

Enhancing Supply Chain Visibility with Pervasive Business Intelligence

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Abstract

This article examines the increasingly important role that pervasive business intelligence (BI) plays in helping manufacturers and service providers manage their supply chains more efficiently and profitably. Using the Supply Chain Council's widely recognized Supply Chain Operations Reference (SCOR) model as a framework, we examine SCOR's five components (plan, source, make, deliver, return) and illustrate how pervasive BI adds value at each stage of the supply chain management (SCM) process by empowering supply chain managers with the appropriate tools.

The basic functionality required by a supply-chain-oriented BI platform includes self-service reporting, ad hoc drill-down capabilities, easily understood dashboards, data integration, time series and trending tools, and real-time information delivery. Advanced tools include demand planning modules, statistical forecasting, and predictive modeling functionality. SaaS-based information delivery and flexible licensing options also play an important role. We illustrate the value that a robust, pervasive intelligence platform brings to supply chain management with two industry-specific examples: a wine and spirits distributor and a major healthcare provider.

Modern Supply Chain Challenges and Opportunities

Manufacturers and service providers face serious challenges maintaining profit margins in the global economic slowdown. The unusual combination of selective raw material inflation and broad-based consumer product deflation, volatile currency fluctuations, fickle consumer demand, difficulty obtaining short-term credit, and the threat of increased regulatory oversight have managers exploring all possible avenues for reducing costs and protecting shrinking margins.

One key focus is corporate supply chain management. Supply chain globalization has created abundant opportunities for manufacturers and service providers. Call centers, contract manufacturers, and raw material suppliers can be located virtually anywhere. Broadband penetration and efficient transportation channels drive costs continuously lower. Despite this progress, managing global supply chains effectively has become even more challenging because it requires more information than ever before, delivered in an accurate and timely manner. Supply chain visibility gained by empowering the entire workforce with pervasive BI solutions delivers immediate benefits, including decreased inventory levels, higher customer satisfaction ratings, and significant cost reductions—each area ripe for the practical use of BI software at all levels of the organization.

SCOR: A Formal Model of Supply Chain Management

With the increasing recognition of SCM's pivotal role in driving cost reduction and operational efficiency, academics and industry professionals have formulated models and frameworks for studying and optimizing the corporate supply chain. Stanford University's Global Supply Chain Forum's Supply Chain Management Framework (SCMF) is based on these eight key SCM processes, with process ownership shared by an organization's marketing, sales, R&D, logistics, production, purchasing, and finance divisions:

- Customer relationship management
- Supplier relationship management
- Customer service management
- Demand management
- Order fulfillment
- Manufacturing flow management
- Product development and commercialization
- Returns management

The Supply Chain Operations Reference (SCOR) model, created by the Supply Chain Council, has gained broad acceptance across a diverse spectrum of both manufacturing and service industries. The SCOR model can be visualized as a matrix, with five columns describing the supply chain processes: *Plan*, *Source*, *Make*, *Deliver*, and *Return* (Gulledge and Cavusoglu, 2005). Three rows consisting of *Strategic Goals*, *Current Situation*, and *Areas of Improvement* complete the matrix. By abstracting industry-specific supply chain attributes into over 300 key performance indicators (KPIs), SCOR allows for straightforward comparisons of supply chain efficiency across both competitors and unrelated industries (Poluha, 2007).

We will explore the five SCOR supply chain processes and the impact of well-designed BI tools capable of supporting all levels of users throughout the organization on understanding and improving each process (see Figure 1).

Planning for Supply and Demand

Both supply and demand planning are iterative processes performed throughout the manufacturing/service-provider cycle to ensure that previous assumptions are still valid within the constantly changing marketplace. On the supply side, manufacturers must plan for:

- Potential supply disruptions of raw materials due to geopolitical turmoil, natural disasters, or demand-based scarcity driven by competing supply chains
- Transportation-based bottlenecks: Are enough cargo ships, trains, or trucks available to reliably deliver procured raw materials from their origin to the manufacturing site on time?
- Manufacturing capacity constraints, especially when third-party or contract manufacturers are used

Service industries have an analogous watch list of potential problems that require careful forecasting and planning, such as demographic changes that impact the future supply of skilled labor in a given geographic area or short-term spikes in utility costs that might force call centers in certain time zones and countries to operate at a loss.

