics for a company in this stage will need to focus on cross-functional processes.



**Figure 3.0** Benefits of cross-functional, process-based measures

- **Extended Enterprise Integration** – a stage in which a company needs to develop excellence in inter-enterprise processes. Metrics for a company in this stage will focus on external and cross-enterprise metrics.

Historically most companies have focused their performance measurement on achieving functional excellence. With the advent of Supply Chain Management (SCM) principles aimed at integrating their supply chains, many have objectives to increase their degree of enterprise-wide integration and extended enterprise integration. In order to achieve these types of objectives, their performance measurement systems will need to align to them. Advice for these supply chain measurement systems falls into five areas that include:

- Function-based measures
- Process-based measures
- Cross-enterprise measures
- Number of measures to be used
- Alignment of executive to management-level measures

A set of measures developed by a leading consumer products manufacturer is also discussed, providing an illustration of the type that might be selected.

### Do Not Focus Only On Function-Based Measures

A major problem encountered with most performance measurement systems is that they are functionally focused. Within these systems, each functional area measures its performance in its own terms, with individuals evaluated based on their ability to meet objectives consistent with their department's performance measures. Individuals working under these measurement systems tend to drive operations toward improving their own area's performance, frequently at the expense of the performance of other functional areas. When each functional area sets its performance measures in isolation from those of others, it often leads to functional silos and conflicting organizational goals.

Figure 2.0 depicts a typical set of function-based supply chain-related performance measures used by many manufacturers. These types of measures used in isolation of each other tend to create conflicting goals among functional areas as follows:

- **Customer Service and Sales** – In these functional areas, employees are measured by their ability to maintain customer service levels. Measured in this context only, these employees tend to drive operations toward satisfying potentially smaller-sized customer orders and carrying high levels of finished goods inventories by

LIST OF POSSIBLE SUPPLY CHAIN MEASURES		
Customer Service Measures	Process, Cross-Functional Measures	Extended Enterprise Measures
Order Fill Rate Line Item Fill Rate Quantity Fill Rate Backorders/stockouts Customer satisfaction % Resolution on first customer call Customer returns Order track and trace performance Customer disputes Order entry accuracy Order entry times	Forecast accuracy Percent perfect orders New product time-to-market New product time-to-first make Planning process cycle time Schedule changes	Total landed cost Point of consumption product availability Total supply chain inventory Retail shelf display Channel inventories EDI transactions Percent of demand/supply on VMI/CRP Percent of customers sharing forecasts Percent of suppliers getting shared forecast Supplier inventories Internet activity to suppliers/customers Percent automated tendering
Purchasing Related Measures	Manufacturing Related Measures	Logistic Related Measures
Material inventories Supplier delivery performance Material/component quality Material stockouts Unit purchase costs Material acquisition costs Expediting activities	Product quality WIP inventories Adherence-to-schedule Yields Cost per unit produced Setups/Changeovers Setup/Changeover costs Unplanned stockroom issues Bill-of-materials accuracy Routing accuracy Plant space utilization Line breakdowns Plant utilization Warranty costs Source-to-make cycle time Percent scrap/rework Material usage variance Overtime usage Production cycle time Manufacturing productivity Master schedule stability	Finished goods inventory turns Finished goods inventory days of supply On-time delivery Lines picked/hour Damaged shipments Inventory accuracy Pick accuracy Logistics cost Shipment accuracy On-time shipment Delivery times Warehouse space utilization End-of-life inventory Obsolete inventory Inventory shrinkage Cost of carrying inventory Documentation accuracy Transportation costs Warehousing costs Container utilization Truck cube utilization In-transit inventories Premium freight charges Warehouse receipts
Administration/Financial Measures	Marketing Related Measures	Other Measures
Cash flow Income Revenues Return on capital employed Cash-to-cash cycle Return on investment Revenue per employee Invoice errors Return on assets	Market share Percent of sales from new products Time-to-market Percent of products representing 80% of sales Repeat versus new customer sales	APICS trained personnel Patents awarded Employee turnover Number of employee suggestions

