



The Supply Chain Index:

Evaluating the Healthcare Value Network

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By Lora Cecere

Founder and CEO
Supply Chain Insights LLC

and Abby Mayer

Research Associate
Supply Chain Insights LLC

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Research Overview

Supply Chain Metrics That Matter is a series of monthly reports published by Supply Chain Insights LLC. Over the course of the past two years, we have published 18 reports to analyze the progress of companies within an industry over the period of 2000–2012. This was preparatory work to build a methodology to gauge supply chain progress using financial ratios.

The Supply Chain Index is a composite metric, measuring a company's improvement on balance, strength and resiliency factors within a peer group for a given time period. In this report, we analyze progress for two time periods: 2006–2012 and 2009–2012.

The goal of this report is to apply the Supply Chain Index framework to help readers understand the state of supply chain in the healthcare value network. For the purposes of this analysis, we define the healthcare value network as a group of trading partners focused on improving healthcare outcomes. In this analysis, we focus on the progress of healthcare providers as well as medical device and pharmaceutical manufacturers.

Disclosure

Your trust is important to us. As such, we are open and transparent about our financial relationships and our research process. This independent research is 100% funded by Supply Chain Insights.

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Research Methodology

The basis of this report is publicly available information from corporate annual reports from the period of 2006–2012. To complete this analysis, and understand the patterns, we partnered with a research team from the School of Computing, Informatics and Decision Systems Engineering at Arizona State University (ASU) during the spring of 2014 to develop the Supply Chain Index methodology to analyze supply chain improvement. Details on the math used in this methodology are outlined in the Appendix of this report.

In the analysis of the Supply Chain Index, we use supply chain financial ratios as opposed to absolute

numbers. The use of ratios allow us to compare large companies to small entities, and also to compare the progress of companies operating in different countries using differing currencies. Additionally, it allows us to track progress over time. In Table 1, we share the ratios we have been mining to understand the trends.

Table 1. Financial Ratios Considered in the Determination of the Supply Chain Index

Financial Metrics			
Growth	Profitability	Cycle	Complexity
Common Shares	Cash	Cash-to-Cash Cycle	Altman Z
Employee Growth	Cash Change in Period	Days of Finished Goods	Capital Turnover
Employees	Cash on Hand	Days of Inventory	Current Ratio
Market Capitalization	Cash Ratio TTM	Days of Payables Outstanding	Quick Ratio
R&D Margin	Cash Ratio Quarter	Days of Raw Materials	Return on Assets
R&D Ratio	Cash Ratio Year	Days of Sales Outstanding	Return on Equity
R&D to COGS Ratio	Cost of Goods Sold	Days of Work in Progress	Return on Invested Capital
Revenue	EBITDA	DPO/DSO	Return on Net Assets
Revenue Growth	Free Cash Flow Ratio	Finished Goods Inventory	Revenue per Employee
Revenue Growth TTM	Gross Margin	Inventory	Working Capital Ratio
Revenue TTM	Gross Profit	Inventory Turns	
SG&A Margin	Net Profit Margin	Receivables Turns	
SG&A Ratio	Operating Cash Flow Ratio	Raw Materials Inventory	
SG&A to COGS Ratio	Operating Margin	Work in Progress Inventory	
	OPEX Ratio		
	Pretax Margin		

Source: Supply Chain Insights LLC

While there are other measurements which we believe are important in the determination of supply chain excellence—like forecast accuracy, case fill rate, carbon footprint, and inventory write-offs—we cannot find a reliable source of data for these metrics that covers all industries and years studied. Instead, the data sources are spotty and largely inaccurate due to the self-reporting of data.

The Supply Chain Index methodology was built on the belief that the supply chain is a complex system with increasing complexity. We believe it is the supply chain leader's role to build and manage supply chains that can drive year-over-year improvements which are balanced, strong and resilient. After two years of research in building the Metrics That Matter reports, we selected four financial ratios as the foundation of the Index: inventory turns, operating margin, Return on Invested Capital (ROIC), and year-over-year revenue growth. These were selected based on interviews with supply chain leaders. In addition, they demonstrated high correlation across industries to market

capitalization. To understand the relationship between supply chain performance and market capitalization, we calculated the correlation of seven years of financial ratios (based on quarterly reporting) to market capitalization (the number of outstanding shares multiplied by the share price). The ratios are presented in Table 2.

Table 2. Correlation of Supply Chain Financial Ratios to Market Capitalization

Morningstar Sector	Discount Stores	Medical Care	Drug Manufacturers - Major	Household & Personal Products	Chemical	Packaged Food	Communication Equipment	Medical Devices	Percentage of Industries Demonstrating Correlation per Metric
Number of Companies	11	38	43	31	25	56	96	78	
Days of Inventory (DOI)	X	X	X	X	X	X	X		88%
Days of Sales Outstanding (DSO)	X	X		X	X	X	X	X	88%
Days of Payables Outstanding (DPO)		X		X	X	X	X	X	75%
Return on Invested Capital (ROIC)	X			X	X	X	X	X	75%
Current Ratio (CR)		X	X		X		X	X	63%
Operating Margin (OM)	X	X	X		X	X			63%
Working Capital Ratio (WC)	X	X		X			X	X	63%
DPO/DSO (DPODSO)	X		X				X	X	50%
Free Cash Flow Ratio (FCF)		X	X	X			X		50%
SG&A to COGS Ratio (SGAC)		X		X			X	X	50%
Return on Assets (ROA)						X	X		25%
Return on Net Assets (RONA)						X	X		25%
Year-over-Year Revenue Growth (YOY)							X	X	25%

Source: Supply Chain Insights LLC

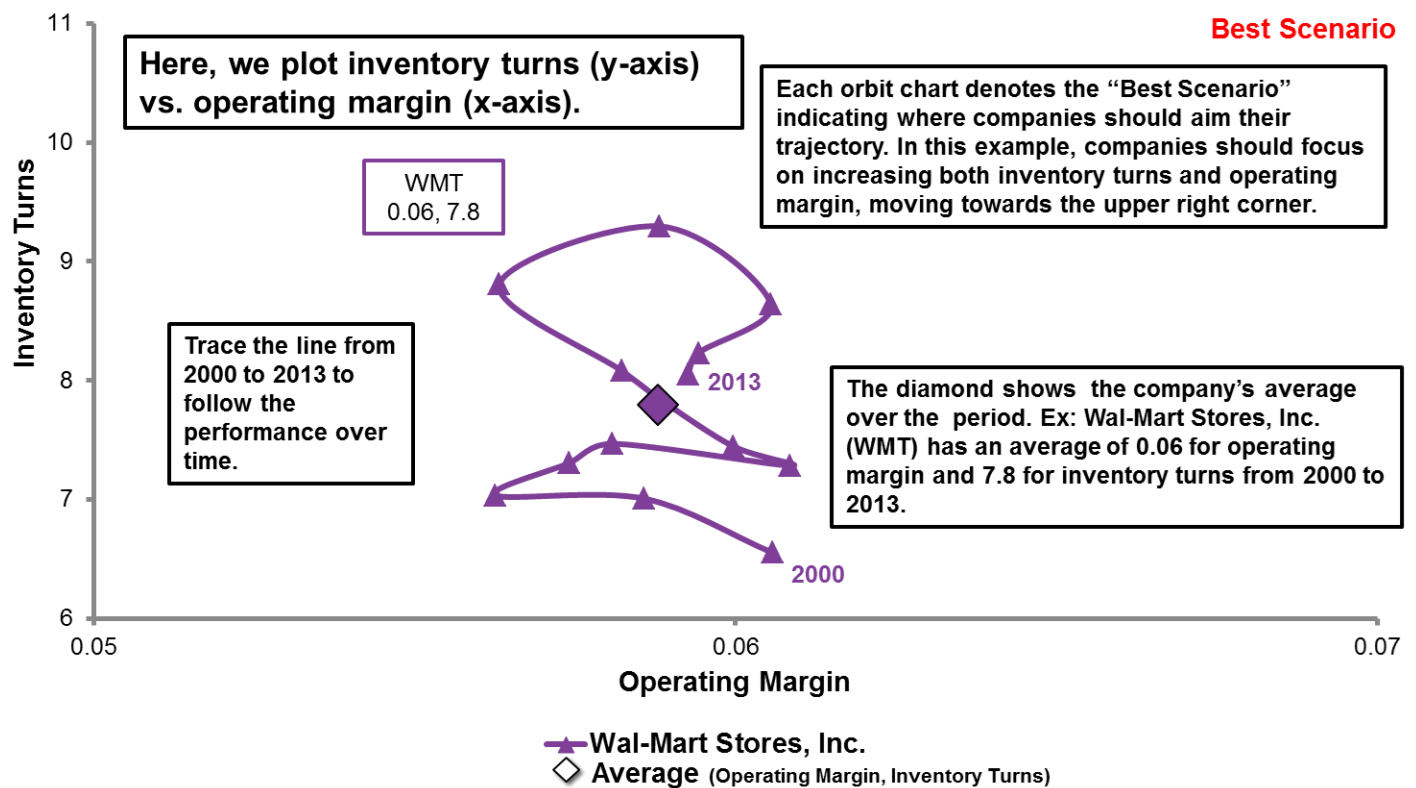
Equations based upon data from 2006Q1 to 2011Q4

Note: The number of companies is the number listed in the Morningstar sector when the peer group was defined between March and June 2013. The number of companies included in the analysis may be smaller due to data availability issues.