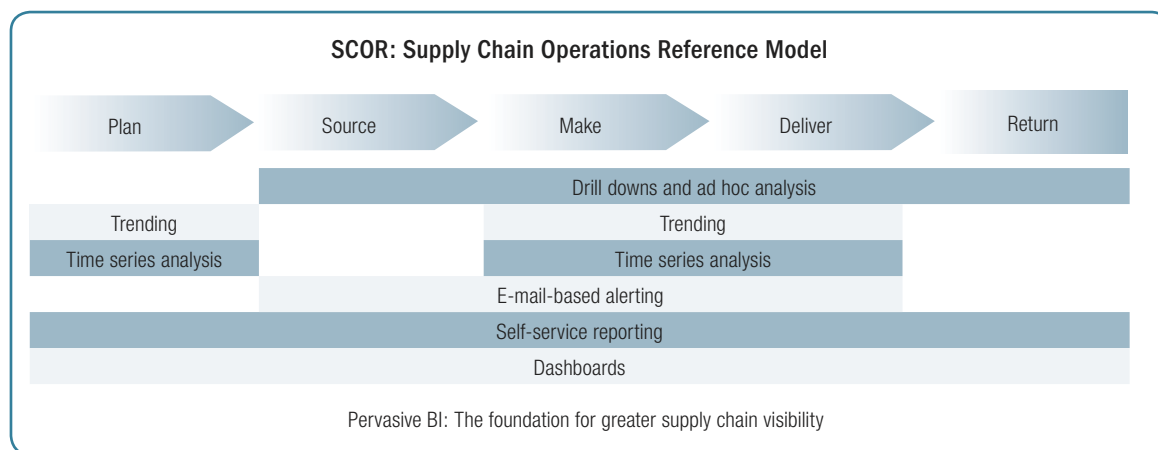


Figure 1. SCOR model empowered by pervasive BI

Demand planning gauges consumer demand for the manufacturer’s product line and feeds this information back into the manufacturing process. Economic turmoil might send consumers downmarket, necessitating a rapid factory retooling to fulfill orders for lower-priced products or a renegotiation of service-level contracts with suppliers. Changes in fickle consumer tastes can result in a buildup of excess finished inventory, requiring discounted pricing to move merchandise (Stadtler and Kilger, 2005). Insatiable demand for a particularly popular electronic device can help a savvy manufacturer reap a potential profit windfall by strategically rationing the product in a way that minimizes transportation costs. Anticipated state sales tax hikes could force retailers to re-examine proposed real estate purchases for future expansion, especially in close proximity to state borders.

Supply chain managers as well as key process stakeholders in other areas of the organization can apply BI to each of these scenarios to gain immediate insight into the underlying dynamics of the planning process. Geographically enabled BI tools provide a visual representation of transportation bottlenecks and alternate delivery routes. Time-based comparisons such as year-over-year (YOY) or month-over-month (MOM) help analysts differentiate an actual drop in demand from seasonal factors. Data segmentation provides visibility into which metropolitan areas or demographic groups are showing growing or waning demand for a particular product. Smoothing

functions and filters such as moving averages can separate an actual commodity price trend from random noise. Making this information available to organizational users at all levels can foster collaboration and help the enterprise develop and deploy strategies that have a bottom-line impact on profitability. Business intelligence solutions can be used to provide role-based insight to supply chain managers as well as brand- or product-line managers, marketing personnel, or operational executives.

Forecasts of future supply and demand levels based on known inputs require BI platforms with statistical forecasting or predictive modeling capabilities. However, the power of forecasting algorithms and their relative ease of use can be abused by personnel without sufficient training in statistical methods. Demand-planning tools, on the other hand, are based less on statistical sophistication than on the experience of seasoned supply chain managers. If an organization lacks sufficient demand-planning experience, the accuracy of the generated plans will likely be suspect.