Figure 3.0 Possible supply chain measures

- stocking inventories in multiple locations close to customers to shorten cycle times
- Logistics – In this functional area, employees are measured by transportation and warehousing costs, and inventory levels. Measured in this context only, Logistics personnel tend to keep inventories low and batch customer orders to ensure that trucks are shipped full and picking operations are minimized. On the inbound side, these employees will want to receive full truckloads at their warehouse docks to minimize receiving costs, usually at the expense of increased inventories.
  - Manufacturing – In this functional area, employees are measured in terms of manufacturing productivity. Measured in this context only, they want to make longer production runs that result in higher levels of finished goods inventories. In a make-to-order manufacturing environment there will be a tendency to consolidate customer orders into longer production runs, making them less responsive to dynamic customer demands.
  - Purchasing – In this functional area, employees are typically measured by

materials costs and supplier delivery performance. Measured in this context only, buyers will purchase in large quantities to get volume discounts and use more suppliers for each item to ensure a low price. This behavior results in purchasing excess, potentially low quality, raw materials.

It is apparent from the behavior described above that use of only function-based measures could drive employees toward changing functional performance in entirely different directions. These types of measures alone have reinforced functional silos, reducing the effectiveness of many supply chains and fostering arms-length transactions among departments, leading to processes that are slow to respond. In addition, performance improvement initiatives get focused on a single objective that frequently runs counter to increasing the efficiency of the total supply chain. For example, an initiative focused on reducing transportation costs focuses on filling up outbound trucks. While this seems benign, it may not be best from a total supply chain perspective when customer orders are held

up to fill up a truck, or if customers are forced to order in greater quantities.

### Include Process-Based Measures to Improve Enterprise-Wide Performance

To help integrate their supply chains, companies are starting to break down the functional silos by organizing around cross-functional processes. This is done by either creating departments responsible for an overall process or creating cross-functional teams that drive an overall process, such as:

- Order fulfillment (e.g., order-to-cash)
- New product development/introduction (e.g., concept-to-first sale or production batch)
- Total cycle time (e.g., materials purchase to customer payment or cash-to-cash)

To support these organizational changes, companies are supplementing function-based measures with some process-based performance measures. While this approach does not advocate the total elimination of function-based measures, it places focus on the performance of an overall process, using these measures as diagnostic information to assess what is affecting overall performance.

For example, the perfect order concept measures the percent of customer orders that are flawlessly fulfilled. This metric is one that measures the effectiveness of the order fulfillment process, crossing the boundaries of functional departments. Under this measurement system, a failure during any step in the process or in any functional department, such as an item shortage on an order line or a wrong invoice, can result in a failure to meet the overall objective of flawlessly fulfilling an order. In addition to measuring the overall perfect order process, diagnostic measures for each task in the fulfillment process would need to be used.

Figure 3.0 depicts a set of order fulfillment measures based on a perfect order process concept. It illustrates the hierarchical relationship of process-based measures with their diagnostic function-based measures. The cross-functional, process-based measures provide visibility to strategic aspects of supply chain performance, while the func-

## PERFECT ORDER PROCESS TASK RELATED MEASURES

Task Related Measure	Description
Product availability	Product available to satisfy all order lines
Order entry accuracy	Order entered correctly in lines and in quantities
Warehouse picking accuracy	All items picked in correct quantities ( e.g., in make-to-stock environment)
Production accuracy	All items produced in correct quantities and quality (e.g., in make-to-order or assemble to order)
On-time product shipment	All items shipped to customer on time
On-time product delivery	All products delivered to customer on time
Product quality	All products delivered are not defective or damaged
Paperwork accuracy	All documentation is accurate, including advanced shipping notices (ASNs) and bills of lading
Customer inquiry service	All queries on order status handled with courtesy and responsiveness
Invoice accuracy	Order correctly billed ( e.g., for pricing and terms & conditions )
Payment accuracy	Payment correctly recorded

Figure 4.0 Perfect order process task-related measures

tion-based measures are more diagnostic in nature, useful for pinpointing problem areas.