The Supply Chain Index methodology also assumes that supply chain improvement takes time. In our research, we find that it takes at least three years to drive significant supply chain change, and that the best improvements take at least five years. We also find that it is difficult for supply chain leaders to sustain the progress. Most companies go through ups and downs. The patterns matter. It is for this reason that we analyze companies' progress from 2006 through 2012, and then again from 2009 through 2012 in order to contrast the two periods. Index calculations compare one company's pattern to those in a like industry. For the purpose of industry groupings, we use NAICS code designations.

The foundation of the Index starts with understanding the resulting pattern when two supply chain metrics (generally ratios) are plotted over time on an orbit chart. As shown in Figure 1, the orbit chart enables the visualization of performance patterns. In this case, the company is **Wal-Mart Stores, Inc.** The average values for the two financial ratios of operating margin and inventory turns are shown in the box, and the annual progress is shown as points on the chart. The best scenario is notated in the upper right-hand corner. This circular pattern of Walmart performance is very characteristic of most companies. We seldom see a company making linear improvement.

Figure 1. Example Orbit Chart of Wal-Mart Stores, Inc.



Source: Supply Chain Insights LLC, Corporate Annual Reports 2000-2013 from One Source

Executive Overview

Supply chain performance matters. It can make or break corporate performance. Now 30-years old, the practice of supply chain management is still evolving. While companies speak of *best practices*, and boast about improvements in operating margin, inventory levels and asset management in conference after conference, we do not see it in our analysis of balance sheet information.

By their nature, supply chain leaders are competitive. They want to drive performance improvements and increase corporate value. Their goal is to outpace competitors. The rate of business change is intense and the personal stakes are high. Day after day, leaders must answer questions like, *“Which path should I to take? What are the best technologies to use? What is an acceptable rate of performance? How am I doing against my peer group? And, what can I learn from others that I can use to improve the performance of my own operation?”* Until the development of the Supply Chain Index by Supply Chain Insights, there was no independent and objective data-driven methodology that could answer these questions. With the development of this methodology, there now is.

While it is easy to say the term *supply chain excellence*, it is difficult to define. Many people think that they know the definition, but there is no agreed-upon standard. The lack of a clear definition, and a methodology to gauge improvement, makes progress hard to quantify and track. The Supply Chain Index is designed to help. It is an objective measurement of supply chain improvement. It enables the comparison of companies’ progress within a peer group for a given time period. The Index is based upon financial performance of companies on four metrics integral to supply chain operations: inventory turns, operating margin, Return on Invested Capital and year-over-year revenue growth. There were three goals.

- 1. Quantify Levels of Supply Chain Improvement.** The Index is a composite metric based on the calculation of balance, strength and resiliency factors for a given time period. In the analysis, there is an underlying assumption that the companies that can sustain the best improvement in these three areas are driving the highest rates of supply chain improvement. The input metrics of inventory turns, operating margin, ROIC and year-over-year revenue growth were selected in part due to their high correlation to market capitalization.
- 2. Bridge the Gap between Finance and Supply Chain.** Our second goal is to bridge the gap between the supply chain organization and the financial team. While the financial team is often backwards-looking at transactions, the supply chain team is forward-looking based on flows. There is often a temptation to focus on a single financial ratio in isolation, like inventory turns,

not realizing that the supply chain is a complex system with tightly interrelated relationships amongst metrics based on supply chain potential. The management of supply chain performance needs to be a system-based approach looking at a portfolio of metrics in a holistic manner.

- 3. Understand the Possibilities.** Each industry has a unique potential. For example, a reasonable inventory turns value for a medical device company is significantly different than that of a fashion apparel company. As a result, the targets or set points need to be different. Why? The inherent rhythms and cycles—product life cycle, the time to manufacture the product, demand and supply volatility, and demand shaping programs—of the supply chain are different. We often see well-intended and unaware executives focus on unreasonable targets for a supply chain performance metric not understanding the differences between industries, the need to manage the supply chain as a complex system, and the market factors that are driving the change. The Supply Chain Index is designed to increase awareness in establishing the best targets for corporate performance for individual companies within an industry, grounded in real possibilities.

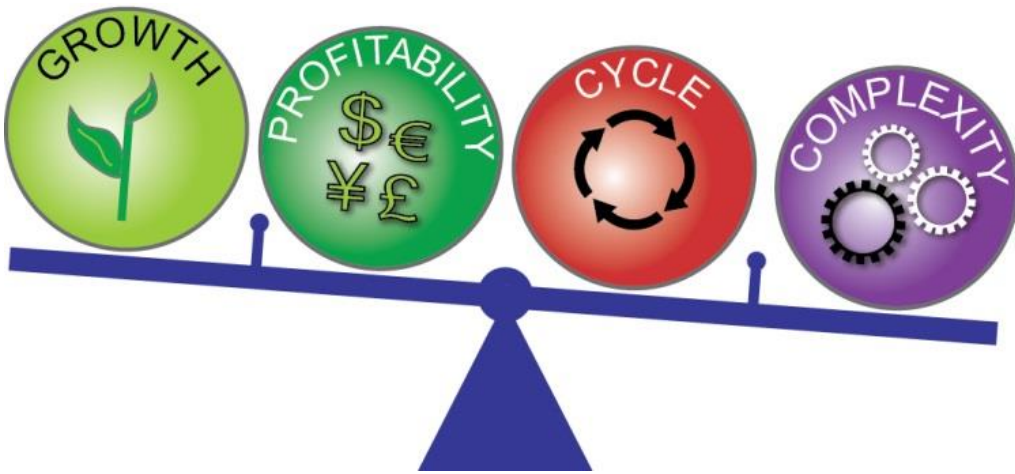
In this report, we apply the Index methodology to three industries comprising the healthcare value chain: hospitals, medical device manufacturers, and pharmaceutical manufacturers. None of the three are supply chain leaders. Companies in these industries have historically enjoyed high margins which enabled success without a strong focus on supply chain performance. Radical changes in the industry with the Affordable Care Act in the U.S., patent cliffs, increasing governmental regulations, and global complexity are reshaping the business environment to make supply chain more important.

Improving Performance on the Effective Frontier

Without a measuring system to gauge performance improvement, supply chain excellence exists in a world of gray, not black and white. As a result, supply chain leaders are faced with the challenge of balancing competing priorities without the ability to measure improvement.

The Supply Chain Index is designed to help. It is based on the belief that a supply chain is a complex system with complex processes with increasing complexity. Improving supply chain performance requires the management of this complex system of tightly linked, and interrelated metrics. In this complex system, supply chain leaders are attempting to balance four distinct priorities: improving growth, improving profitability, reducing cycle time, and managing the ever-increasing complexity. We termed this the *Supply Chain Effective Frontier* as seen in Figure 2.

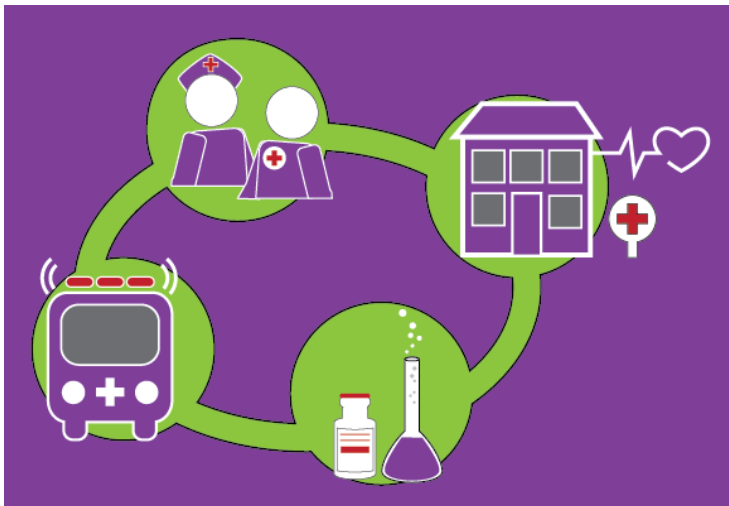
Figure 2. The Supply Chain Effective Frontier



What Is a Value Network?

A value network is a collection of industry-specific supply chains spanning across companies to deliver value to a common customer. The relationships are not linear: they are complex with many links between trading partners. This report focuses on supply chain improvement within the healthcare value network including the hospital, medical device and pharmaceutical industries.

Figure 3. The Healthcare Value Network



While we define the interactions between these industries as a *value network* for the purposes of this report, the healthcare value network has not excelled at intercompany cooperation to drive value. Today, it is more of a supply network than one aligned to improve value. Contrary to the leadership demonstrated by companies in the consumer value network, no member of the healthcare industry has stepped forward to drive supply chain improvements across the larger value network. As a result, there is little progress being made across the network in aggregate.

Who Is the Customer?

In the consumer value chain, it is clear. The customer's role is clear. Companies realize that the person who uses the product is the consumer, the person who buys the product is the shopper, and the company that sells the product is the retailer. For the operations teams in the consumer value network, the focus is on delivering value to maximize the shopper's experience. They work with the retailer to improve this customer experience while maximizing the value for the retailer. This includes having the correct product at the shelf when the shopper wants to buy it while ensuring product quality at the point of delivery. These companies are now in their third decade of refining the processes.

