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SUPPLY CHAIN MANAGEMENT REVIEW

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What's Next?

When I was younger and ready to invest my life savings in the Next Big Thing that couldn't wait, I'd ask my dad what he thought of the idea. He had a standard reply meant to settle me down: "Take a deep breath," he'd say. "No one knows what the future holds." He was right, of course, and thanks to his advice, I may have missed out on a few Big Ideas, but I still have a few bucks in the bank.

As supply chain managers we are challenged year in and year out to figure out new, innovative ways to improve our operations. We have to translate educated guesses about what's next into new investments in our processes. Such may be the case with robotics, 3D printing and additive manufacturing, and investments in new mobile technologies.

Clearly supply chain managers are eyeing all three and wondering if they are, indeed, the Next Big Thing that will deliver a competitive advantage. The stakes are potentially high, according to Scott Sopher, Global Supply Chain Leader of Deloitte Consulting's Supply Chain Practice, and one of the authors of *The 2015 MHI Annual Industry Report: Supply chain innovation—making the impossible possible*. "Only 35 percent of companies are early adopters that expect to deploy these innovations before their competitors," Sopher told me recently. "But by delaying now, a company may be forced by the competition to take action. That may have worked in the past, but in this new environment, I really think the companies that adopt these emerging technologies now may get a sustainable competitive advantage."

Bob Trebilcock, Editorial Director
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To learn more about what's next, *SCMR* asked three experts to weigh in on the state of three disruptive technologies: robotics, additive manufacturing, and mobility. I hope you'll find their reports informative and useful as you think about what's next for your organizations.

To fill out the issue, you'll find two in-depth and thought provoking articles from industry stalwarts Jeff Karrenbauer and Robert J. Trent. Both authors challenge readers to think differently about their supply chains. Karrenbauer, for instance, outlines why too many S&OP initiatives fail and suggests a new way to use network design and optimization tools to achieve the desired results. Meanwhile, Trent explains how managers can take a much broader view of supply chain flexibility to reduce the risks in their operations and improve their resiliency.

After all, as my dad would say, no one knows what the future holds. However, successful planning, including planning for risk, resiliency, and flexibility, can help prepare you for whatever is next.

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BY LARRY LAPIDE

My Year as a Corporate Cassandra

Cassandra suffered from a special curse: She was the Greek prophetess that no one believed—sometimes to his or her detriment. The same can be true for demand forecasters and the sales and operations planning (S&OP) team when they are planning for, or living through, a downturn that no one else sees coming or believes is possible. As the steadfast harbingers of bad news, their mettle will be tested as pressures are brought to change their forecasts. In order to survive, it's important for them to remember that they are indeed partners in setting and helping a company meet its corporate financial objectives.*

The brunt of these pressures largely falls upon the demand forecasting organization because demand forecasts drive supply plans. When, like Cassandra, the forecast is for a significant downward change in business, sales and marketing personnel will deny it could happen; finance will panic about operating margins, and executives will have doubts. I know this because I experienced a tough year during my five-year tenure managing the forecasting organization for the field service division of a Fortune 500 computer manufacturer. While assuming the role of Corporate Cassandra was stressful, it was both my best and worst year in forecasting because it was an important developmental year.

This column gives an account of a period that began with the preliminary revenue forecast for the following year's budgeting process. I use it to discuss lessons learned should forecasters and their S&OP partners experience a similar year that could involve surviving an awkward, unsettling, and politicized environment.

The Best and Worst Forecasting Year

The period was my best because up to that time, my team had a pretty good track record in forecast accuracy. It wasn't difficult because of the nature of computer-service revenues, which are largely predicated on the installed base of contracts. Every year, more than 90 percent of existing contracts renew.**

However, new computer contracts represent a significant portion of revenue growth. Enter the part that made for the worst year. Historically, the division had double-digit percentage revenue growth, so this was the expectation that executives initially had in mind for the next year. Indeed, a slowdown in new computer sales in a year with a healthy double-digit service revenue growth was the harbinger of flat revenues on the horizon. Because service revenues don't typically change that much, our executives were skeptical of the forecasts—just the beginning of the struggles for our forecasting organization. Luckily, because we historically were transparent about the facts, figures, and assumptions incorporated in forecasts, our credibility never wavered throughout the budget process. But, our executives did need to be convinced.

To do so, we spent many weeks working with our finance group delving into greater detail than ever. Our final conclusion was grounded in recent increases in contract back-billing revenue. (A back bill is generated when a piece of contracted equipment retroactively gets put on to a service contract.) The installed revenue base was unchanged because of a slow-down in computer sales that year, yet revenue growth was 15 percent. The lion's share of that growth was attributed to back-bill revenue, and resulted from a field operations program conducted to make sure that contracts were billing accurately for the equipment that was being serviced. We forecasted that revenue growth would not replicate the following year because the program was complete and back-bill revenues had been written-off as

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some customers refused to pay the back-bills.

Once the executives were convinced that revenues would likely be flat the next year, the cost-side of the budgeting process began. In the past, our collaborations with a host of other managers were positive and they were our network of "friends." Unfortunately during the budgetary process, the number of friends in our network dwindled.

Once a flat revenue number was set, everyone recognized that next year's cost budget would shrink and that there would likely be no new hiring, few employees would get salary raises, and layoffs were a possibility. Previously, whenever we bumped into these friends, they would always ask: How are we doing in revenue? After giving them the same bad news a few times, they stopped asking. We had quickly become persona non grata; no one wants to hear from a harbinger of bad news. And company politics reached a new high as many employees tried to prove their worth in order to keep their jobs.

Early the next year, an SVP was brought in from outside to run the division. When briefed on the revenue picture he too was skeptical. The revenue forecast prevailed throughout the year because it turned out to be relatively accurate: Instead of flat growth, revenue actually shrunk by 1 percent—it may have been unsettling, but we were 99 percent accurate. During monthly meetings he was routinely disappointed by the fact that none of the fixes was changing the revenue picture. Despite the accuracy of our forecasts, the SVP harbored concerns about me, as was pointed out during my annual performance review. Eventually, as the year was almost over, I was vindicated. During an executive briefing, the SVP said: "Larry is the only person in the division who will tell me what he really believes."

Lessons Learned

The major forecasting lessons I learned during this stressful year are summarized below.

- **Do Opinion Free Forecasting.** Forecasts must be devoid of opinion—especially during a downturn. There is much wishful thinking from others brought into a forecasting process during tough times. Fight the urge to go along and base forecasts solely on the facts, figures, and assumptions used as input to your forecasting models. Position the forecast numbers as "innocent until proven guilty." The forecast is incorrect if it can be proved that some of the facts, figures, and assumptions are incorrect. If that turns out to be the case, then (and only then) updated forecast numbers should be generated using the correct data.
- **Provide an Estimate of Forecast Accuracy.** Because all forecasts are fraught with unavoidable errors, an estimate of error (such as a confidence range) should accompany forecasts. This is important so that planners can use the estimates to mitigate risks associated with the uncertainties. In addition, it might placate those naysayers whose forecast opinions are consistent with the uncertainties (such as when their opinions fall within the confidence range provided).
- **Be Professional.** Successful forecasting organizations are those that are the most credible—not necessarily the most accurate. A history of credibility can go a long way toward getting through the most difficult of times. This mostly comes from acting in a professional manner: Executives need to believe that no one inside or outside of the company could do a better forecasting job. Basically, the executive team needs to fully trust the organization and believe, such as the SVP finally believed about me, that the forecasting organization will tell executives even an ugly truth.

A forecasting organization should always be viewed as unbiased, unemotional, and having no hidden agendas.