### Include Cross-Enterprise Measures To Improve Extended Enterprise Performance

The cross-functional process approach to measuring supply chains is applicable for inter- as well as intra-enterprise processes. For example, many would agree that the two most important bottom-line measures of overall supply chain performance relate to:

- The availability of the right products at the point of consumption
- The total landed cost to get the products to the point of consumption (including all material, manufacturing, transportation, warehousing, and inventorying costs along the supply chain)

While these are the penultimate of supply chain measures, it is rare for one organization to control its whole supply chain's performance. Supply chains are typically comprised of many value-adding trading partners that control the portions in which they transact business. While this might be the case, SCM principles dictate that significant benefits can accrue when integrated inter-enterprise processes are in place, to synchronize and optimize the supply chain. These inter-enterprise processes should also be measured to help ensure that they are effective.

To ensure the effectiveness of cross-enterprise processes, a company should

measure performance of parts of their supply chain that lie outside their own enterprise. This leads to the question of "Should you measure what is not within the domain of your enterprise or what you cannot control?" Some more specific questions relating this issue are:

- Is a manufacturer responsible for the fact that its products have poor availability on the retail shelf?
- Is a shipper responsible for the freight operations of downstream customers that pay for their own transportation or pick up products at the shipper's location?
- Is an upstream component parts supplier responsible for the fact that a manufacturer's order could not be produced due to lack of the supplier's part?
- Is a manufacturer responsible for on-time delivery to the customer after it has tendered a shipment to a transportation carrier?

Most people would answer "no" to most of these questions, stating that it is useless to measure anything on which you have little or no control. In situations, however, where performance directly or indirectly impacts the availability or cost of products at the point of consumption, the answer should be "yes" to all of these questions.

As an illustration, take the case of a leading toy manufacturer's sales executive who hired people to visit a sample of some of his customer's retail stores shortly after the end of the Christmas holiday season. He had pictures taken of the shelves to assess

the availability of his product following the Christmas rush. The pictures showed that in many cases the state of the shelves was a mess, with most items in disarray and most products out of stock – sure to impact the manufacturer's post-holiday sales! This executive, who took the position that his company needed to share some of the responsibility for this, started initiatives to correct it. He implemented programs that were aimed at working more closely with customers on joint store-level planning and in-store merchandizing. The strategy paid off resulting in better product availability on his customer's store shelves.

The lesson to be learned from this illustration is that at times it does make sense to measure what you cannot control, as you may uncover a deficiency in your supply chain's performance. Once found, initiatives can be developed to address the problem and the performance measures can be used as the "call to action." These initiatives usually involve some form of program aimed at taking some level of control of upstream or downstream supply chain activities – extending beyond one's enterprise. Some manufacturers have been implementing SCM programs to extend their control. These programs and their associated performance measures include:

- Vendor Managed Inventory (VMI) programs: customer sales, in-stock availability, and inventory turns
- Continuous Replenishment Programs (CRP): customer sales, in-stock availabil-

- ity, and inventory turns
- Quick Response initiatives: customer sales, in-stock availability, and inventory turns
- Forecast-sharing programs: forecast accuracy, order fill rates, and inventory turns
- Production scheduling sharing programs: adherence to schedule and order cycle time
- Category Management programs: customer category sales and in-stock availability

As more companies implement SCM programs, they will be placing greater emphasis on cross-enterprise processes, extending beyond their enterprise. This will lead to the need to implement performance measurement systems that include some external measures, including some for processes that lie outside of a company's domain of control.

#### Choose A Limited Number of Metrics

A major challenge for many companies when developing a supply chain performance measurement process is limiting the number of measures. Most companies are involved in complex business operations that span across multiple business divisions and geographical boundaries, involving a multitude of sub-processes, tasks, and organizational departments. Wanting to measure everything, there is a tendency to measure too much. The number of measures needs to be limited to ensure that the process is not too cumbersome to administer. One strategy-consulting firm recommends that their clients limit the number of measures to be tracked in each area to between three and five, helping to ensure that the measurement process is not unwieldy.