In healthcare, it's a different story. In the delivery of supply chain excellence it is critical to know the customer's expectations. But what if the customer is not clearly identified? The role of the customer is not so clear in healthcare. Suppliers, both pharmaceutical and medical device companies, are confused. Who should the supplier serve? Is it the physician? The hospital? The patient? The insurer? The Group Purchasing Organization (GPO)?

In this value network, each party has a slightly different focus, and the payment systems are more bifurcated than other value networks (split payments to multiple parties). As a result, it is hard for the industries within the network to align on clear metrics that define customer-centric excellence.

Traditionally, the healthcare value chain sold products to physicians. Over the last decade the focus has been slowly changing. Today, the customer is the hospital or the GPO. This shift was, and continues to be, difficult for manufacturers. Sales and marketing organizations were aligned to sell to the doctor. As more and more suppliers to hospitals are asked to focus on value-based outcomes for patients, it redefines the entire value network.

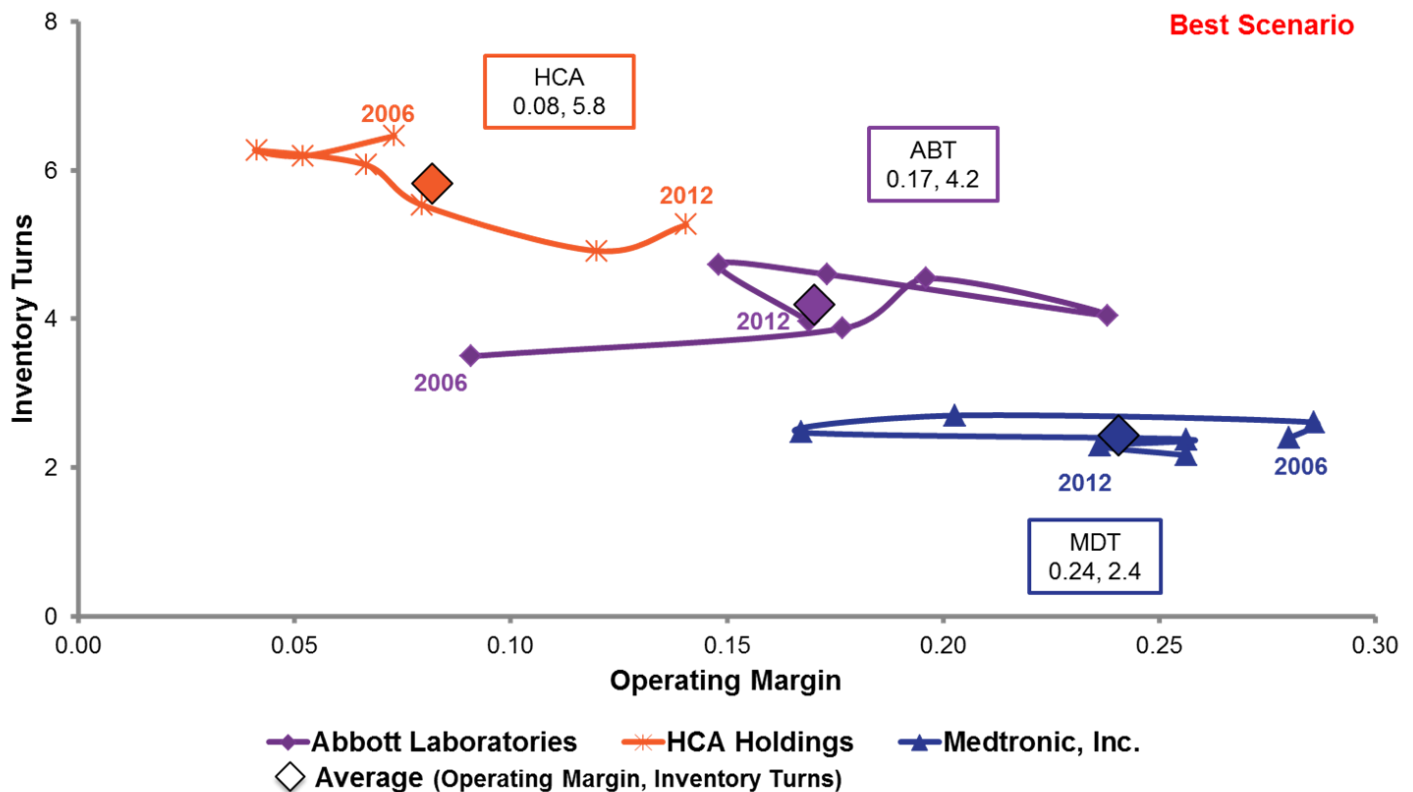
While the physician is aligned with nursing, the gaps between the physician and the hospital administration, finance and supply chain are large. As long as the players within healthcare struggle on alignment, progress on affordable healthcare will be slow. The parties at the hospital are not aligned. The gaps are large. This is a major obstacle.

This lack of alignment is a barrier to progress. Over the course of the last decade, while companies have improved productivity (as defined by revenue per employee) in all three sectors of healthcare—hospitals, medical device manufacturers, and major pharmaceutical companies—margins have fallen for hospitals and medical device companies. More recently, margins have also fallen for pharmaceutical companies.

Each Company Operates at a Unique Potential

The network is composed of individual industries. Figure 4 illustrates performance of three representative companies in the healthcare value network: one hospital, one medical device manufacturer and one pharmaceutical manufacturer. Each company operates on its own Effective Frontier and occupies a different portion of the chart. Hospitals, located closest to the consumers, operate with relatively high inventory turns and low margins. The farther back in the healthcare value network one moves, inventory turns slower and the margins are greater.

Figure 4. Healthcare Value Network Orbit Chart



Note that all three of these individual companies have a circular pattern. The path is not linear. This is common for most companies that we study and is not unique for this value network.

While each company can make improvements and drive changes in process, there are limitations to what is possible. Every company operates at a different potential. The key to driving higher levels of supply chain improvement is in improving potential. As a result, a medical device manufacturer will never turn inventory as fast as a consumer electronics manufacturer. Understanding the reality of the industry and the starting point for improvement is a critical piece of the puzzle to determine metrics set points.

Industry Performance within the Value Network

When we take the longer view of 2000-2012, and analyze changes in the financial ratios over that time, several clear patterns appear. Operating margins are under pressure, while cash-to-cash performance is improving in all three industries. The improvement in C2C is primarily driven by lengthening payables. Revenue per employee is improving, but is lower than the rates of improvement that we see in the industries in the consumer value network. We capture these changes in Table 3.

Table 3. Healthcare Value Chain (2000-2012)

Healthcare Value Chain (2000-2012)					
Industry	Operating Margin	Inventory Turns	Cash-to-Cash Cycle	Revenue per Employee (K\$)	SG&A Ratio
Hospital Industry (n=6)	0.07 ↓11% ⁿ	11 ↑53% ⁿ	-84 ↓3215% ⁿ	165 ↑68% [*]	12% ↓-54% [*]
Pharmaceutical Industry (n=24)	0.19 ↑12%	3 ↓8%	139 ↓1%	462 ↑98% [*]	27% ↑24% [*]
Medical Device Industry (n=6)	0.16 ↓56%	3 ↑2%	141 ↓4%	270 ↑59% [*]	28% ↓3% [^]

Source: Supply Chain Insights LLC, Corporate Annual Reports 2000-2012

Industry Average comprised of public companies (hospital: NAICS 62211), (medical device: NAICS 339112), (pharmaceutical: NAICS 325412) reporting in One Source with 2012 annual sales greater than \$5 billion

ⁿCalculated from 2001-2012 due to data availability; ^{*}Calculated from 2002-2012 due to data availability; [^]Calculated from 2003-2012 due to data availability

Index Methodology

There are four components of a Supply Chain Index score: balance, strength, resiliency and a peer input. It is a composite metric. In this report, a company's balance, strength, and resiliency factors are calculated and then stack ranked within its industry. Each contributes 30% of the final score. In August, we will complete the peer rankings. Here we outline the Index methodology. For a more detailed explanation of the math behind the Index, please refer to the Appendix.

Balance

Balance in the supply chain is a constant struggle. As growth increases, there is usually an increase in demand error which can reduce the Return on Invested Capital. Reduced inventory without improving form and function of the inventory elements can wreak havoc on customer service levels. Excess inventory leads to high carrying cost and product obsolescence. Excessively long days of payables lead to weakened supplier health. The examples are endless: balance in supply chain metrics is critical.

Figure 5. Balance



The two metrics that comprise our balance measure are revenue growth and Return on Invested Capital. ROIC is a less well-known metric compared to Return on Assets (ROA). ROA has a narrower focus. Our research indicates that ROIC has better correlation with market capitalization and provides a broad perspective on cash flow generation and profitability based on shareholder equity.

$$\text{Return on Invested Capital} = \frac{\text{Operating Income} + \text{Income Tax Total}}{\text{Total Shareholder's Equity}}$$

It is a measurement of the company's use of capital. The goal is to drive higher returns than the market rate of the cost of capital.

To calculate the balance factor, we start with an orbit chart of year-over-year revenue growth and ROIC. The balance measure in the Supply Chain Index is a mathematical calculation of the vector trajectory of the pattern between growth and ROIC for the given period. The overall trajectory of this vector from Year 0 (2006 or 2009) to the ending year (2012) is simplified into a single value which represents the company's ability to balance growth and ROIC.