- **Stay out of Politics.** A forecasting organization should always be viewed as unbiased, unemotional, and having no hidden agendas. Forecasters should always be viewed as "wearing their corporate hats" and not siding with one side or the other when it comes to forecasting. While some political people might appear to thrive for a short period of time, these people come and go depending upon which corporate regime is in place. Generally, a "trusted politician" is an oxymoron.

While I learned these lessons as a forecaster, they are also valuable for S&OP planners charged with developing accurate supply-demand plans. Additionally, because planners are partnered with the forecasting organization, they should not be throwing forecasters "under the bus" when the going gets rough. There was no S&OP team in place during my forecasting tenure. I wish there had been; a Corporate Cassandra needs people to lean on during a difficult year.

* In *Navigating a Course with Planning and Forecasting*, my Insights column from the May/June 2014 issue of *Supply Chain Management Review*, I advocated for having an unbiased and professionally run forecasting organization responsible for generating the demand forecasts used by the S&OP team, yet independent of it.

** See my May/June 2012 Insights column, *Installed-based Supply Planning*, to read about the method used to accurately forecast service revenues.

Disruptive Innovation in the Classroom

By Chris Caplice

Chris Caplice, Ph.D., is Executive Director of the MIT Center for Transportation & Logistics. He can be reached at caplice@mit.edu.

A new platform for education might not figure in your top 10 list of supply chain innovations, but the arrival of the MOOC (Massive Open Online Course) is a transformative disruption in educational terms and a significant step in the industry's efforts to meet the demand for talent.

The MIT Center for Transportation & Logistics (MIT CTL) recently completed the first MOOC in our planned three-course, online supply chain management certificate. This experience provided some important lessons about the design and application of MOOCs.

Disrupting Influence

The college education industry has not changed its product for more than 100 years. The basic format of a lecturer teaching to a room full of students has remained more or less the same. Yet the cost of a college education has gone up 146 percent in real terms since 1984. The average cost of a private college education is currently around $34,000; in 1984 it was $14,000 (in 2014 dollars).

Enter the MOOC: a disruptive technology forcing change. At MIT, the advent and availability of a MOOC made us step back and readdress our core educational mission and methods.

At the base of it, there are just three steps to learning: Someone explains the concept, the student practices, and the student receives feedback.

The traditional vehicle for this process is the classroom. At the college level, an instructor typically lectures for 90 minutes to a class, and tends to align the pace of the lecture to the number of nodding heads, that is the individuals who appear to get it. Practice is done via homework, which is assigned and returned with feedback.

A refinement of this process that has become popular over the last decade or so is active learning, where 90-minute sessions are chopped into smaller segments. The same basic process of explain/practice/give feedback applies, but in a more modular and highly interactive format. Students receive feedback more quickly and the learning experience is more immediate.

What is a MOOC?

Online learning turns both the traditional and active learning methods on their heads. The idea is not new. For example, MIT inaugurated its free OpenCourseWare program in 2001 that offers MIT classes online and has attracted some 125 million visitors since it started.

The MOOC, which is less than a decade old, differs from these established online offerings in a number of key ways. These characteristics also enable the new platform to overcome many of the fundamental drawbacks that come with traditional, classroom-based education. MOOC programs are interactive. The backbone of the platform is the video. The videos can be talking heads, blackboard-type shots, or live action shots. Importantly, they can be downloaded along with the transcript (very important for non-English speaking students), and students can alter the speed at which the videos are delivered. This means that individuals can learn at their own pace; a critical step forward in education.

Also critically important is that the MOOC contains interactive problems. These can be multiple choice or more involved problems, but in every case students get instant feedback on their performance—a major distinction from the OCW program. Similarly, the teacher gets instant feedback on how well each student is doing.

Online discussion forums complement and enrich this feedback and help to engender a sense of community.

The MIT CTL Offering

MIT CTL launched MIT's first supply chain MOOC, CTL.SC1x, on September 29th 2014.

CTL.SC1x is the first of three courses that are being developed as part of an MIT XSeries in Supply Chain Management. The courses are intended, but not required, to be taken in sequence, as follows.

• *CTL.SC1x–Supply Chain and Logistics Fundamentals.* This first course is a survey of the fundamental analytic tools, approaches, and techniques used in the design and operation of logistics systems and integrated supply chains.

• *CTL.SC2x–Supply Chain Design.* The second course builds off of the concepts taught in SC1x and applies them to supply chain design. There is a greater focus on more complex and in-depth problems.

• *CTL.SC3x Supply Chain Strategy.* The final course in the series extends the supply chain concepts previously covered and demonstrates how they affect and influence business strategy.

The first course was completed in late December 2014, and almost 30,000 students from 186 countries signed up for the 11-week program.

MOOCs are bringing long overdue change to education. But, a lot more work needs to be done before we can fully realize the benefits of this disruptive innovation.

The largest share of students came from the U.S. (20 percent), India (12 percent), and Brazil (4 percent), followed by the United Kingdom, Spain, Canada, Mexico, and Germany. Some 2,600 students in Africa and 1,700 in the Middle East signed up. The median age of students was 30, with about half of the total population falling in the 26 to 40 age group. Most of the students, about 75 percent, were male, and the majority were educated to bachelor's or master's degree levels.

Of course, just recruiting this huge number of individuals to the program does not guarantee that they will actively participate, and most of the recruits chose not to do any course work. Initially about 12,000 students actively participated, whether that entailed watching a video or completing a problem. As the program progressed this number declined to about one-third of the total population.

Despite the steep fall off in the number of actively engaged students, this first installment of our supply chain MOOC was very successful. A total of 2,200 certificates were awarded to graduates, much smaller than the number who joined, but equivalent to 28 years of classes at MIT, assuming the average traditional classroom contains 70 to 80 students.

How well did the MOOC students do, keeping in mind that the course problems they were given were very similar to those that our classroom-based students tackle? Of those who completed all 11 weeks, the average grade was 84 percent across all home works. That is a solid B—on par with the performance of traditional classes.

What Have We Learned?

The first MOOC provided many lessons both on personal and industry levels. First, MOOCs help MIT fulfill our long-standing mission to "educate the world for free." However, individuals who want some type of credential such as a formal certificate signed and sealed by MIT should, in my opinion, cover the institution's costs. One of the main challenges facing MOOCs is developing a viable business model for these programs. Up until now MIT has devoted resources—and they are considerable because creating a MOOC requires huge amounts of faculty time—without recouping the costs. We need to clarify the cost structure in order to put MOOCs on a firmer footing.

A critical lesson is that MOOCs will not replace conventional, campus-based education, but will complement it. In fact, this is already happening. MIT CTL is using material from our supply chain MOOC in our Supply Chain Management master's classes. Our master's students find that the MOOC videos reinforce their classroom learning.

In addition, the traditional model offers features that are not available in a MOOC class. Socratic learning, which relies on real-time discussion and commentary from students, is a powerful teaching method that will continue to be important. But it's almost impossible to replicate the Socratic experience in an online environment. Another advantage of campus-based learning is that instructors can adjust a class midstream if necessary. But once a MOOC video is created and released, it is essentially cast in stone.

An extremely encouraging lesson is that MOOCs offer companies another training option that is centralized and consistent. Moreover, the platform can be customized and, once created, is relatively cheap to operate.

Even more encouraging from an industry perspective is that this first MOOC revealed huge interest in supply chain management across the globe. The number of people who signed up for our inaugural program and its geographic reach are testament to the thirst for supply chain education. Another strong indicator is that the program, which ended months ago, continues to attract about 250 to 300 students per week completing the practice problems and watching the archived videos. To help meet this pent-up demand, we are planning to re-launch CTL.SC1x this summer.