#### Align Executive to Management-Level Measures

To ensure that a reasonable number of metrics is defined, an organizing framework is required to select only those that are most important. A key-enabling concept taken from the Balanced Scorecard approach is to focus the measurement process on managing the business, not monitoring and controlling it. Measures should be aligned to supply chain performance objectives to be

achieved, not to whether employees are adhering to managerial practices and directions. In this way supply chain performance, not actions, are measured.

To establish a rational set of performance measures, one needs to start with an understanding of the strategic supply chain objectives of a company's executive team. For example, to what degree is the company trying to achieve functional, enterprise-wide integration and extended enterprise integration excellence? Once understood, a limited and balanced set of measures that directly aligns to these strategic objectives needs to be developed. These become the executive level measures used to provide the executive team with indicators as to whether or not their supply chain is performing according to their strategic intent. This set should include a balance of cause and effect type metrics helping executives determine when a particular process area needs to be improved.

In addition to executives, management personnel also need performance measures to help ensure that their supply chain activities are performing well. These measures will be more detailed, tracking both tactical and operational types of activities. To ensure that the executive and management teams are not driving the organization in different directions, the management-level measures need to be aligned with the executive-level measures. Figure 4.0 graphically depicts the relationship and contrasting nature of executive and managerial measures. Using the lower level measures, managers can gauge how well they are doing relative to the overall strategic goals set in place by the executive team. In addition, the lower-level metrics enable executives to drill-down into the more diagnostic metrics, detecting where corrective actions are needed.

#### An Illustrative Set of Supply Chain Performance Measures

A number of leading-edge companies are beginning to implement supply chain performance measurement systems, some calling them scorecards, while others call them dashboards or cockpits.

While the metrics shown are largely executive-level in nature, this company

has plans to break out each of the metrics into more detailed managerial levels. This set of measures provides a good illustration of a balanced set of measures that might be selected to support a manufacturer's supply chain performance measurement process.

#### What Methods Are Available For Setting Performance Targets?

An important issue in performance measurement is how a company can use measures to gauge its supply chain's performance. To do this effectively, a target for each measure needs to be established, providing the framework for determining the answer to three questions that arise when evaluating a performance metric:

- Has the metric improved from the last time it was reviewed?
- By how much?
- How close is the metric to where it should be?

In order for this evaluation to be meaningful, however, the direction of improvement needs to be established. Should the metric have gone up or gone down? Frequently, in looking at productivity-related metrics an increase represents an improvement; similarly, for cost-related metrics a decrease represents an improvement. This is not always the case! For example, an increase in manufacturing productivity and a decrease in cost would normally be considered an improvement. It would not be an improvement if it caused degradation in customer service performance.

In a way similar to picking a set of balanced metrics, performance targets need to be jointly, not individually, developed. To achieve objectives some metrics may need to increase and others may need to decrease. Each metric in the set has to be viewed in conjunction with the others to determine its proper target. For example, in a situation where a company is trying to achieve same day delivery, delivery times should decrease, while warehouse handling and transportation costs might actually increase.

Thus, while there a variety of ways

in which to set performance targets, they should always be jointly set in the context of strategic objectives. Generally, there are four methods that can be used to set performance targets, described in detail below:

- Historically based targets
- External benchmarks
- Internal benchmarks
- Theoretical targets

#### Historically Based Targets

Historically based target setting is the most frequently used among all the methods. In using this method, performance targets are based on historical baseline levels. For example, a company having an historical order fill rate of 90% might set a performance target at 95%, trying to improve by five percentage points. This method is the most frequently used because it is the easiest to implement. Once the baseline metrics are established, the same procedures and systems that were used to establish the baseline numbers can also be used on an ongoing basis to measure changes in the metrics.

#### External Benchmarks

Using external benchmarks to help set performance targets is currently popular, but difficult to use in practice. In general, benchmarking has been in the business limelight for almost ten years, with companies looking outside their operations for best practices and performance comparisons. This method relies on collecting information on performance metrics of companies internal and external to one's industry. A few organizations have collected some benchmarking data in a formal way, including:

- Herbert W. Davis and Company (Fort Lee, NJ) is a small consulting firm that has been conducting logistics cost and service surveys for over 20 years, including its most recent survey that is comprised of information on around 300 North American manufacturer, distributor, and retailer companies. (Davis uses the results to support its consulting business.)
- Pittiglio, Rabin, Todd & McGrath (PTRM)

(Weston, MA) conducts a supply chain a benchmarking study, its Integrated Supply-Chain Benchmarking Study. The last published study, fourth in the series, included information on about 225 worldwide participants. (The company uses the results to support its consulting business.)