Central to the success of any BI-based planning initiative is access to and availability of the correct data. Trending and forecasting assumes that sufficient and valid historical data is available for the period examined, whether YOY or MOM. If weekly or daily forecasts are required, monthly data granularity will be useless. Analysis involving factors external to an organization’s data sources (such

as weather, commodity prices, and freight charges) will require the purchase and integration of those sources into the organization's BI platform to ensure that accurate forecasts are developed. In addition, BI platforms can provide supply chain managers and operations personnel with the ability to look at historical accuracy against developed plans over time, allowing users to fine-tune their planning processes to improve their forecast accuracy (Copacino, 2009). BI solutions can then be used to distribute this information to the appropriate individuals to keep everyone working toward a common goal.

Intelligent Sourcing

Industrial manufacturing inputs vary and can include raw materials such as copper, commoditized and pre-manufactured components such as memory chips, and custom-engineered entities such as alloy rims. Service providers require commodities such as electricity, broadband, and gas to power their fleets, while skilled human labor ranks at the top of the input hierarchy. Making BI accessible across the enterprise empowers users to analyze and gain greater visibility into sourcing issues. Sourcing encompasses two primary components: vendor performance and raw material procurement/inventory management.

Vendor Performance

Vendor scorecards are a standard tool in SCM. Although vendor scorecards can incorporate virtually any relevant metric, a widely used implementation includes:

- Can suppliers ship on time?
- Is the shipment complete?
- Is the shipment damage free?
- Is the documentation correct?

Supply chain managers should find that implementing a vendor scorecard is a straightforward exercise, given the rich scorecarding functionality found in current BI platforms. Vendor scorecards deliver objective and quantifiable metrics for fact-based price negotiations with service vendors and materials suppliers. By calculating

and monitoring metrics consistently across competing vendors, companies can recognize opportunities for price concessions. A vendor that delivers packages on time 73 percent of the time might be more amenable to renegotiating prices than a vendor that consistently delivers at a much higher rate, especially if the material delivered by these vendors is not mission critical and some deviation in delivery times can be tolerated without adversely affecting manufacturing.

Developing a "pervasive" strategy for deploying BI tools in your organization is essential to long-term success. For example, BI tools can deliver real-time alerts to manufacturing and other stakeholders when problems such as rejected or damaged shipments surface. Purchasing agents can make scorecards available to their vendors via BI-based Web portals, communicating adherence to service-level agreements (SLAs) in a transparent and timely manner.

Using the data integration capabilities available in most BI platforms, purchasing managers can obtain an enterprisewide view of materials procured by other departments and business units. This view can help drive vendor standardization efforts while decreasing prices thanks to higher purchase volumes. Streamlining orders and monthly deliveries provides the additional benefit of minimizing warehouse storage costs and loading dock staffing requirements.

Raw Material Procurement/Inventory Management

Another important BI function that provides tremendous utility for supply chain analysis is the ability to model complex scenarios and perform "what-if" analysis (Aberdeen Group, 2007). With creeping raw material price inflation, especially for petroleum and industrial metals, managers must constantly monitor price increases. Even a relatively minor price fluctuation in a commodity can destroy manufacturer pricing power and profit margins.

For commodities and manufactured subassemblies that are available from different countries, a company's ability to model the impact of pricing in foreign currencies can uncover significant cost savings without accepting poorer quality or delivery terms. By analyzing the volatility of

commodity inputs, manufacturers can identify candidate inputs for substitution. Insights gained from volatility analysis might prompt a confectioner to switch from beet sugar to cane sugar or a power plant to switch fuel deliveries from barge to rail.

Boosting operational efficiency via intelligent scheduling and resource allocation is one of the leading challenges confronting the industry.

Managing inventory requires detailed accounting for on-premises inventory that is fed back into the planning component to ensure the accurate inventory forecasts required by manufacturing. Business intelligence solutions providing what-if analysis help supply chain managers model the trade-off between the costs of storing excess inventory purchased at a discount against just-in-time delivery of raw materials purchased at market rates. Forward-thinking corporations also use pervasive BI to share information with their sourcing vendors through Web portals. This practice greatly improves supply chain efficiencies and improves satisfaction rates with partners and suppliers.