MOOCs are bringing long overdue change to education. But, a lot more work needs to be done before we can fully realize the benefits of this disruptive innovation.

Patrick Burnson is the executive editor at *Supply Chain Management Review.* He welcomes comments on his columns at pburnson@peerlessmedia.com

BY PATRICK BURNSON

New Supply Chain Risk Index Shows Significant Geographic Shift

If the U.S. trade embargo with Cuba is finally lifted, risk mitigation experts will have one more new wrinkle to evaluate in the global supply chain.

The United States' effort to remove Cuba from the list of states that sponsor terrorism is a limited but significant step likely to lead to the reopening of embassies, say trade analysts. But the overall engagement will still be limited by the U.S. embargo. Risk management experts are tracking the issue closely.

Air cargo carriers are likely to increasingly request permission to start scheduled services, and agricultural exporters are seeking greater flexibility to obtain credits, analysts say. These gradual measures can also present a more favorable outlook for Cuba's newly developed super-container port of Mariel and the special economic zone that is to open around it.

"This is a limited but significant step that will move the bilateral relations toward appointing top-level diplomatic representation in each country by reopening embassies, but will still be limited by the U.S. embargo," says Diego Moya-Ocampos, a senior analyst with IHS Global Insight.

The U.S. embargo on Cuba was imposed in 1960 and intensified in 1962 following Cuba's nationalization of U.S. citizens' and corporations' assets, in the hopes that it would accelerate the fall of the Castro brothers' Communist government, now in power for 56 years, or lead to a process of democratization.

In terms of regional trade, Cuba's removal will have almost no implications, as the majority of Cuba's partners in the Latin America and Caribbean region are already openly doing business with Cuba.

"However it will moderately benefit trade and investment—especially with U.S., Western, and transnational companies—in the agriculture, sugar, financial services, and transport and tourist sectors in the three-year outlook, although only in the extent that these activities are not restricted by the U.S. embargo," IHS concludes.

Present Levels of Global Risk

Ukraine, roiled by conflict with neighboring Russia, poses significant challenges for companies considering expanding their supply chains there. So does Thailand despite the years that have passed since the popular manufacturing destination's devastating floods.

Exactly what risk do these countries present? Their vulnerabilities, as well as those of many other countries, are quantified in the definitive ranking of supply chain resilience around the world, the 2015 FM Global Resilience Index.

Ukraine fell 31 places in this year's FM Global Resilience Index to 107th, the biggest year-over-year fall in the rankings, owing directly to Russian military intervention there.

Thailand, one of the world's top exporters, fell 20 places to 82nd of 130. In particular, the ranking reflects poorer perceptions of the country's infrastructure and the quality of local suppliers as well as a decline in political stability and the quality of fire risk management. These matters compound the misery from the country's 2011 floods that wreaked an estimated $45 billion in losses and business disruption worldwide.

The Republic of Korea—often deemed one of the most dynamic "Asian Tigers"—is ranked 70th, hindered significantly by its exposure to natural hazards, and by its relatively low ability

to respond effectively to them.

There was good news, however, for Taiwan. It soared 52 places in the annual rankings to 37th overall, a bigger rise than any other country. Its ascension is mainly due to a substantial improvement in the country's commitment to risk management, both natural disaster and fires.

Updated annually by commercial property insurer FM Global, the data-driven 2015 FM Global Resilience Index gauges resilience (the flipside of risk) along nine dimensions. The Index compiles vetted data from sources such as the International Monetary Fund, World Bank, World Economic Forum, and FM Global's database of more than 100,000 client locations. Countries and territories examined are ranked from most to least resilient.

Not surprisingly, Norway is ranked first in the Index as the country best suited for companies seeking to avoid disruptions in their global supply chain operations. The three regions of the United States—East, Central, and West—all rank in the top 25.

"C-Suite" Concern

The London-based analytics and advisory firm Oxford Metrica compiles the information for FM Global. According to Dr. Deborah Pretty, principal at Oxford Metrica, the index provides a unique and compelling look at how 130 countries/territories stand up to disruption.

"CEOs, CFOs, and other decision makers can now make informed investments knowing the vulnerability of these countries to supply chain disruption and their ability to recover," she adds. Pretty notes that this is the second time her firm has helped FM Global with the research.

"In the past this information may have been directed to a company's supply chain manager, but now we see the data moving up the chain to the C-suite," she says. "We suspect this information will also be used to determine how much insurance may be needed to cover exposure in nation's with a multiple risk profile."

Linda Conrad, head of Strategic Business Risk at Zurich Insurance, concurs, noting that multinational decision makers have taken a new interest in examining the added danger of adding multiple tiers of suppliers.

"Over 40 percent of supply chain disruptions occur at the sub-tier level," she observes. "Executives at every level are now making sure that they can measure and anticipate contingent business interruptions."

And while Cuba has yet to be included in the FM Global index, analysts warn that Venezuela—currently its closest trading partner—is ranked last on the list of the 130 countries and territories listed.

EXHIBIT 1

The Top 10 in 2015

	Factors							
	Composite		Economic		Risk Quality		Supply Chain	
Country/Region	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Norway	1	100.0	2	97.8	9	77.2	13	84.4
Switzerland	2	94.9	3	93.2	100	49.9	1	100.0
Netherlands	3	93.3	14	70.9	5	81.2	3	92.4
Ireland	4	92.7	11	73.9	1	100.0	25	73.3
Luxembourg	5	91.7	1	100.0	84	50.5	10	86.4
Germany	6	91.1	12	72.2	12	75.4	5	91.4
Qatar	7	90.7	4	89.6	15	73.7	24	75.5
Canada	8	90.1	15	68.6	2	87.0	16	83.3
Finland	9	88.8	9	77.1	35	62.7	4	92.0
United States Region 3	10	88.3	17	67.7	3	86.0	19	81.2

Source: Oxford Metrica/FM Global

EXHIBIT 2

The Bottom 10 in 2015

	Factors							
	Composite		Economic		Risk Quality		Supply Chain	
Country/Region	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Tajikistan	121	25.0	113	24.2	111	33.6	99	31.1
Egypt	122	22.9	125	11.8	73	51.6	110	24.1
Pakistan	123	22.2	128	7.7	76	51.4	105	26.7
Jamaica	124	21.8	126	8.8	116	30.3	71	41.7
Honduras	125	21.7	121	19.3	116	30.3	97	31.6
Dominican Republic	126	19.0	74	36.6	130	0.0	90	33.9
Nicaragua	127	18.8	117	22.5	116	30.3	116	22.6
Mauritania	128	15.2	129	2.7	37	61.7	129	8.4
Kyrgyz Republic	129	10.7	130	0.0	111	33.6	111	24.0
Venezuela	130	0.0	127	8.1	127	14.4	128	9.3

Source: Oxford Metrica/FM Global

Advancing the Cause of Supply Chain Management *and* Sales and Operations Planning *Through* Advanced Analytics

Organizations have talked about integrated business processes for decades, but most of us still operate in silos. The result is inefficient supply chains and disappointing results from S&OP. To realize the promise of SCM and S&OP, organizations need to apply new analytic tools and a network view of the supply chain.