- The Demand Activated Manufacturing Architecture (DAMA) project, a part of the American Textile Partnership, has collected benchmark data on the performance companies, mostly in the 'soft goods' industries. This data was obtained from Kurt Salmon Associates, Inc. (Atlanta, GA) and The Garr Consulting Group, a division of Deloitte & Touche, Inc. (New York, NY), and The Logistics Institute of the Georgia Institute of Technology.

Once external benchmarking metrics are collected, a company's internal metrics are generated and a gap analysis is done – typically looking at the best-in-class within their own industry as well as external to it. This is followed by more analysis to assess the degree to which the company can achieve these performance levels, including what business practice changes are necessary to close the gaps.

While appealing, the external benchmarking method has a major shortcoming to it as to which set of companies are comparable. A substantial amount of analysis is required to ensure that external benchmarks are meaningful, especially when using data from companies that operate within different business environments (e.g., differing products or sales channels). This makes the use of external benchmarks difficult, since comparable external benchmarks may not be available or too controversial. On the other hand, external benchmarks, especially from one's competitors, may be extremely important towards keeping an organization's supply chain competitive.

#### Internal Benchmarks

Performance target setting using internal benchmarks is a common approach, since it requires only internal measures. Within this method, comparable functional depart-

ments, processes, and facilities within a company are measured in the same way. For example, there may be a set of metrics in use for all warehousing facilities, another set for all manufacturing plants, and another set for all customer service departments. Similar to the external benchmarking approach, "best-in-class" functional organizations are identified and their benchmark metrics are used as the basis for establishing performance targets for other functional organizations.

In contrast to external benchmarking, internal benchmarking data is easier to collect. The method is less controversial when comparing business operations since internal organizations usually operate in similar business environments. While this internal benchmarking method is easier to implement, it too has some serious drawbacks to it. The major one involves stretching the organization to achieve better performance. That is, using a "best-in-class" internal organization to set targets may limit the company's performance relative to its competitors.

#### Theoretical Targets

The use of theoretical target setting is a relatively new method advocated by some consultants. Under this method a company conducts an analysis to theoretically determine how its supply chain performance could be improved. It would then implement the business changes necessary to achieve these improvements and put a set of performance targets in place based on estimates made during the analysis.

In particular, one consultant, Paul Bender of Bender Consulting/SynQuest, Inc. (Atlanta, GA), advocates the use of supply chain optimization to help set theoretical performance targets. Using his approach, a company would first undergo an analysis to determine how it should optimize supply chain performance. It would then use the estimates made during the analysis to set its performance targets. For example, a company might determine that in order for it to maximize its long-term profits, it should increase on-time order due-date performance, while increasing its manufacturing costs and decreasing its air freight charges. The company would



### ILLUSTRATIVE SET OF BALANCED METRICS DEVELOPED BY A CPG MANUFACTURER

Supply Chain Measure	Corresponding Metric
Customer Service	Order fill rate Line item fill rate Dollar fill rate Cycle time components and variability On-time delivery Backorder duration Perfect order fill rate Customer satisfaction survey results
Asset Management	Inventory days of supply Inventory accuracy Inventory turns Cash-to-cash cycle time
Forecast Accuracy	Orders versus forecasts Shipments versus forecast
Costs	Various costs
Value-Added	Economic value added
Manufacturing Measures (MRPII) <ul style="list-style-type: none"> <li>• Customer Service</li> <li>• Sales Plan - family product level</li> <li>• Detailed Sales Forecast</li> <li>• Production Plan</li> <li>• DRP Replenishment Performance</li> <li>• Master Schedule Performance</li> <li>• Master Schedule Stability</li> <li>• Manufacturing Performance</li> <li>• Supplier Performance</li> <li>• Materials Inventory Accuracy</li> <li>• Bill of Materials Accuracy</li> <li>• Routings</li> </ul>	% Complete shipments on-time Actual sales versus plan Actual sales versus plan Actual production versus plan Warehouse receipts versus orders % Items completed % Schedule changes Actual production versus schedule Actual receipts versus scheduled Accurate records versus counted Accurate bills versus audited Accurate processes versus audited

Figure 5.0 Balanced metrics developed by a CPG manufacturer

then use the results of the analysis to increase its performance targets for manufacturing costs and on-time order due-date performance, while appropriately decreasing the target on its airfreight charges.