In the calculation, companies that were able to drive improvement in both metrics score the best, while companies that deteriorated in both metrics did the worst. A negative score on the balance score translates to a supply chain that lost ground on the metrics compared to the starting year. In this report, we calculate this factor for two time periods. Our initial analysis considers performance based upon a time period of 2006-2012. Additional analysis focuses on a narrower time period of 2009-2012 to examine corporate performance emerging from the Great Recession. The balance metric comprises 30% of the total Supply Chain Index calculation.

Strength

A successful supply chain is a strong supply chain. Supply chain leaders deliver year-over-year improvements. Our research over the past two years has uncovered a rich relationship between operating margin and inventory turns. For most supply chain leaders, these are some of the most

important measures of their performance. Not only are they important, they are more directly influenced by supply chain decisions than other broader corporate metrics. It is for this reason they are the two components of our strength metric.

Figure 6. Strength



The strength measure in the Supply Chain Index is a mathematical calculation of the vector trajectory of the pattern between inventory turns and operating margin for the period of 2006 (or 2009) to 2012. Inventory turn and operating margin performance is graphed on an annual basis from an origin point (0,0) representing performance on the two metrics at Year 0 (2006 or 2009). The overall trajectory of this vector from Year 0 (2006 or 2009) to the final year (2012) is simplified into a single value which represents strength. Improvement on both metrics simultaneously is graphically shown as movement to the upper right quadrant with increasing values for both inventory turns and operating margin over the period.

The strength metric comprises 30% of the total Supply Chain Index calculation. Sustained improvement on both inventory turns and operating margin indicates a strong supply chain and is reflected in a high strength score.

Resiliency

Resiliency is an adjective easily tossed around as one of the key qualities of a successful supply chain in today's volatile world. However, the concept of resiliency is more difficult to define, and there is rarely clarity among stakeholders as to what resiliency is or should be. Here we provide a clear and concise definition.

As we plotted chart after chart, we could see that some supply chains had very tight patterns at the intersection of operating margin and inventory turns, and that other companies had wild swings. We wanted to find a way to measure this. We turned to the experts at ASU. After evaluating several methods to determine the pattern in the orbit chart, we settled upon the Euclidean mean distance between the points.

Figure 7. Resiliency



In our March 2014 report: [Supply Chain Metrics That Matter: Improving Supply Chain Resiliency](#), we define resiliency as the tightness of the pattern at the intersection of inventory turns and operating margin. These metrics are also part of the strength factor.

The tightness of the pattern (mathematically speaking, the Euclidean mean distance) indicates the ability of a supply chain to maintain a tight, consistent pattern across these two metrics as the business environment shifts and changes over a seven year period (2006-2012) or four year period (2009-2012).

The resiliency metric is similar to the cash-to-cash cycle in that companies should work to minimize the value. A lower number for resiliency is an indicator of a tighter pattern and greater reliability in results over the time period. The resiliency metric comprises 30% of the total Supply Chain Index calculation.

Peers

The final 10% of the score will be a peer vote contributed by members of the Shaman's Circle. The Shaman's Circle is a group of 350 supply chain leaders from a variety of industries and company sizes that form an informal networking group within the Supply Chain Insights community. In August, each of the leaders in the Shaman's Circle will be asked to rank the results by value chain. In September, we will publish the final results for all industries.

The balance, resiliency, and strength values will be populated and stack ranked prior to the vote by the Shaman's Circle. Our intention is to create a voting environment that is open to individual perspective, but also balanced with a full scorecard of objective measures to inform the voting process. The values of a table like that in Table 4 will be created for each industry peer group for the period of 2006-2012.

Table 4. Supply Chain Index Ranking System

Supply Chain Index								
NAICS Code	Balance	Balance Ranking	Strength	Strength Ranking	Resiliency	Resiliency Ranking	Peer Ranking	Overall Ranking

Source: Supply Chain Insights LLC

In the analysis, each industry segment, as defined by NAICS classification codes, will be considered on an individual basis. As a result, **Merck & Co., Inc.** will not be directly compared against **Ford Motor Company** or **Wal-Mart Stores, Inc.** The definition of a best-in-class supply chain varies by the complexities and realities of the operating environment and it is not a one-size-fits-all business environment.

Why the Time Period Matters

The Supply Chain Index is a measure of improvement. For this reason, the beginning year of the measurement is of critical importance to the ranking. It is the basis for the entire analysis. Initially, we considered the time period of 2000-2012. However, supply chain leaders gave us feedback that thirteen years was too long. The rigors of global supply chain management are so different from what they were in 2000. Based on this feedback, we have thus adjusted the methodology to focus on two different time periods: 2006-2012 and 2009-2012. The larger seven year time period encompasses the recession and its aftermath, and is a good study of resiliency. The 2009-2012 time period takes a narrower focus on the recovery from the Great Recession.

In some industries, the rankings change drastically based on the timeframe. We see this less in the healthcare industry than we saw in the analysis of the consumer value network.

A Closer Look at the Healthcare Value Network

In this section, we start by sharing the average factors, shown in Table 5, and then the results of the individual industries.

Table 5. Supply Chain Index Healthcare Value Network Performance (2006-2012)

Industry	Number of Companies	Balance	Strength	Resiliency
Hospital	5	-0.15	0.03	2.52
Pharmaceutical	13	0.18	0.06	0.50
Medical Device	14	0.05	-0.04	0.48

Source: Supply Chain Insights LLC, Corporate Annual Reports 2006-2012

Using the average factors of the Supply Chain Index, it is clear that healthcare providers (hospitals) are struggling with both balance and resiliency. The improvement on strength is primarily the result of shifting inventory responsibility backwards in the chain. Pharmaceutical companies score the highest of the three industries on the Supply Chain Index, but excessive merger & acquisition (M&A) activity endangers stability within the industry, creating larger companies that struggle to manage twisted supply chains. Finally, the medical device industry has been losing ground on the strength factor since 2006. While they lead the pack on resiliency, deeper analysis indicates that this resiliency more often equates to stasis than improvement. This industry is struggling to make improvement.

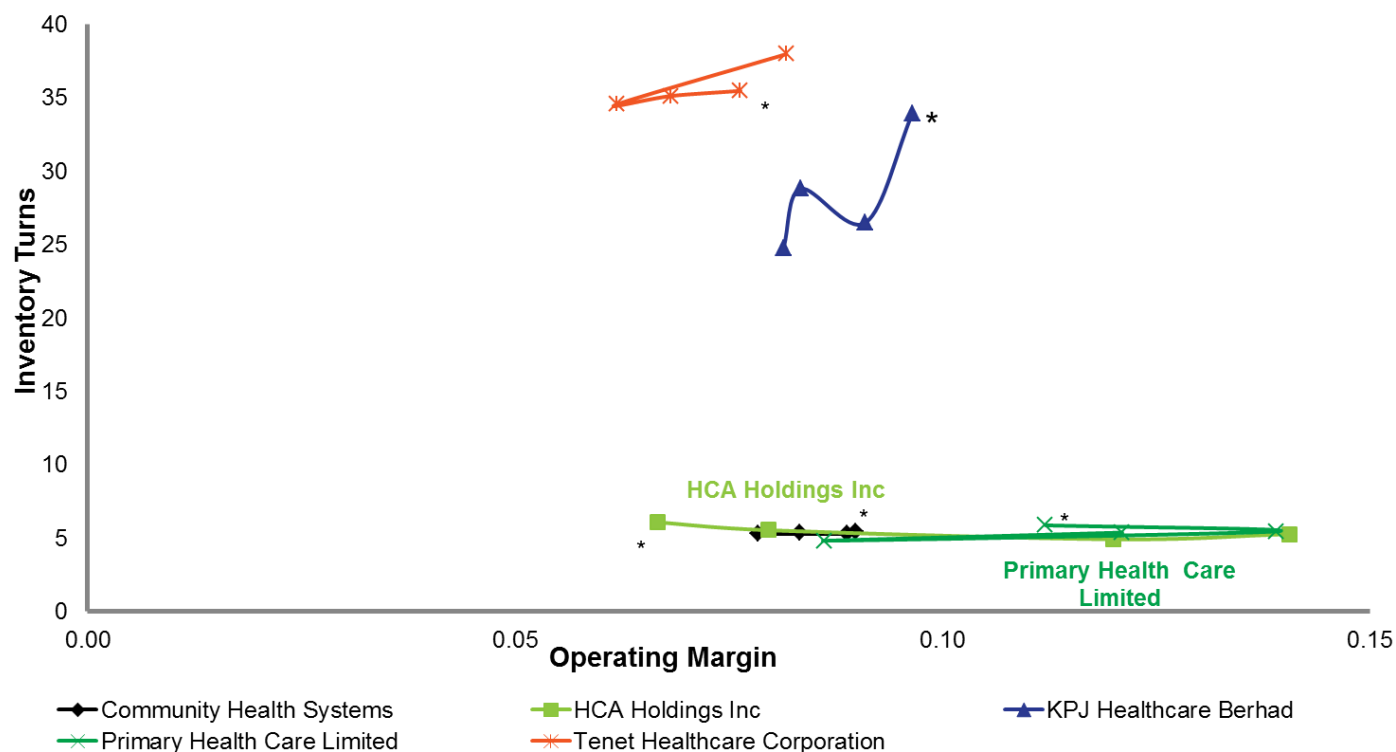
Hospitals

Hospitals have the advantage of being located the closest to the consumption of products in the healthcare value network. As a result of this location, they are best equipped to understand the changing needs and demands of the healthcare value chain from the patient back. Their supply chain organizations are new—an average of six years of maturity—and the processes are maturing. Most of the focus has been on sourcing: the automation of procurement and aggregate buying. The focus has been on the lowest sourced cost. As a result, the hospital organization struggles to know what practices drive the lowest total cost and the greatest value based on patient-based outcomes.