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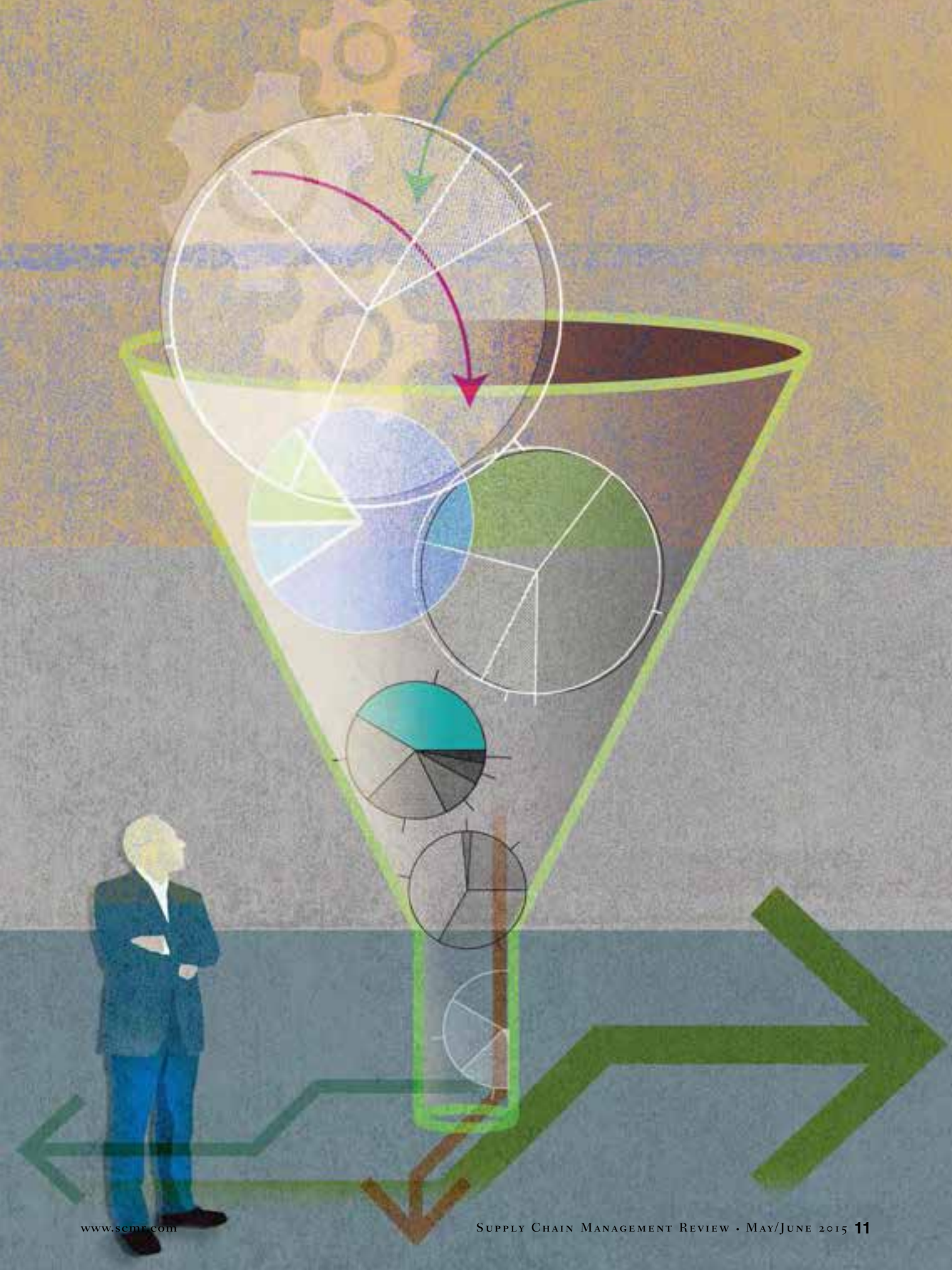
By Jeff Karrenbauer

Supply Chain Management. The words are a freely exchanged coin of the realm. The promise is considerable: an overarching discipline that incorporates all of operations, finance, customers, suppliers, and even research and development as well as critical aspects of sales and marketing into a single scope that ultimately focuses on maximizing the financial performance of the firm. Yet after over 50 years of evolutionary development, reality has fallen well short of expectations: Cross-functional integration is impeded by corporate organizational structures, culture, and inappropriate performance metrics.

Certain processes and tools, most notably sales and operations planning (S&OP), have been developed to address such shortcomings. Yet these have often failed to live up to their promise as well, often due to inadequate decision support technology. This results in substantial expenditures of time and money with little of substance to show for the effort. So, are SCM and S&OP misguided and overrated? Or, is it a matter of not having the right analytics tools and implementation processes?

Those are questions we will explore in depth over the following pages. Before that, let's be clear at the outset what this article is *not* about. First, it is not a primer on either SCM or S&OP. That territory has already been mapped by others. Rather, we assume that the reader has a working knowledge of both subjects. It is also *not* a comprehensive presentation of analytics—advanced or otherwise.

We do so to set the stage for how the causes of SCM and S&OP have been hampered by a silo management mentality and how they can progress by means of advanced analytics. We then extend S&OP to a level beyond even Integrated Business Planning (IBP) by using an extension of the same analytics.



Sales & Operations Planning

Let's begin by setting a baseline for S&OP. Definitions abound; here is a representative one published in *Supply Chain Digest* from Wallace and Stahl:

> ***A set of decision-making processes to balance demand and supply, to integrate financial and operational planning, and to link high level strategic plans with day-to-day operations.***

From such concepts has grown an immense literature about the S&OP process, typically presented as a series of steps that might include:

- Data gathering.
- Demand planning that assesses historical accuracy and generates collaborative (cross-functional and customer input) forecasts.
- Supply planning, to assess historical accuracy, determine capabilities (procurement, manufacturing, logistics), and develop feasible plans to synchronize supply and demand.
- Working group meetings that identify conflicts and propose resolutions, assess those plans against corporate strategy and financial goals, and set the agenda for the executive meeting.
- Executive meetings where recommendations are reviewed, conflicts are resolved, plans are assessed against strategies and goals, and a plan is approved and issued.

Some authorities argue for seven, nine, or even 10 steps in the process. Our advice: Pick a representative set that is relevant to your organization and focus on implementation.

The above and related literature demonstrates that S&OP is fundamentally a cross-functional process that seeks to balance—or synchronize—supply and demand. If only it were as simple to implement as it is to describe.

Evolution of Supply Chain Management

Before we move forward, it's helpful to take a quick trip down memory lane to examine the evolution of supply chain management, with particular emphasis on aspects of cross-functional integration critical to successful implementation of S&OP. A convenient starting point is the 1960s, a decade that saw the first real studies dedicated to the study of physical distribution management, as well as the founding of the National Council of Physical Distribution Management (NCPDM), a precursor to the current Council of Supply Chain Management Professionals (CSCMP).

The focus was squarely on the distribution of finished goods or the flow of product from the end of the production line to the customer. Procurement and manufacturing were separate areas of expertise, more or less divorced from each other and certainly from distribution. Worse yet, finished goods distribution was really a disparate set of responsibilities spread throughout the organization with no single manager in charge. The result was separate silos for procurement and manufacturing, and well, a rather disorganized mess.

Around this time a few lonely voices suggested a better way. One of the most prominent was Dr. Bernard J. (Bud) LaLonde, now a Professor Emeritus at The Ohio State University, who prepared the diagram shown in Exhibit 1. Procurement and manufacturing were shown together as materials management and the aforementioned disparate functions were collectively labeled physical distribution management. But the remarkably prescient conceptual breakthrough was the bottom line: The whole thing, indeed all of operations, was collectively called "business logistics." The implication was clear: It should all be managed within a single scope of responsibility.