While conducting an optimization analysis is an intuitively appealing method for determining performance targets, it is not always the easiest to do. Another alternate approach involves the use of supply chain simulation analysis that includes conducting what-if studies on initiatives to improve performance. The results of these studies could then be used to set theoretical targets. For example, a “what-if” study might be conducted to assess inventory reductions that might accrue from statistical safety stock setting. The study’s estimated reductions would be used to reset performance targets for inventory turns.

Setting performance targets on a theoretical basis is most useful for insuring that a balanced set of metrics is devel-

oped. Often, only by doing a thorough analysis can one assess how an initiative would impact various aspects within a supply chain.

In practice, a combination of the four performance target-setting methods described above should be used. No one method is practical for determining targets since one cannot always get a full set of comparable benchmarking information or conduct the extensive analyses needed to develop a full set of theoretical performance targets.

#### What Are Application Vendors Doing To Support Supply Chain Performance Measurement?

Application vendors are faced with a challenge when trying to provide supply chain performance measurement functionality within their software products. Users often wish to include metrics relating to infor-

mation not residing within the vendor’s application database. (Figure 5.0 shows the potential sources from which a supply chain performance measurement system may have to draw data). This is especially the case when measuring the performance of cross-functional and inter-enterprise processes, which involve drawing information about any functional department within a company, or about customer/supplier activities. Also, most advanced planning and scheduling (APS) applications focus on the future, rarely concerned with what went on in the past (except relative to measuring forecast errors). While Enterprise Resource Planning (ERP) vendors that offer SCM functionality have more of the necessary data within their product suites, they have not focused on supply chain-related performance measurement. Until recently they have focused most of their historical reporting functionality on providing transactional auditing, tracing, and tracking.

Given the interest shown in supply chain performance measurement, substantially driven by business consultants, vendors have started to consider supplementing their product suites by offering enhanced supply chain performance reporting capabilities.

#### Traditional SCM Vendors Provide Reporting On A Limited Number of Metrics

Traditionally SCM application vendors have focused their development efforts on enabling planning, scheduling, and execution, targeted toward supporting decision-making, not tracking historical performance. Some SCM vendors have functionality to report historical supply chain performance focused around either functional or planning-related metrics. For example, SynQuest provides standard reporting on a variety of metrics such as forecast error, inventory turns, and order completeness, while also allowing users to define related metrics within each of its function-based modules. Similarly, Manugistics (Rockville, MD) provides standard reporting functionality on forecasting performance and on-time delivery, as well as some general purpose capabilities to report on user-defined metrics such as order fulfillment, factory

floor conformance, warehouse space utilization, and promotional effectiveness.

In contrast to these two vendors, i2 Technologies (Irving, TX) provides a solution, RHYTHM Reporter, which is enabled by incorporating OLAP technology from Arbor Software's (Ann Arbor, MI) Essbase product. The solution allows users to create reports on information contained within the Supply Chain Planner application and includes a variety of standard reports focused on master planning, profit optimization, and demand fulfillment. Similar to i2, Logility (Atlanta, GA) provides some reporting capability by incorporating OLAP technology from Cognos (Ottawa, Canada). Logility provides standard interfaces into Cognos' solution to support users doing customized analysis. Logility also provides standard reporting capabilities within its functional modules that can report on a variety of measures such as forecast error, assembly line utilization, late orders, and warehouse receipts.