Margins are very thin, and the industry is fragmented. It is hard to establish an economy of scale. As a result, Group Procurement Organizations (GPOs) emerged working as a source for aggregate buying. In addition, the industry is currently undergoing a number of mergers and acquisitions.

Figure 8 illustrates performance for individual companies from 2009-2012 at the intersection of inventory turns and operating margin. Note that **HCA Holdings Inc.** and **Primary Health Care Limited** are operating in a similar plane of performance; whereas, the performance of **Tenet Healthcare Corporation** and **KPJ Healthcare Berhad** are at different levels. Not a single company is making linear progress towards improvement in both operating margin and inventory turns.

Figure 8. Hospital Orbit Chart (2009-2012)



Source: Supply Chain Insights LLC, Corporate Annual Reports 2009-2012

Since the Supply Chain Index is a measurement of supply chain improvement, we feel that it is critical to start with an overview of individual company performance. This is the goal of Figure 8. To understand the progression, we have placed an asterisk next to each line indicates the starting year (2009). This allows the reader to follow the pattern for the four years.

In the chart, **KPJ Healthcare Berhad** and **Tenet Healthcare Corporation** demonstrate significantly higher inventory turns over the period, but the industry norm falls closer to 5 turns per year. **HCA** demonstrates the most improvement in the figure and in the Index rankings for 2006-2012 shown in Table 6.

Table 6. The Supply Chain Index: Hospitals (2006-2012)

Company	2012 Revenue (billions USD)	Balance	Balance Ranking	Strength	Strength Ranking	Resiliency	Resiliency Ranking	Index (0.3B + 0.3S + 0.3R)	Ranking
HCA Holdings Inc	33.0	0.41	1	0.12	2	0.70	1	1.2	1
Primary Health Care Limited	1.4	-0.17	3	0.25	1	2.05	3	2.1	2
Community Health Systems	13.0	-0.22	4	0.02	3	0.80	2	2.7	3
KPJ Healthcare Berhad	0.7	-0.10	2	-0.02	4	3.98	4	3.0	4
Tenet Healthcare Corporation	9.1	-0.65	5	-0.23	5	5.06	5	4.5	5

Source: Supply Chain Insights LLC, Corporate Annual Reports 2006-2012

Consistent with the industry averages, four of the five companies record a negative balance factor indicating a loss of ground at the intersection of ROIC and year-over-year sales growth. High resiliency factors illustrate the large swings that exist within the industry. These are higher than any other industry studied. The results for 2009-2012, which are shown in Table 7, are comparable.

Table 7. The Supply Chain Index: Hospitals (2009-2012)

Company	2012 Revenue (billions USD)	Balance	Balance Ranking	Strength	Strength Ranking	Resiliency	Resiliency Ranking	Index (0.3B + 0.3S + 0.3R)	Ranking
HCA Holdings Inc	33.0	0.31	1	0.33	1	0.62	3	1.5	1
Primary Health Care Limited	1.4	-0.29	3	0.00	3	0.55	2	2.4	2
Community Health Systems	13.0	-0.57	4	-0.03	4	0.10	1	2.7	3
Tenet Healthcare Corporation	9.1	-0.97	5	0.05	2	1.77	4	3.3	4
KPJ Healthcare Berhad	0.7	-0.11	2	-0.14	5	4.97	5	3.6	5

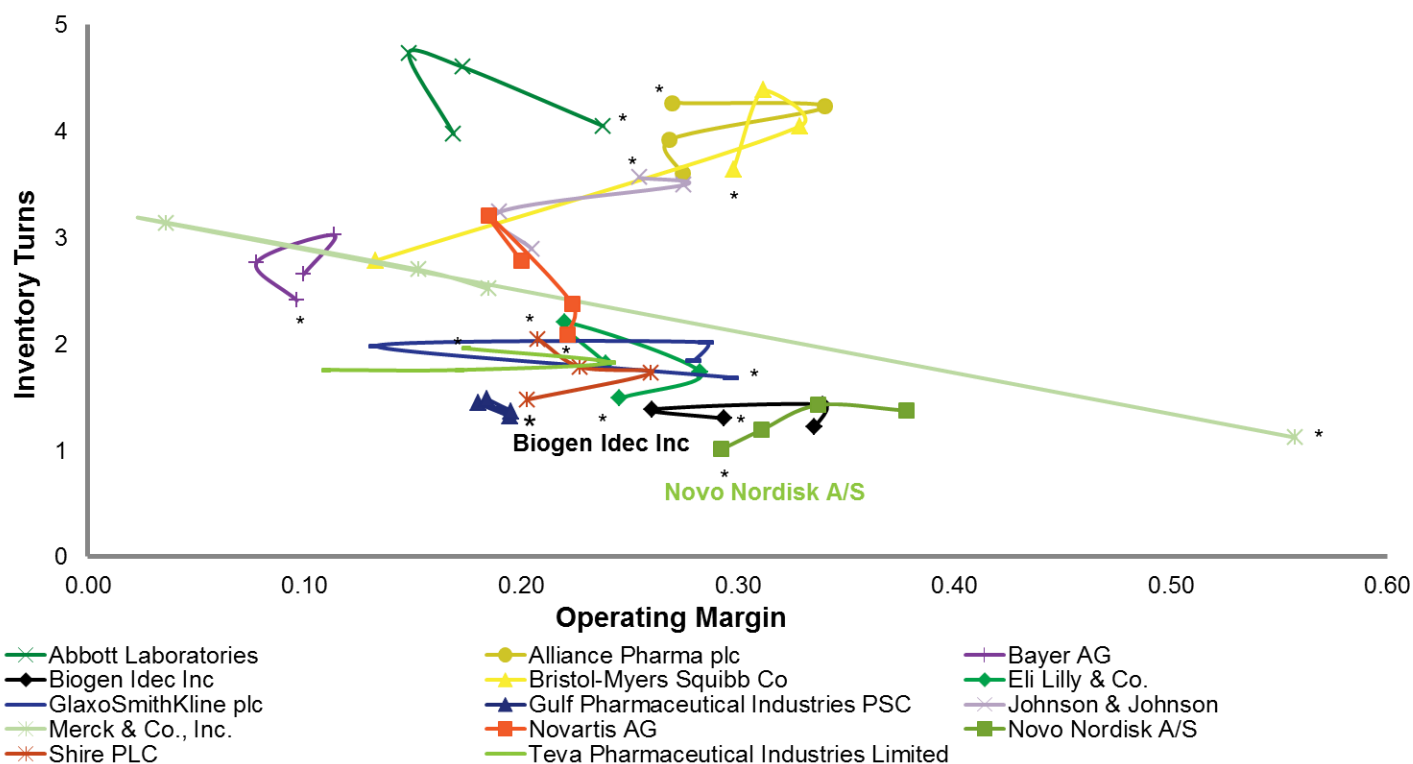
Source: Supply Chain Insights LLC, Corporate Annual Reports 2009-2012

HCA Holdings Inc retains the top spot and **Primary Health Care Limited** holds onto the number two position. This industry displays a pattern in that companies that are doing well on one metric are generally doing well on all three. Companies that are struggling are struggling on all three. This pattern is more prevalent in the longer 2006-2012 time period, but still visible for 2009-2012. In the final section, the results of the medical device industry will demonstrate a very different pattern when it comes to uniform rankings across companies for the two timeframes for the three factors.

Pharmaceutical

The second industry of the healthcare value network is pharmaceutical manufacturers. The challenges of pharmaceutical suppliers are shared by medical device manufacturers: global complexity and increasing regulation with the added challenge of patent cliff issues. Figure 9 illustrates the industry's performance since 2009 on operating margin and inventory turn metrics.

Figure 9. Pharmaceutical Orbit Chart (2009-2012)



Source: Supply Chain Insights LLC, Corporate Annual Reports 2009-2012

The patterns are much more erratic in this industry. Note that many companies, like **Abbott Laboratories**, **Bristol-Myers Squibb Co**, **Johnson & Johnson** and **Merck & Co., Inc.**, are going backwards in the rankings; and that several companies, like **Novartis AG** or **Shire PLC**, are making improvement in inventory turns, but losing ground on operating margin.

Similar to the hospital industry, the companies that lead the pack on the Index rankings (**Biogen Idec Inc** and **Novo Nordisk A/S**) are not leading the pack on either margin or turns; but, they are making year-over-year progress on both of the metrics simultaneously. Again, the rankings do not reward the best, but rather, the most improved. Results for 2006-2012 are shown in Table 8.