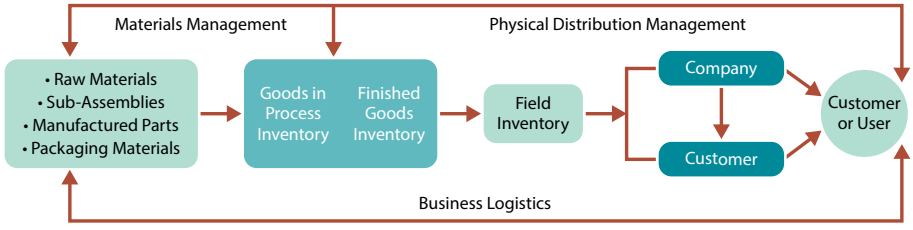
Predictably, community resistance was fierce. No vice presidents worth their well-honed turf protection skills would willingly cede their domains to an upstart overarching discipline. Any logistician who suggested otherwise would be unceremoniously sent to their silo penalty box, such as it was. And truth be told, few logisticians shared this integrated view, anyway. The 1970s saw some genuine improvement. The disparate functions within physical distribution were gradually organized under a single manager—only rarely a vice president. However, as shown in Exhibit 2, silo management was still firmly entrenched: We now had three silos instead of two. The fundamental driver was considered truly breakthrough at the time: The total cost concept stated that what mattered was the sum of all physical distribution costs, not the cost of any one activity. One made improvements by identifying cost tradeoffs across functions but within the silo. This basic application of a bottom line perspective may seem quaint in retrospect but it was a major focus of professionals in the 1970s and is still valid today.

By the 1980s there was renewed interest, at least in academic circles, in the larger notion of cross-functional integration. NCPDM was renamed the Council of Logistics Management (CLM) in 1985 and their corresponding definition of logistics encompassed all commodity and related information flows. Similarly, faculty members of Michigan State University presented the results of an important study that identified the attributes of leading edge firms in logistics. One of them consisted of subsuming the silos shown in Exhibit 3 under a single line-level vice president. The researchers called this "integrated logistics management," an idea consistent with LaLonde's notion of business logistics developed two decades earlier.

Remarkably, it has been the author's experience over the past 40 years that silo management still reigns supreme.

EXHIBIT 1

1963-Business Logistics Management (OSU)



Source: Professor Bernard J. LaLonde, The Ohio State University, 1963; used with permission

To wit:

- At numerous professional conference presentations, informal show-of-hand surveys reveal that only a tiny fraction of a given audience hails from firms where a single line-level executive has responsibility for procurement, manufacturing, and finished goods distribution.
- What's more, in our experience, many industry leaders strictly limit the scope of the analysis to finished goods distribution, despite our strenuous objections. This even in light of world-wide supply chains, where matters such as the location, mission, costs, and capacity limits of procurement and manufacturing are critical to overall supply chain design and operation, not to mention related issues such as duties, taxes, customs and brokerage fees, intellectual property theft, vulnerability, and so on. That is, the conventional silos are inextricably intertwined. Nevertheless, it has not yet migrated into most organization charts, operating procedures, or analytic scopes.
- And we have not yet discussed the stretch goal beyond operations: the integration of operations with sales and marketing. Is that even possible? More on that later.

But wait, you protest. What about supply chain management? Doesn't it imply a single scope of responsibility across the entire supply chain? Well, yes, at least in theory. The term first appeared in the early 1980s and finally gained traction in the mid-1990s and beyond. Yet the silos from the 1970s largely persist. The organizational structure, metrics, and analytical tools impede progress. We talk much more than we walk.

One of the more sophisticated notions of SCM has been developed by members of The Global Supply Chain Forum sponsored by The Ohio State University:

…the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders.

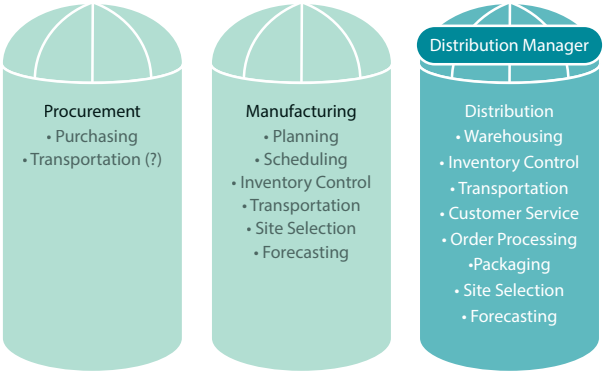
They go on to develop in detail eight such processes:

- customer relationship management;
- customer service management;
- demand management;
- order fulfillment;
- manufacturing flow management;
- supplier relationship management;
- product development and commercialization; and
- returns management.

And they do mean cross-functional. In this view, representatives from procurement, manufacturing, logistics, R&D, sales and marketing, and finance form actual teams for each process that set strategic objectives and operational responsibilities. In short, they establish the

EXHIBIT 2

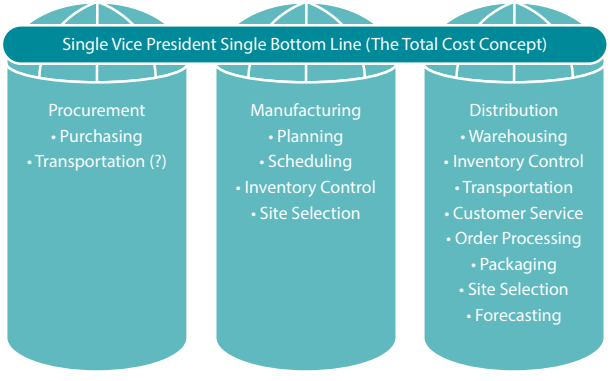
The 1970s-Era of Functional Integration



Source: Insight, Inc.

EXHIBIT 3

The 1980s-Era of Integrated Logistics



Source: Insight, Inc.

imperative and the procedures for collaboration across functions, and they tie the results to corporate financial goals. And, by means of customer relationship management and supplier relationship management, they include members of the supply chain that are outside traditional organizational boundaries. So, here is our bottom line with respect to SCM evolution:

• SCM prescribes cross-functional integration; however, theory has far outstripped practice.

• We do not lack for the bandwagon effect. No self-respecting professional, whether practitioner, academic, or consultant, would fail to utter the words "supply chain" when describing their role. In reality, however, we practice silo management.

• There are underlying organizational impediments to the successful implementation of any inherently cross-functional process such as S&OP. In particular, rare is the presence of an executive with the requisite line authority to mandate compliance across all of operations.

Regrettably, due to space limitations we must mention only in passing an additional major impediment and a critical topic in its own right: the metrics chosen to establish goals and measure supply chain performance.

Seen in this light, the unsatisfactory results of many S&OP efforts are more understandable. Yet we need S&OP, or its equivalent, to bridge these divides. Can it be implemented to meet the challenge?

Strategic Supply Chain (Network) Design Advanced Analytics Tool

Most readers probably have at least an informal understanding of an optimization-based strategic supply chain (network) design tool. But because numerous misconceptions persist, we provide a summary of the salient details.

Exhibit 4, on page 16, shows a simplified schematic of an international supply chain (the ships represent ports). Obviously, this is but one example of a large number of variations that may, for example, include other types of locations (pool points, cross docks, rail heads, and so on) and other transportation links (for example, plant direct to customer). To avoid clutter we also do not show alternative customer channels (such as omni-channel) and various types of commodities. The latter may include raw materials, intermediate products, and finished products.

An important extension, one critical to S&OP, is to build a multi-period network model. In this instance, one partitions customer demand into time "buckets" such as months. Other volume-related inputs such as capacities are similarly defined. The model has simultaneous visibility across the entire planning horizon. In particular, inventory can be passed from one period to another, thereby enabling seasonal pre-build analyses.