Similar to i2 and Logility, AMR Research expects that other SCM vendors will start to provide OLAP-based solutions to allow their customers to track additional supply chain performance measures. For example, webPLAN (Ottawa, Canada), formerly called Enterprise Planning Solutions, is developing a product, onPLAN, which will provide users with a KPI business report card. The product, which was released in 1998, imbeds OLAP technology from InterNetivity, Inc. (Ottawa, Canada) that enables numeric and graphical reporting, and the drilling down and slicing and dicing of data.

There are two new noteworthy SCM vendors that focus exclusively on performance measurement. One is VIT (Palo Alto, CA), which offers the SeeChain software application suite that consists of five modules: Demand Accuracy, Raw Materials, Production Performance, Finished Goods, and Fulfillment. The vendor has a unique graphical user interface that allows users to drill down from higher, aggregated measures to lower detailed measures, enabling them to easily diagnosis non-performing supply chain elements. This vendor comes the closest to

### TYPICAL FUNCTION-BASED MEASUREMENTS AND RELATED GOALS

PURCHASING	MANUFACTURING	LOGISTICS	CUSTOMER SERVICE/SALES
<b>Measures</b> <ul style="list-style-type: none"> <li>• Supplier Performance</li> <li>• Cost Per Unit Purchased</li> </ul>	<b>Measures</b> <ul style="list-style-type: none"> <li>• Set-ups and changeover Times</li> <li>• Plant Utilization</li> <li>• Waste and Scrap</li> </ul>	<b>Measures</b> <ul style="list-style-type: none"> <li>• Inventory Turns</li> <li>• Transportation Costs</li> <li>• Warehouse Productivity</li> </ul>	<b>Measures</b> <ul style="list-style-type: none"> <li>• Customer Satisfaction</li> <li>• Customer Order Cycle Time</li> </ul>
<b>Goals</b> <ul style="list-style-type: none"> <li>• Multiple Supplies (potential varying quality)</li> <li>• Large Purchase Orders</li> <li>• Increased Materials Inventories</li> </ul>	<b>Goals</b> <ul style="list-style-type: none"> <li>• Long runs</li> <li>• Increased Finished Goods</li> <li>• Decreased Materials Inventories</li> <li>• Bulk Customer Orders</li> <li>• Product Quality</li> </ul>	<b>Goals</b> <ul style="list-style-type: none"> <li>• Decrease Finished Goods Inventories</li> <li>• Centralized Stocking Locations</li> <li>• Bulk Customer Orders</li> </ul>	<b>Goals</b> <ul style="list-style-type: none"> <li>• Increased Inventories</li> <li>• Multiple Stocking Locations Close to Customers</li> <li>• JIT Customer Orders</li> </ul>

Figure 6.0 Function-based measurements and related goals

offering an application that enables users to view their overall supply chain, limited only by data that can be drawn by a company into a single database structure the company provides. Another SCM vendor that provides unique performance measurement functionality is Maxager Technology (San Rafael, CA). The company specializes in an application that reports on historical product-level profitability and production performance. The vendor provides users with shop floor data collection applications and uses constraint-based costing methods to assess product level production performance. Similar to other SCM solutions, the application provides refined estimates of manufacturing performance representing only a portion of the overall supply chain performance measures needed.

#### ERP Vendors Offering SCM Functionality Are Starting to Address Supply Chain Performance Measurement

Some ERP vendors also offering SCM functionality have put more focus on historical performance measurement than the SCM

vendors; having specialized in providing solutions focused more on transactional history. While these vendors have built some OLAP-based performance reporting functionality into their product suites, they are still a long way from fully meeting the needs of supply chain performance measurement.

SAP (Walldorf, Germany) has been offering a logistics-related performance-reporting product, its Logistics Information System (LIS). This R/3-based application allows a user to assemble information from a range of R/3 modules and provides functionality to analyze the data in a number of ways, including in tables and graphs. As part of its new Advanced Planner and Optimizer (APO) product initiative, the company is planning to provide users with functionality that measures a set of pre-defined supply chain KPIs within its Supply Chain Cockpit product. The company has also recently laid out ambitious plans to develop more general-purpose functionality under its Business Intelligence initiative, announced at SAPHIRE '98. In addition,

SAP recently purchased a minority share in ABC Technologies, Inc. (Beaverton, OR), a leading player in activity-based costing and management solutions. ABC Technologies will integrate its functionality into R/3 to enable general-purpose performance measurement based on the ABC approach. This functionality will also be applicable to measuring supply chain performance.