Table 8. The Supply Chain Index: Pharmaceutical (2006-2012)

Company	2012 Revenue (billions USD)	Balance	Balance Ranking	Strength	Strength Ranking	Resiliency	Resiliency Ranking	Index (0.3B + 0.3S + 0.3R)	Ranking
Biogen Idec Inc	5.5	1.39	1	0.17	2	0.19	2	1.5	1
Novo Nordisk A/S	13.5	0.29	5	0.15	4	0.21	3	3.6	2
Gulf Pharmaceutical Industries PSC	0.3	0.31	4	0.04	6	0.22	4	4.2	3
Abbott Laboratories	39.9	0.78	2	0.17	3	0.55	10	4.5	4
Bayer AG	51.1	-0.01	8	0.03	9	0.28	6	6.9	5
Shire PLC	4.7	0.52	3	0.03	8	0.58	12	6.9	5
Alliance Pharma plc	0.1	0.04	7	0.20	1	1.26	16	7.2	7
Eli Lilly & Co.	22.6	-0.35	14	0.04	5	0.32	7	7.8	8
Teva Pharmaceutical Industries Limited	20.3	-0.06	9	-0.01	13	0.27	5	8.1	9
Novartis AG	57.6	-0.24	11	0.04	7	0.52	9	8.1	9
GlaxoSmithKline plc	41.9	-0.28	13	-0.04	14	0.19	1	8.4	11
Bristol-Myers Squibb Co	17.6	0.17	6	0.02	10	0.97	15	9.3	12
Johnson & Johnson	67.2	-0.14	10	-0.05	15	0.34	8	9.9	13
Pfizer Inc.	59.0	-1.03	16	0.00	11	0.58	11	11.4	14
AstraZeneca plc	28.0	-0.47	15	0.00	12	0.64	13	12.0	15
Merck & Co., Inc.	47.3	-0.24	12	-0.10	16	0.89	14	12.6	16

Source: Supply Chain Insights LLC, Corporate Annual Reports 2006-2012

In general, large pharmaceutical giants have made less progress on supply chain excellence since 2006 compared to more narrowly focused and smaller peers. This holds true for the analysis beginning in both 2006 and 2009, although **GlaxoSmithKline plc** ranks significantly higher in the narrower time period.

Table 9. The Supply Chain Index: Pharmaceutical (2009-2012)

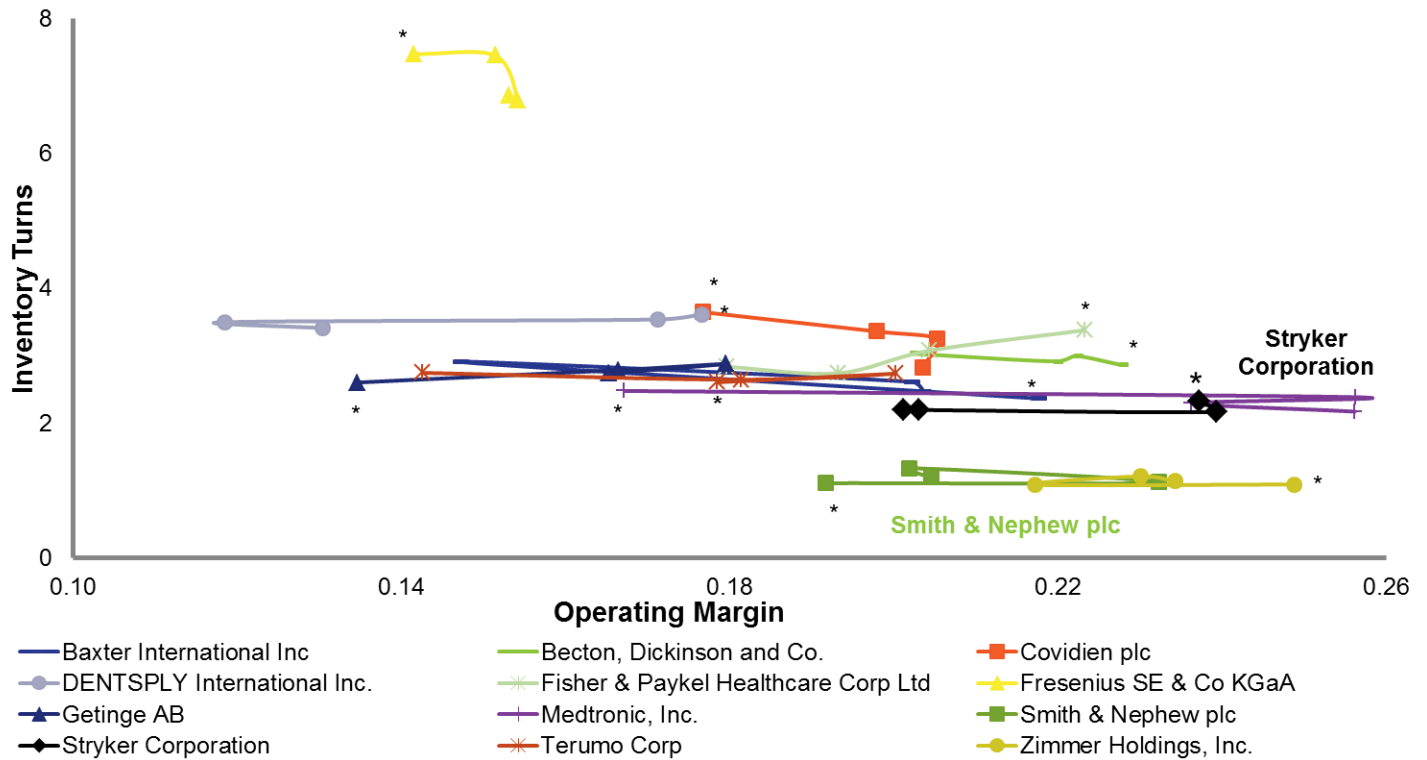
Company	2012 Revenue (billions USD)	Balance	Balance Ranking	Strength	Strength Ranking	Resiliency	Resiliency Ranking	Index (0.3B + 0.3S + 0.3R)	Ranking
Novo Nordisk A/S	13.5	0.47	2	0.22	2	0.25	5	2.7	1
Biogen Idec Inc	5.5	0.20	3	0.03	7	0.13	2	3.6	2
Gulf Pharmaceutical Industries PSC	0.3	-0.08	4	0.02	8	0.10	1	3.9	3
GlaxoSmithKline plc	41.9	1.30	1	0.01	9	0.23	4	4.2	4
Bayer AG	51.1	-0.16	6	0.04	6	0.33	7	5.7	5
Eli Lilly & Co.	22.6	-0.79	11	0.06	5	0.37	8	7.2	6
Teva Pharmaceutical Industries Limited	20.3	-0.29	7	-0.16	15	0.15	3	7.5	6
Novartis AG	57.6	-0.55	10	0.08	4	0.62	13	8.1	8
Abbott Laboratories	39.9	-0.16	5	-0.10	12	0.48	11	8.4	9
Merck & Co., Inc.	47.3	-0.52	9	0.19	3	1.07	16	8.4	9
Alliance Pharma plc	0.1	-0.44	8	-0.05	10	0.39	10	8.4	9
Pfizer Inc.	59.0	-1.83	14	0.42	1	0.70	14	8.7	12
Shire PLC	4.7	-7.06	16	-0.10	11	0.30	6	9.9	13
Johnson & Johnson	67.2	-0.83	12	-0.13	14	0.38	9	10.5	14
AstraZeneca plc	28.0	-1.89	15	-0.12	13	0.59	12	12.0	15
Bristol-Myers Squibb Co	17.6	-1.40	13	-0.26	16	0.88	15	13.2	16

Source: Supply Chain Insights LLC, Corporate Annual Reports 2009-2012

Medical Device

Companies within the medical device industry are struggling to keep their supply chains stable. The industry has high margins, and has made little progress on supply chain improvements. Supply chain priorities historically took a back seat. Figure 10 illustrates the industry's performance over the last four years at the intersection of inventory turns and operating margin.

Figure 10. Medical Device Orbit Chart (2009-2012)



Source: Supply Chain Insights LLC, Corporate Annual Reports 2009-2012

Each industry has a range of normal values for most financial metrics. This plot makes that “normal” clear for medical device companies. Overall, note the high operating margin and low inventory turn values. The Index rankings for 2006-2012 help to illustrate some of the differences in year-over-year performance.

Baxter International Inc. and **Boston Scientific Corporation** tie for first in the rankings. Both companies struggled on resiliency and the company that leads on resiliency (**Zimmer Holdings, Inc.**) is far below in the rankings. The overall rankings (2nd column to the right) which are calculated as 30% of each ranking are significantly higher for medical device companies than for other industries. For example, the top hospital for the 2006-2012 had a composite Index score of 1.2 while **Baxter** and **Boston Scientific** tie for first at 4.2. What does this mean?