Using Exhibit 4 as a guide, we summarize the inputs, both mandatory and optional:

Network Description
- commodities
- raw materials
- work intermediate products (WIP)
- finished products (typically aggregated from SKU level)
- locations
  - raw material suppliers
  - plants/vendors/co-packers
    - drill-down to lines/processes
  - DCs/pools/cross-docks/ports
    - drill-down to lines/processes
  - customers (typically aggregated from ship-to level)
- Other
  - customer channels
  - time periods

• Customer Demands
- table by customer/channel/finished product/time period

• Transportation Costs
- inbound (supplier to plant)
- transfer (between facilities)
- outbound (to customer)

• Facility Data (mostly optional)
- mission data (eligibility of commodities at a given location)
- procurement costs, capacities, and violation penalties
- manufacturing costs, capacities, and violation penalties
- DC location costs, capacities, and violation penalties
- bills of material
- inventory targets and holding costs
- stock open/close options

• Other (optional)
- duties, taxes, currency conversions
- selling prices (needed for profit max studies)
- customer service limits
- data scaling options
- energy usage and carbon emission factors/constraints

Following are several pertinent observations:

• Notice that the list is consistent with the operating characteristics of a complete manufacturing supply chain. No aspect of operations has been omitted.

• While virtually all of the facility data is technically optional, their omission would cripple the application

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of this technology to S&OP. This is the time to go deep with respect to these inputs. In particular, one must pay attention to capacities such as procurement, manufacturing, throughput, and storage.

• The more accurate the operating costs the better. In particular, while activity-based costing values are not essential, they serve as a welcome improvement to the meaningless financial averages too often used as shortcuts.

The model is formulated as a mathematical optimization problem, more specifically one that requires a mixed integer linear programming algorithm to solve.

The challenge is to find the set of facilities and transportation links and associated product flows that either minimizes total costs or maximizes total profit, subject to the following restrictions and constraints:

- procurement contractual limits;
- manufacturing capacity limits;
- DC throughput limits;
- storage limits;
- inventory targets;
- customer service limits;
- other transportation link restrictions;
- energy consumption limits; and
- carbon emission limits.

S&OP, SCM, and Advanced Analytics

Despite theory, expert consultants, and best intentions, let's see how S&OP too often evolves in practice:

• Sales and marketing come to the meeting armed with spreadsheets containing their latest forecast.

• Manufacturing sits down with the latest capacity numbers, also in (you guessed it) spreadsheets.

• Manufacturing professes to be appalled by the implications of the forecast and once again concludes that sales and marketing haven't a clue about the real world of operations.

• Marketing responds that their aim is to maximize corporate revenue by satisfying customer requirements.

• Both parties argue, compromise, adjust respective spreadsheet numbers, and with sighs of relief all around, agree on a plan to present to senior management. No one knows how much money has been left on the table and there is no way to find out—the problem seems overwhelmingly complex. Finding something that at least works is deemed an acceptable outcome.

• No one leaves satisfied, all believe that there must be a better way, and resentment toward S&OP builds.

Little wonder that in too many instances, the S&OP process is consigned to the trash heap of promising ideas that ultimately fell short of expectations.

Let's unpack the typical process just a bit to understand some of the reasons why it fails:

• Sales and marketing typically develop the forecast. Wrong. SCM principles tell us that every process must be fully cross-functional. All of the principal functions must participate in developing this critical input, including sales and marketing, procurement, manufacturing, logistics, finance, important customers, and so on.

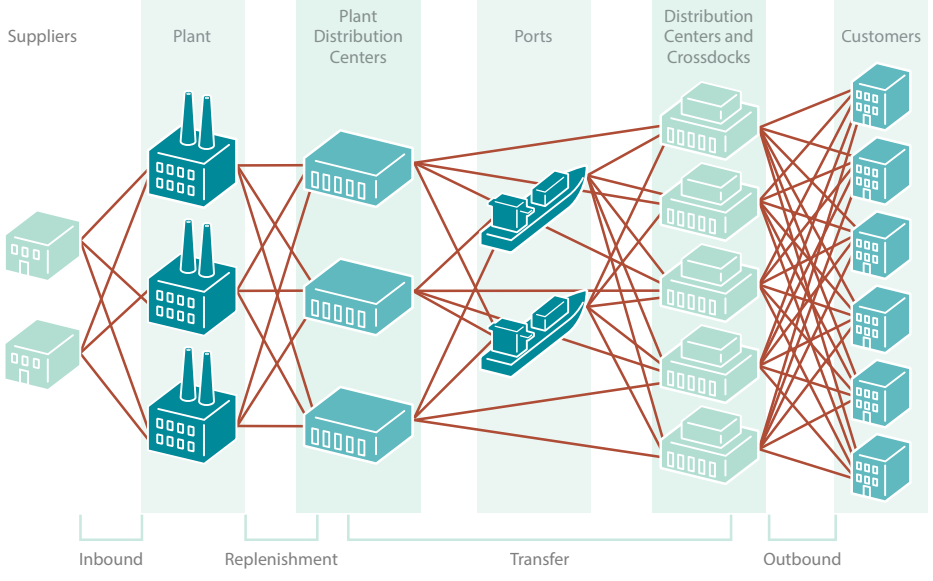
• The synchronization scope is often limited to manufacturing. Wrong again. SCM principles tell us that it should span the entire supply chain.

• The methodology used to establish the synchronization is almost always remarkably ill-suited to the challenge, typically what has been accurately dubbed by an experienced participant as "warring spreadsheets."

These are important limitations. Perhaps the

EXHIBIT 4

Supply Chain: Comprehensive Scope



Source: Insight, Inc.

most disappointing is the utter lack of appropriate analytics to address synchronization.

Network Design: There Must Be a Better Way

So what can be done to improve the shortcoming of the analytics? Consider the strategic supply chain design tool. Once again you protest: Isn't that the stuff used for facility location studies? In one sense, yes. Supply chain design tools were originally developed to address facility location questions; to this day, that is a very common application. However, their contemporary scope is much more extensive, as illustrated by the following list:

- the number and location of raw material suppliers, plants/vendors/co-packers, production lines/processes, and DCs, pools, cross-docks, and ports;
- transportation links and flows, including inbound from suppliers to plants, transfers between facilities, and outbound to DCs and to customers;
- facility ownership issues, including owned, leased, public, and 3PL facilities, and outsourcing;
- facility mission issues, such as commodities procured, manufactured, distributed per location, and costs and capacities; and
- business decision/policy issues, such as strategic sourcing, customer profitability (cost-to-serve), S&OP, supply chain/marketing integration, and energy/carbon footprint/sustainability.

Notice the mix of issues traditionally considered as strategic with those regarded as tactical, the latter including S&OP, master capacity planning, and seasonal demand/supply. So how do we persuade a strategic network design tool to support the tactical world of S&OP? Consider the following approach:

- Build a truly comprehensive, multi-period model of the supply chain, from raw material acquisition to final customer demand. Specify a suitable period.
- Freeze all customer assignments to pre-determined customer facing locations.
- Use forecasted demands for the relevant planning horizon (typically 12 to 18 months).
- Lock down the facility locations but not the facility volumes or inter-facility transportation flows. Note: At least some open/close decisions at the production line level are typically left to the discretion of the model.
- Run the model.