Oracle (Redwood Shores, CA), a database vendor that has always provided some performance measurement functionality, has plans to expand it. Similar to SAP, it will offer ABC costing functionality, having recently purchased PriceWaterhouse-Coopers LLP's (New York, NY) activity-based costing, budgeting, and management software, ACTIVA. While more general purpose in nature, some of the ABC functionality should be applicable to measuring supply chain performance.

PeopleSoft (Pleasanton, CA) is also adding general-purpose performance measurement that will be applicable to supply chain measurement. The vendor is currently working with on an initiative to provide a solution based on the Balanced Scorecard and ABC approaches.

#### How Should A Company Get Started?

Based on our research, we have concluded that there is no one recommended approach or set of measures to be used to measure one's supply chain performance. While espousing the importance of measuring supply chain performance, leading consultants have no definitive set of metrics to recommend. All agree, however, that approaches such as the Balanced Scorecard, the SCOR Model, The Logistics Scoreboard, and others discussed herein, provide excellent guidance when developing a supply chain performance measurement system. In addition, although the software vendors we polled enable a limited range of supply chain performance measures, they are improving and planning to add more functionality to their product sets. Over time, we expect vendors to offer more complete packaged applications for supply chain performance

measurement.

All this should not dissuade users, however, from starting to measure their supply chain's performance in the context of assessing the success of initiatives aimed at achieving strategic objectives. It is too important! With substantial resources – dollars and people – being applied towards implementing various supply chain programs, users should measure performance to insure desired change happens.

For those users just getting started, implementing supply chain performance measurement should not be done all at once. For example, one could start by first implementing executive-level scorecard measures in a manual fashion. This could then be followed up with more automation, through the use of database tools and the addition of managerial-level metrics. As application vendors develop more capabilities in the area of performance measurement further automation of the process can be implemented over time.

Based on the research done for this report, we would recommend the following steps be taken when implementing supply chain performance improvement and measurement:

- Have executives articulate the strategic supply chain vision and company objectives, including the degree of focus to be placed on achieving functional, enterprise-wide integration and extended enterprise integration excellence. For example, the functional excellence portion of the vision might be that “we will reduce our manufacturing costs over the next two years” and related objectives would be to reduce manufacturing operating and material costs.
- Define executive level measures for each objective for their scorecard. The total number of measures used should be limited to up to 20 or so. For example, these might be metrics such as material cost per pound purchased and operating manufacturing cost per unit produced.
- Establish managerial level objectives and measures that align to the executive

level ones. These should be more tactical and operational, providing diagnostic information on whether executive objectives are being met. Breaking down the higher-level measures typically does this. For example, these might be measures for a particular plant's cost per ton purchased for a specific class of material.

- Identify supply chain initiatives that specifically address the executive and managerial performance improvement objectives. For example, this might include a core supplier program reducing the number of material suppliers to ones with the lowest cost, meeting quality standards.
- Establish targets for all metrics defined, using a combination of historical performance, external/internal benchmarks, and theoretical estimates (often obtained from operational quantitative analysis of the supply chain initiatives). A timeline for achieving the targets needs to be established for each metric, consistent with the schedules developed for the supply chain initiatives. For example, while a program might be expected to ultimately reduce material costs by 3%, targets for its first year of implementation might be only 1%, with an additional 2% improvement the next year.
- Implement new initiatives in concert with a formal measurement system to keep track of performance improvement over time, using a combination of whatever technology makes sense; be it based on spreadsheets, database products or a vendor's suite of packaged applications.

While these steps are useful for getting started, ongoing supply chain performance measurement requires that the steps be revisited on a routine basis, as objectives change and new programs and initiatives are undertaken. Keeping the measurement process aligned to supply chain objectives and activities will provide the information needed to drive your supply chain's performance, helping to ensure that resources are appropriately applied and desired strategic change is happening.