Table 10. The Supply Chain Index: Medical Device (2006-2012)

Company	2012 Revenue (billions USD)	Balance	Balance Ranking	Strength	Strength Ranking	Resiliency	Resiliency Ranking	Index (0.3B + 0.3S + 0.3R)	Ranking
Baxter International Inc	14.2	-0.03	4	0.01	2	0.23	8	4.2	1
Boston Scientific Corporation	7.2	0.02	3	0.04	1	0.39	10	4.2	1
Terumo Corp	4.9	2.06	1	-0.06	11	0.15	4	4.8	3
Getinge AB	3.6	-0.06	6	0.00	5	0.22	7	5.4	4
Stryker Corporation	8.7	-0.14	9	-0.02	7	0.11	3	5.7	5
DENTSPLY International Inc.	2.9	0.25	2	-0.06	12	0.19	6	6.0	6
Smith & Nephew plc	4.1	-0.25	14	0.00	4	0.10	2	6.0	6
Becton, Dickinson and Co.	7.7	-0.15	11	-0.01	6	0.15	5	6.6	8
Cardinal Health Inc	107.6	-0.10	7	0.01	3	1.97	15	7.5	9
Medtronic, Inc.	16.2	-0.13	8	-0.03	9	0.23	9	7.8	10
Fresenius SE & Co KGaA	25.1	-0.05	5	-0.02	8	0.98	13	7.8	10
Zimmer Holdings, Inc.	4.5	-0.21	13	-0.06	13	0.10	1	8.1	12
Covidien plc	11.9	-0.20	12	-0.05	10	0.47	12	10.2	13
Fisher & Paykel Healthcare Corp Ltd	0.4	-0.15	10	-0.12	14	0.45	11	10.5	14
Olympus Corp	10.7	-0.31	15	-0.19	15	1.08	14	13.2	15

Source: Supply Chain Insights LLC, Corporate Annual Reports 2006-2012

There is less uniformity—good or bad improvement—in the medical device industry. Companies are not uniformly ranking high across all three factors. The results are much more jagged compared to the hospital and pharmaceutical industries. This raggedness remains for the 2009-2012 rankings shown in Table 11.

Table 11. The Supply Chain Index: Medical Device (2009-2012)

Company	2012 Revenue (billions USD)	Balance	Balance Ranking	Strength	Strength Ranking	Resiliency	Resiliency Ranking	Index Ranking (0.3B + 0.3S + 0.3R)	Ranking
Stryker Corporation	8.7	18.87	1	-0.07	12	0.09	2	4.5	1
Smith & Nephew plc	4.1	1.10	4	0.05	5	0.13	6	4.5	1
Getinge AB	3.6	0.81	5	0.09	3	0.15	7	4.5	1
Boston Scientific Corporation	7.2	1.45	3	1.27	1	0.36	11	4.5	1
Terumo Corp	4.9	0.19	7	-0.05	11	0.10	3	6.3	5
Zimmer Holdings, Inc.	4.5	-0.59	14	-0.01	7	0.08	1	6.6	6
Medtronic, Inc.	16.2	-0.11	13	0.14	2	0.18	8	6.9	7
Becton, Dickinson and Co.	7.7	0.03	11	-0.02	9	0.10	4	7.2	8
Baxter International Inc	14.2	0.11	9	-0.01	8	0.30	9	7.8	9
Olympus Corp	10.7	1.99	2	-1.68	15	0.40	12	8.7	10
Covidien plc	11.9	0.21	6	-0.02	10	0.43	13	8.7	10
Fresenius SE & Co KGaA	25.1	0.10	10	0.00	6	0.44	14	9.0	12
Cardinal Health Inc	107.6	-0.05	12	0.07	4	0.91	15	9.3	13
Fisher & Paykel Healthcare Corp Ltd	0.4	0.14	8	-0.12	14	0.36	10	9.6	14
DENTSPLY International Inc.	2.9	-3.91	15	-0.11	13	0.12	5	9.9	15

Source: Supply Chain Insights LLC, Corporate Annual Reports 2009-2012

Is Bigger Better?

Growth is slowing and R&D costs are higher. With many companies sitting on cash, M&A activity during the last six years has been high. Pfizer/Schering-Plough, Merck/Wyeth, Medtronic/Zimmer Holdings and failed attempts to take-over AstraZeneca. In general, larger companies that have moved through M&A activities move slower on the Index. It takes a while to regain ground from M&A activity, and larger companies, in general, make supply chain improvements at a slower rate.

As seen in Table 11, the larger the company the better the results in the healthcare value chain on operating margin; but as shown in Table 12, there is an inverse relationship on inventory performance. The larger the company, the worse results are in inventory turns. This is unique in this industry, and is largely driven by the lack of maturity in supply chain planning, Sales and Operations Planning (S&OP), network design, and value chain analysis.

Table 11. Average Operating Margin by Company Size

Operating Margin for Years 2000-2012		
Industry Segment	Companies between 1-5B in Annual Revenue	Companies Greater than 5B in Revenue
Automotive	.03	.04
Chemical	.08	.10
Consumer Electronics	.03	.03
Consumer Packaged Goods	.11	.13
Contract Manufacturers	.02	.04
Food and Beverage	.08	.05
Hospitals	.09	.14
Mass Retail	.04	.03
Medical Device	.15	.16
Pharmaceuticals	.11	.19
Semiconductors	.03	.04

Table 12. Average Inventory Performance for the Period of 2000-2012

Inventory Turns for Years 2000-2012		
Industry Segment	Companies between 1-5B in Annual Revenue	Companies Greater than 5B in Revenue
Automotive	7.4	7.5
Chemical	5.3	4.6
Consumer Electronics	6.5	6.8
Consumer Packaged Goods	4.1	4.8
Contract Manufacturers	7.6	7.2
Food and Beverage	6.2	11.1
Hospitals	13.3	11.1
Mass Retailers	10.5	7.6
Medical Device	4.7	3.2
Pharmaceuticals	3.6	2.7
Semiconductor	7.6	6.5

Excessive M&A activity can significantly hinder supply chain improvement. The effects of instability during merger activity can often endure for up to three years with uneven financial results.

In some industries, we find economies of scale, but for most, the relationship is weak. Thus, we do not believe a larger company enjoys any inherent advantage over a smaller one when it comes to supply chain improvement. The Supply Chain Index enables us to rank all public companies, regardless of size. In many of the industries we have completed so far, smaller companies with less global footprints have risen to the top.

Who We Admire

When it comes to the healthcare value network, it is hard to not admire the improvements by **Biogen** **Idec Inc** and **Novo Nordisk A/S**. However, based on the rankings, it is clear that there are few spots of light of supply chain excellence in the healthcare industry. It remains an opportunity for all.

Conclusion

The Supply Chain Index is a measurement system to track supply chain performance. When we apply the methodology to the healthcare industry, we find the healthcare value network is significantly behind the consumer value network; and despite rising regulations and reform, no company within any industry has stepped up to lead on a mission towards improved supply chain practices. With increasing complexity, the passage of the Affordable Care Act in the U.S., regulation pressure, and patent cliffs, supply chain will become more important for this value network. It is our hope that the Supply Chain Index enables companies to identify a peer group and measure improvement over a set time period on critical capabilities of balance, strength and resiliency to achieve these important gains to improve healthcare.

Appendix

To measure performance, companies need to compare and benchmark. To make this easier, we developed the Index. In building the Index, we used financial ratios versus absolute numbers. The use of ratios allowed us to compare companies regardless of size, and also compare companies across currencies.

The math behind the Index is defined below. This methodology was built in cooperation with an operations research team and faculty at Arizona State University (ASU) in the spring of 2014.

Balance

To develop the balance factor used in the Index, we evaluated a scatter plot of revenue growth and Return on Invested Capital (ROIC) for a specific company. The balance factor (B) is the proportional difference of points on an orbit chart for the period of 2006-2012 at the intersection of revenue growth and Return on Invested Capital. To calculate the balance factor, let REV_i denote the revenue growth of the i^{th} time period, $ROIC_i$ denote the return on invested capital of the i^{th} time period and n denote the total number of periods under consideration. Thus the balance factor is defined as:

$$B = \frac{1}{n-1} \left(\frac{REV_n - REV_1}{REV_1} + \frac{ROIC_n - ROIC_1}{ROIC_1} \right)$$