What, then, is the moral of story? One need not do a "wide-open," full-scale network optimization whenever using such a tool. Rather, one can pre-specify components of the network. In this instance, one could pre-specify customer assignments and the open/close status of facilities and still leverage the tool's considerable power, most especially its ability to adjudicate limited capacities. This is much more realistic in the short term; one does not redesign a supply chain on a monthly basis. In fact, numerous authorities recommend a redesign analysis at least annually. This contrasts favorably with the practice of many firms to re-examine this issue every three to five years, or longer.

So what do you get for your trouble? For starters, all of the following, reported by period and commodity:

- raw material requirements by supplier;
- production volumes by location and line/process;
- storage requirements by location;
- throughput volumes by location;
- inventory carryover;
- transportation flows by lane;
- total costs;
- capacity utilization analysis (including violations); and
- energy and carbon audits.

Notice that this is precisely what we want from the supply/demand synchronization step in the S&OP process and, in most cases, is far more extensive than what most S&OP processes can deliver. Moreover, it uses truly advanced analytics (optimization), which is the only type of analytics, advanced or otherwise, capable of properly addressing two issues inherent to S&OP: the necessity to allocate limited raw material, manufacturing, and storage resources (capacity limits); and open/close decisions by production line and shift.

We repeat: These mathematically and managerially complex issues cannot be properly addressed by heuristics, expert systems, simulation or, worst of all, spreadsheets. The real irony here is that the above is a classic example of a problem that has been extensively studied for decades in the operations research community and is very well understood. So, what have we typically done with this body of knowledge? We have thrown it out in favor of simplistic spreadsheet wars that are virtually guaranteed to produce substandard results.

A critical benefit: At least with respect to cost minimization, the problem of leaving money on the table disappears. Optimization eliminates the guesswork, the compromises, and the myopic search for something that works. It deals with the apparently daunting complexities head-on, without restriction.

The next time someone approaches you with a proposed S&OP process, drill down hard on the details. Be especially wary of the supply-demand synchronization step. Do not accept the response: "We use analytics." It is a catchall buzzword that can mean anything from basic descriptive statistics through predictive approaches to truly advanced prescriptive tools and a whole host of options in between. And spreadsheets are unquestionably

the most overused analytics tool in existence ("when all you have is a hammer…..").

One final methodological note: There is nothing to prevent one from developing a special purpose, optimization-based package to address a given S&OP problem. And in certain specialized instances with many idiosyncratic details, that is the correct approach. But custom applications are time consuming and expensive to develop, certify, maintain, and support. It is far better to use readily available tools where possible.

Major Extension: Integrating Supply Chain and Sales & Marketing

Let's go back to the evolution of SCM for a moment. Most definitions, and virtually all practitioners, focus on traditional operations, however partitioned they are into silos. The closest one comes to integrating sales and marketing with operations lies with approaches such as those advocated by the Supply Chain Forum discussed above, wherein customer relationship management, customer service management, and demand management are explicitly recognized by other authorities as cross-functional business processes.

So, too, for advanced analytical tools that focus on supply chain strategy and tactics such as those presented above. Beyond the presentation of demand, there is no explicit consideration of sales and marketing activities in traditional network design models.

S&OP, on the other hand, is all about synchronizing supply and demand. The process forces sales and marketing teams to sit down with operations and adjudicate differences. It begins with a demand forecast, preferably generated by a cross-functional team. If we examine that forecast closely, we see that it typically contains the estimated impact ("demand lift") of various scheduled marketing campaigns or initiatives. The challenge is to respond to forecasted demand levels, which are taken as a given.

But this process begs several important questions. Even if the initiatives are successful, should they be implemented at all? Are they worth the cost? And can we answer such questions while simultaneously addressing the synchronization issues?

We can address all of the above questions analytically. But to do so we must change our focus from the traditional metric of cost minimization to the uncomfortable notion of profit maximization. Why uncomfortable? Ask yourself the following: Beyond a subset of the executive suite (CEO, CFO), whose compensation is based on profit maximization? The honest answer is no one. Consider that classic performance metrics tied to sales force compensation, the success of marketing initiatives, manufacturing utilization, and procurement stress volume, not profit and maximization.

Are there additional metrics specific to certain functions? Of course there are. But the entire organization readily lines up behind volume and cost. So how can we approach this problem analytically? The answer is to describe to the model each proposed marketing initiative.

- Budget: fixed and variable costs.
- Activity limits for the given budget (e.g. number of new hires, advertisements purchased, etc.). These are effectively "capacity" limits.
- Anticipated demand lift.
- Add selling prices by customer/channel/product/time period to measure revenue as well as cost.
- Instruct the model to maximize profit rather than minimize cost.
- Allow the model to choose from available marketing initiatives. At the outset, the demand forecast does not include their anticipated lift.

In turn, the model will accept initiatives that are profitable and feasible. It will reject initiatives where the selling price for a given order exceeds the cost to serve, or where there is insufficient capacity in the network to meet the requisite volume. In short, the algorithm finds the maximally profitable quantity that can actually be produced. The bottom line is a profit maximized corporate strategy to guide the CEO and CFO.

Realizing the Promise of S&OP

For many decades we have recognized that the essence of supply chain management is cross-functional cooperation, if not complete integration. Unfortunately, the evolution of the organization structures to support that concept essentially stalled in the 1970s. What remains is what always existed: functional silos without a line-level executive structure to exploit the promise of SCM. This organizational stumbling block shows no signs of going away. Nevertheless, firms have recognized the need for cross-functional cooperation and have adopted processes and tools to facilitate it—most notably S&OP. Unfortunately, the associated analytical tools are typically underpowered for the task, resulting in anger, frustration, and a lack of support.

It is possible to rescue the promise of SCM and S&OP, but the process can be long and arduous. Ideally it involves organizational restructuring, the formal adoption of cross-functional processes, and a concurrent adoption of new performance metrics. Regardless, powerful tools are needed to address the complexity inherent in cross-functional integration or supply-demand synchronization. S&OP is indeed a multi-step process that can facilitate that goal. In turn, it must be supported with suitable analytics, lest the promise go unrealized.

REEL IN RISK with a Broader View of

By Robert J. Trent

Robert J. Trent, Ph.D. is the Supply Chain Management Program Director at Lehigh University. He can be reached at rjt2@lehigh.edu.

In an era when supply chain risks are soaring, senior managers are putting more of a premium on supply chain flexibility. But they now need to view the concept as more than just adjusting manufacturing supply to demand—a narrow perspective that can lead to problems. Here's how managers can take a much broader view of supply chain flexibility, with risk reduction foremost in mind.

It has become a classic example of the effects of supply chain disruption: the time when fire destroyed the premises of a supplier that provided Nokia and Eriksson with critical components for mobile phones.