Information-centric Manufacturing

Manufacturing finished goods and providing value-added services can be thought of as the central “link” in supply “chain” management. Significant opportunities for pervasive BI exist in this arena for adding value and visibility by empowering everyone, from machine operators and call center technicians to plant managers, with capabilities such as self-service reporting and ad hoc analytics. Manufacturing lends itself to measurement and data collection; the key is to determine which data and measurements can be gathered and transformed into actionable information cost-effectively and to establish what subset of KPIs should be communicated via

dashboards and alerts to manufacturing and operations personnel to enable timely, data-driven decisions.

Boosting operational efficiency via intelligent scheduling and resource allocation is one of the leading challenges confronting the industry. Manufacturers seek to optimize the pairing of available machines with qualified available operators to produce the desired product mix subject to constraints (such as available raw materials). Airlines illustrate an analogous scenario for service-based organizations. Each day, thousands of available planes must be paired with the appropriate flight crews, fuel, and other supplies, and must deliver passengers to the destinations of their choice safely and on time.

Business intelligence provides manufacturers and service providers with insights that help re-deploy excess capacity and underutilized assets, reduce waste, and decrease operating costs. Cross-tabulating machine utilization rates against product mix may uncover that some machines could be put to more profitable use manufacturing higher-margin items. By analyzing production rates and associated metrics (such as the variance in output rates across shifts and days of the week), plant managers can make changes that positively impact profitability. If third-shift productivity consistently lags the first shift and exhibits greater variance in output and quality, managers may consider eliminating the shift altogether, especially if third-shift labor costs are higher due to payment of a shift differential.

A brewer may collect a time series on a BI platform consisting of hourly measurements across several critical variables that impact product taste and quality, including agitation rate, dissolved oxygen content, yeast concentration, temperature, and elapsed time. Using real-time graphic overlays of the current time series compared to historic data provides an early warning system that can spell the difference between rejecting an entire batch of beer and saving it with a mechanical intervention.

Employees at all levels of the organization as well as supply chain partners—both upstream and downstream—can be affected by market or production variations. Utilizing BI tools to disseminate business-critical data by setting

intelligent parameters for threshold-based alerts allows the impact of any variation to be minimized across the supply chain, so contingency plans can be followed and inventory can be properly allocated to service core accounts and geographical markets.

In the service sector, BI helps with resource allocation. Hospitals and other labor-intensive service organizations use BI to produce “approaching overtime” reports to identify contract nurses who are nearing the end of non-overtime hours in the current pay period. This allows managers to maintain staffing calendars using other nurses and helps to contain staffing costs.

Communicating real-time manufacturing information derived from BI to the supply chain’s planning, sourcing, and delivery components is essential to avoiding stockouts, bloated inventory, or depleted raw materials. Business intelligence tools provide a broad range of e-mail, instant message, and mobile-device support to ensure that key decision makers at every level—from the plant floor and warehouse to the front office—receive role-appropriate information quickly.

Enhanced Delivery Using Geographically Aware BI

Manufacturers typically have a choice between competing distribution options, such as truck, rail, or air. Likewise, service providers dependent on utilities (such as telecommunications providers or overnight delivery services) have several vendors at their disposal. Business intelligence provides an effective means to benchmark transportation firms against one another to find the most cost-effective carriers. Much like a vendor scorecard, competing firms can be measured across a broad range of metrics, including price per mile charges, percent of on-time deliveries, and percent of damaged goods delivered per shipment.

With increasingly flexible but more complicated delivery-pricing plans, BI is needed to fully evaluate these plans. Geographic segmentation may reveal that pricing is less attractive for certain metropolitan areas than the average price advertised by the vendor. Delivery prices during certain weekdays or days of the month may be vastly preferential to other periods—information that can be fed back to manufacturing to adjust factory schedules.

Firms have begun factoring delivery options into factory and warehouse site selection, using geographically enabled BI to determine the optimal proximity to suppliers and major transportation corridors, and within financial overlays such as local labor costs and property tax rates.