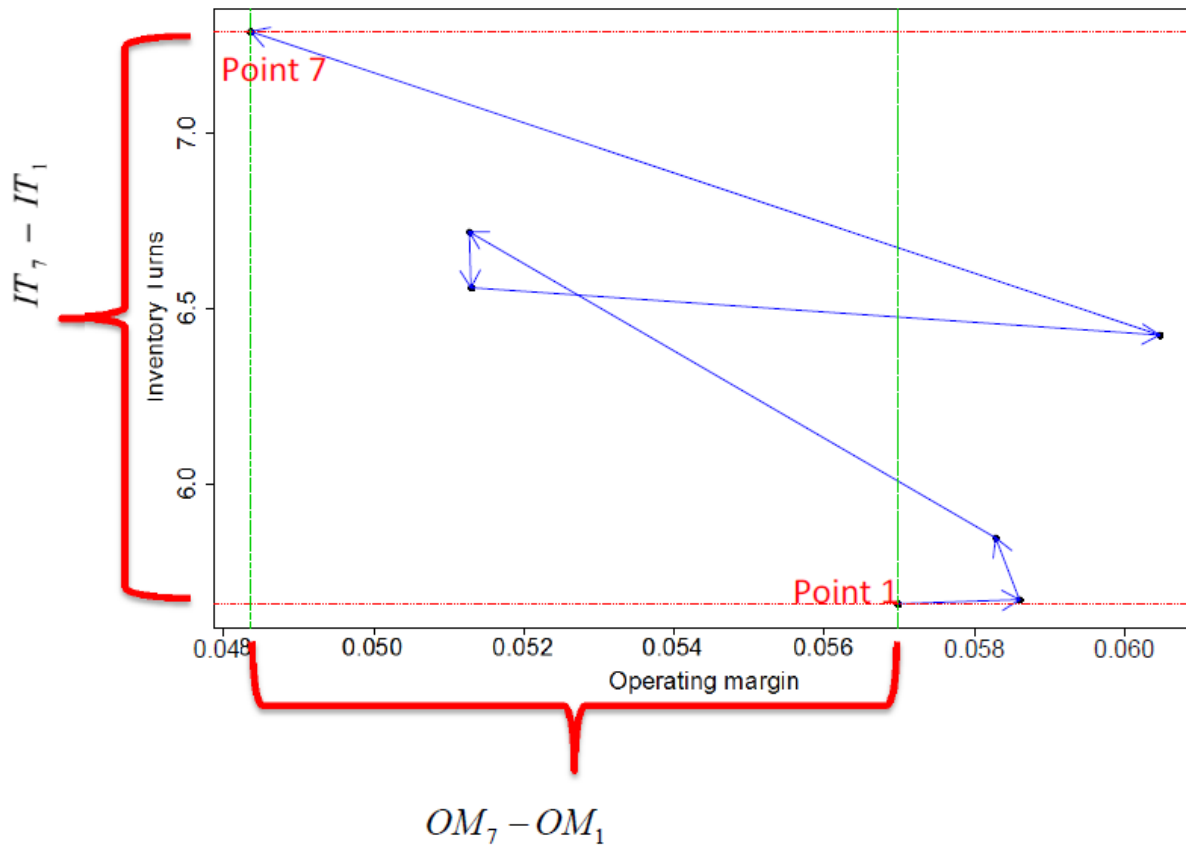
Strength

Strength factor is a similar calculation to the balance factor, but with a focus on the intersection of operating margin and inventory turns. For this analysis, we used a scatter plot of operating margin and inventory turns on an orbit chart for a specific company. Let OM_i denote the operating margin of the i^{th} time period (e.g. i^{th} year), IT_i denote the inventory turns of the i^{th} time period and n denote the total number of periods under consideration. The strength measure (S) is defined as:

$$S = \frac{1}{n-1} \left(\frac{OM_n - OM_1}{OM_1} + \frac{IT_n - IT_1}{IT_1} \right)$$

The denominator reflects that there are $n-1$ differences between n time periods. Figure A depicts the intersection of operating margin and inventory turns for an example company. The difference in operating margin and inventory turns between the first and last time period is shown.

Figure A. Inventory Turns and Operating Margin Intersection for an Example Company



Resiliency

The resiliency factor is a measurement of the tightness of the pattern at the intersection of operating margin and inventory turns for a given company. For companies that did well, and had a tight pattern, the value will be lower than companies that lacked reliability for the period. To develop the value, we considered a scatter plot of operating margin and inventory turns for a specific company. Let d_{ij} denote the Euclidean distance between a pair of points i and j and let m denote the total number of pairs. The resiliency measure (R) is defined as the mean distance of all possible pairs of points at the intersection. That is,

$$R = \frac{1}{m} \sum_i \sum_{j>i} d_{ij}$$

Figure B shows an example of the operating margin and inventory turns intersection for an example company.

Figure B. Calculation of Resiliency at the Intersection of Inventory Turns and Operating Margin for a Given Company

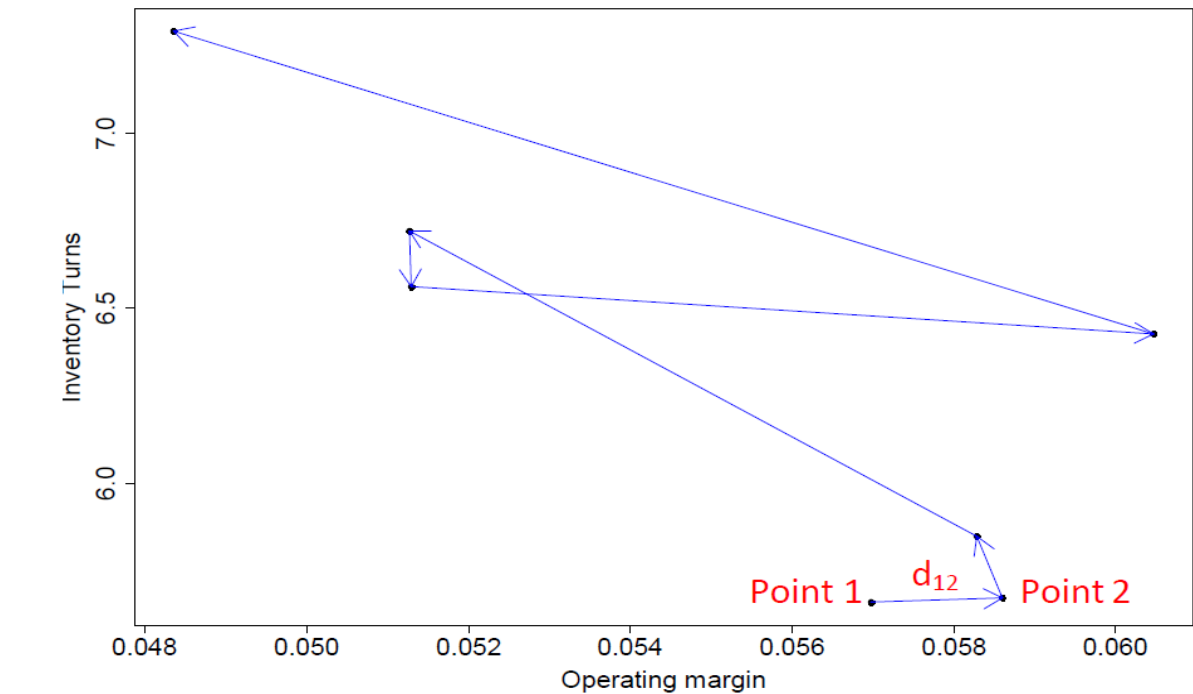


Table A shows the distances between every possible pair of points at the intersection. The resiliency is calculated from the mean of the distance values and is equal to 0.7335.

Table A. Calculation of Euclidean Distances for an Example Company

0.013255					
0.18865	0.17549				
1.061544	1.0484	0.872912			
0.901407	0.888264	0.712778	0.16014		
0.766595	0.753434	0.577946	0.295086	0.135114	
1.630622	1.617476	1.441988	0.569077	0.729216	0.864097

Alternative Measures Considered for Resiliency

To develop the resiliency factor, we considered a number of alternative approaches. One method considered was Principal Components Analysis (PCA). It is a traditional method used to summarize multidimensional data. We considered measures commonly applied with PCA based on eigenvalues and eigenvectors. (e.g., the condition index, percentage of variance explained by the first principal component). Although these measures were reasonable they did not distinguish between orbit plots that were visually different as well as simpler approaches.

We also considered other measures based on the distances (e.g., sum, maximum, minimum and the coefficient of variation of the distances). The mean distance was finally selected to measure the compactness of a set of points. In fact, a similar measure called cohesion is frequently used in cluster analysis to measure the compactness of a set of points. Rather than taking the sum of distances (as in cohesion), we consider the mean to account for the potentially different number of points for each company.

Other Reports About The Index

[Supply Chain Metrics That Matter: Improving Supply Chain Resiliency](#)

Published by Supply Chain Insights in March 2014

[Supply Chain Index: Improving Strength, Balance and Resiliency](#)

Published by Supply Chain Insights in April 2014

[Supply Chain Index: Evaluating the Consumer Value Network](#)

Published by Supply Chain Insights in May 2014

About Supply Chain Insights, LLC

Founded in February, 2012 by Lora Cecere, [Supply Chain Insights LLC](#) is focused on delivering **independent, actionable, and objective advice for supply chain leaders**. If you need to know which practices and technologies make the biggest difference to corporate performance, turn to us. We are a company dedicated to this research. We help you understand supply chain trends, evolving technologies and which metrics matter.

About Lora Cecere



Lora Cecere (twitter ID [@lcecere](#)) is the Founder of [Supply Chain Insights LLC](#) and the author of popular enterprise software blog [Supply Chain Shaman](#) currently read by 5,000 supply chain professionals. She also writes as a LinkedIn Influencer and is a contributor for Forbes. Her book, [Bricks Matter](#), (co-authored with Charlie Chase) published on December 26th, 2012. She is currently working on a second book, *Metrics That Matter*, to publish in 2014.

With over ten years as a research analyst with **AMR Research, Altimeter Group, and Gartner Group** and now as a Founder of Supply Chain Insights, Lora understands supply chain. She has worked with over 600 companies on their supply chain strategy and speaks at over 50 conferences a year on the evolution of supply chain processes and technologies. Her research is designed for the early adopter seeking first mover advantage.

About Abby Mayer



Abby Mayer (twitter ID [@indexgirl](#)), Research Associate is one of the original members of the Supply Chain Insights LLC team. She is also the author of the newly-founded blog, Supply Chain Index. Her supply chain interests include connecting financial performance and supply chain excellence, as well as talent management issues and emerging markets. Abby has a B.A. in International Politics and Economics from Middlebury College and a M.S. in International Supply Chain Management from Plymouth University in the United Kingdom. She has also completed a thru-hike of Vermont's 280 mile Long Trail, the oldest long distance hiking trail in the United States. As part of the planning and food prep process, she became interested in supply chain management when she was asked to predict hunger pangs for the entire three-week trip before departure. If that isn't advanced demand planning, what is?!?!