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Using BI tools to drill down into regional distribution-center fulfillment rates and cost per shipment can determine which center is most efficient at order fulfillment and under what conditions. Analogous to manufacturing, a careful analysis may reveal that certain shifts are more productive than others, or that a distribution center staff’s idle rate is too high due to poor synchronization with manufacturing schedules. Business intelligence tools allow for better communication and collaboration across departmental lines (Stefanovic, Majstorovic, and Stefanovic, 2006). For example, the information gained here could be applied by operations managers to effect change at underperforming locations. Service providers also realize benefits from extensive BI-based analysis, uncovering call center slack times or periods that result in higher customer complaint rates because of understaffing.

Another core functionality of BI tools is drill-down capability. The ability to get details from high-level summary reports or dashboards provides users with answers to other important questions. Are customers in certain geographical locations too expensive to deliver

to, perhaps due to limited and costlier transportation options, liability insurance, or unrealistic on-time delivery expectations? If so, the manufacturer should consider implementing service charges, renegotiating existing pricing, or even terminating the relationship with the customer. Would more business be gained by utilizing overnight shipping, and could the increased shipping costs be recovered without adversely impacting profit margins? Can cheaper or lighter packing materials be substituted without affecting product quality?

Since product delivery is a time-based operation, BI's time-series tools can wring inefficiencies out of the system. Organizations find that constructing a workflow model from the factory floor to the customer's receiving dock, augmented with accurate measurements of elapsed time at each stage, can often highlight critical issues requiring resolution. Insufficient staff or an undersupply of packing materials, un-optimized transportation routes, and unacceptable levels of product spoilage can be resolved once supply chain managers have been made aware of the problem. Whether total time consumed at a particular step is too high or whether day-to-day variance creates unpredictable outcomes downstream, BI provides a comprehensive tool kit for uncovering a wide range of distribution problems.

Minimizing Returns

For service providers, returns take the form of service cancellations or refund requests, while manufacturers realize the impact of returns as shipping costs and excess, damaged, or obsolete inventory. On the surface, product returns from either retail or wholesale customers present organizations with an unwanted nuisance that hurts their bottom lines and may, in well-publicized cases, create reputational risk. In the pharmaceutical industry, recent Vioxx and Heparin recalls cost the respective manufacturers exponentially more from litigation and public relations charges than the actual cost of the defective merchandise.

Manufacturers and service providers that use BI tools can derive valuable feedback by performing an in-depth analysis of returns data that feeds back into the sourcing and manufacturing components of their supply chains.

Information-centric organizations that capture and analyze their returns data have discovered:

- Deficiencies in product documentation, perhaps due to poorly written assembly instructions or incomplete parts lists
- Fleeting consumer tastes in particular models, product configurations, or product attributes such as color, size, or packaging
- Disadvantageous price points
- Erroneous product information relayed from account managers to customers
- Shippers who consistently damage goods or deliver them late
- Poor customer support, perhaps due to limited call center hours or language barriers

Business intelligence provides users with the tools (such as segmentation) to analyze the root causes of returns, drill downs to individual customer return records, and unstructured text analysis.

Segmenting returns data along dimensions such as state, model number, and distribution channel can highlight the forces behind customer returns. This information can be distributed to users based on their role in the organization—whether they are brand or product managers or work in the manufacturing, operations, or marketing department. For example:

- Early spring weather in northern states will result in excess returns of snow shovels and parkas
- A faster, cheaper portable disk drive introduced by a competitor causes electronics retailers to pull stagnant merchandise from store shelves, sending a formerly top-selling item into early obsolescence

- A frozen foods packager experiencing spikes in returns of spoiled merchandise may pinpoint a particular distributor with a defective warehouse

Although segmentation is useful for exposing trends affecting a majority of returns records along particular dimensions, statistical outliers require a user to drill down to individual transactions. If the majority of returns range in wholesale value between \$50 and \$100 and can be largely explained by the statistical distribution of expected defects, a return of \$100,000 surely warrants additional analysis.

Business intelligence tools supporting unstructured text analysis can mine important data from customer comment cards or recorded call center customer interactions, and can help refine customer surveys to provide more relevant feedback. Comments can be organized into categories to give marketing and sales executives better insight into customer issues, or they can highlight new uses for products or brands that can then be repackaged for alternate uses and marketed accordingly to provide new revenue streams.

Creating and analyzing frequency distributions of words can pinpoint problems. For example, above-average occurrences of a particular model number, store location, or customer representative's name likely points to a problem worth investigating.

The following profiles illustrate two pervasive BI implementations that provided valuable insight into the respective organizations' supply chains.

Managing the Wine and Spirits Supply Chain with Pervasive BI

Realizing the benefits of empowering their employees and partners with a pervasive BI solution, a leading U.S. importer of over a dozen exclusive, top-shelf brands and a growing product portfolio deployed a SaaS-based BI platform. Driven by the need to gain a clearer understanding of their rapidly expanding supply chain, the supplier was able to integrate product movement and brand performance data from the Beverage Data Network and the National Alcohol Beverage Control Association

with shipment, financial, purchasing, and inventory data stored in their corporate transaction system.

The integrated view allows the supplier to obtain an account-level view for every brand in their portfolio, something that was not previously possible. Users now have access to standardized reports on brand performance, depletions, and distributor inventories. Historical data is used in trend comparisons across geographic and time-based dimensions. With unprecedented visibility into production data, complex brand transitions are now managed easily.

With a SaaS-based BI solution, both the distributor and its partners benefit from pervasive BI. The standardized reports and intuitive dashboards minimized the training required for user productivity. An on-demand deployment ensures that sales representatives and partners can access supply chain information from virtually anywhere using only a Web browser and an Internet connection. The fixed monthly subscription rate delivers a low total cost of ownership, provides all employees with role-appropriate BI, and frees the distributor from hardware purchases and future scalability concerns.

Pervasive BI Drives Healthcare Supply Chain Cost Containment

One of Florida's largest healthcare providers had already realized the benefits of pervasive BI for monitoring clinical data and generating physician scorecards. Confronted with mounting supply chain costs and reduced insurance reimbursements, a cross-functional profitability committee decided to apply the on-premises BI platform to analyze inefficiencies in their supply chain. Analysts applied the 80/20 rule to identify the 20 percent of all orthopedic procedures that constituted 80 percent of the costs. That subset was knee and hip implants. Implants are categorized as physician preference items (PPIs) because physicians typically enjoy wide latitude in deciding which vendor to use for a particular implant. With 1,200 cases annually, the healthcare organization's systemwide implant spending had reached \$8.5 million.

The committee used the BI platform's data integration capabilities to access several discrete information sources,

including materials management, the charge entry system, a surgery documentation system, and the decision support system. This enabled analysts to simultaneously merge and view information from the disparate systems to provide all stakeholders with important visibility into the orthopedic implant supply chain. Because the materials system was only storing the current price paid for supplies, a price history was built so that the correct item price would be assigned based on date of service.

The BI platform allows role-appropriate drill-downs to detailed levels of data to view individual cases and examine supply costs. Analysts can examine an individual case to see if it has no associated supply costs (possibly due to an erroneous coding or a missing code in the organization's charge master). These cases are flagged and passed to the Patient Financial Services group for research. Finding such exceptions is critical to supporting profitability initiatives.

Based on the insights gained from their orthopedic implant supply chain, management focused on reducing operational expenses in joint replacement surgery. Key strategies included renegotiating orthopedic implant rates (the rates paid per device to implant vendors) and reducing the number of vendors they deal with in orthopedics.

Through analysis using the BI tool and external benchmarking practices, management realized that the prices they had set were not competitive and were higher than the mean. Management engaged two of their higher-volume vendors in discussions, offering them exclusive supplier status in exchange for additional discounts. Vendor comparison studies have shown that limiting vendor selection generates outcomes equivalent to, if not better than, a broad vendor selection. Despite all of the vendor-based marketing, the devices are roughly equivalent; they are of high quality and largely interchangeable. An additional benefit to limiting vendor selection is that the surgical staff becomes more familiar with the particular tools for a specific vendor and therefore less likely to make mistakes.

Due to the flexibility with which its pervasive BI platform disseminates role-appropriate information, profitability

reports were generated and shared with top administrators and high-volume surgeons. The reports incorporated external benchmarking data, painting a compelling picture of the organization's implant costs relative to its peers. Once surgeons saw cost breakdowns by vendor and as a share of total surgery cost, as well as cost relative to peer averages, support for the profitability initiative grew. ■

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