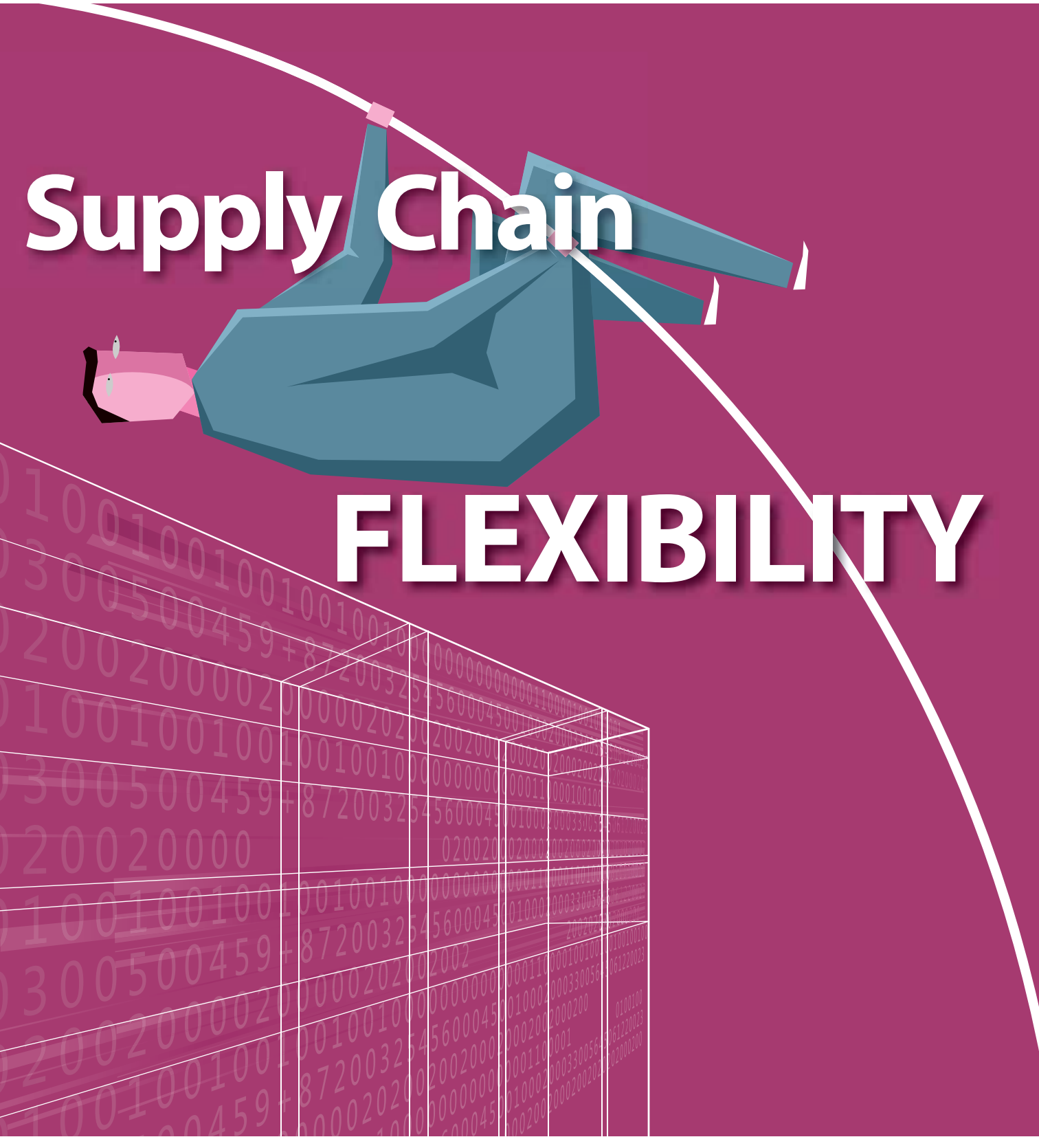
The two companies had entirely different responses to the event, resulting in a dramatic industry shift. Nokia was able to secure components quickly from other sources. By contrast, Eriksson struggled to respond. The disruption not only cost the company several hundred million dollars in lost sales; it essentially ended its position as a player in the growing wireless phone business. Poor business continuity planning by Eriksson, combined with a lack of supply chain flexibility, turned a hazard risk into a strategic risk.

As the search continues for new and improved ways to manage supply chain risk, senior managers will put more and more of a premium on operations that are as flexible as possible. The concept of flexibility is receiving increased attention in the popular press as well as from supply chain professionals. A global supply chain survey conducted by PwC and reported in *Industry Week* concluded that almost 65 percent of respondents plan to implement greater flexibility to better respond to supply chain challenges, making flexibility a top supply chain priority.

Rethinking Traditional Definitions of Flexibility

If those challenges are to be fully met, however, broader interpretations of supply chain flexibility are required. It is neither a static nor a monolithic concept. Yet many managers view it in terms of adjusting volumes in a manufacturing environment. Consider this definition from one business dictionary: "Flexibility is the ability of a system, such as a manufacturing process, to cost effectively vary its output within a certain range and given time frame."

Supply Chain FLEXIBILITY



In fact, supply chain flexibility involves much more than that, and managers need to view it broadly rather than narrowly. They have to think in terms of an organization's ability to be agile, adaptable, and responsive to change—particularly changes brought about by risk events. Flexibility should be an important supply chain objective—a characteristic that enables companies to enhance the resilience of their supply chains. Resilient supply chains can adapt quickly to changes or risk events, according to authors Mark Stevenson and Martin Spring in the *International Journal of Operations Management*, including supply disruptions or changes in demand, while maintaining appropriate customer service levels.

Experience, literature searches, and research with hundreds of companies enable us to identify more than a dozen dimensions of supply chain flexibility, along with possible ways to achieve that flexibility.

The point here is that effective risk management requires the ability to respond quickly to a risk event with alternatives, sometimes within minutes. Nokia's supply chain had that kind of in built flexibility; Eriksson's didn't.

To help foster a broader view of supply chain flexibility, this article presents a variety of interpretations of the concept. Experience, literature searches, and research with hundreds of companies enable us to identify more than a dozen dimensions of supply chain flexibility, along with possible ways to achieve that flexibility (See Exhibit 1). For practical purposes, though, this article focuses on three aspects where attention from senior management will pay the greatest dividends. We will also look closely at three approaches that facilitate the transition from a conceptual understanding of supply chain flexibility to embedding it in the organization's thinking and culture.

Supply Chain Design Flexibility. Supply chains are rarely as neat and tidy as those presented in academic models. In fact, they often feature a multitude of forms as companies pursue a variety of customer segments and work through different sourcing and distribution channels. Supply chain design flexibility means that an organization has designed or can adjust its supply chain to satisfy specific requirements.

Dell Computer, a company that faces strategic risk as customers shift from personal computers and laptops to tablets and other devices, realized that the supply chain it had established to support make-to-order online sales would not readily support its expansion into retail sales and other market segments. Dell has since developed four supply chains, as described by David Simich-Lefi in the *Sloan Management Review*. Each is dedicated to a different customer segment that provides much more flexibility to respond to a broader array of market opportunities. The build-to order supply chain supports Dell's online customer segment; the build-to-plan supply chain supports the retail segment; the build-to-stock supports the company's online/popular configurations segment; and the build-to-spec supply chain supports its corporate segment.

Logistics Flexibility. Logistics flexibility means being able to adjust the route or mode of transportation taken to move goods, funds, and even information. This kind of flexibility allows shipments to be rerouted when natural hazards occur, roads are closed due to accidents, a strike occurs at a port or a carrier, or a mode of transportation becomes less viable.

The benefit of logistics flexibility is increasingly evident in the U.S. oil industry. A proposed $2 billion pipeline (a fixed, inflexible mode of transportation) designed to take plentiful crude oil from West Texas to California has failed to generate interest among large California refiners because of the flexibility offered by rail cars. Relying on rail shipments to transport oil allows refiners to source from different locations around the U.S. and route the oil to their California refineries, something that is not feasible with a fixed pipeline. A growing supply of North American crude oil is coming from locations where prices fluctuate, allowing refiners to use different routes and modes of transportation (such as rail cars) to make opportunistic purchases for their crude supply.

Material Flexibility. Material flexibility—allowing producers to shift from one material to another with relative ease—is valuable to industries that rely extensively on raw materials. It is especially useful when commodity prices are volatile, as they are today. The size of fluctuations in commodity prices has more than tripled since 2005 compared to 1980-2005, based on International Monetary Fund data.

Some users of nickel have already come to appreciate this facet of flexibility. In the not too distant past, the price of nickel soared, making it prohibitively expensive for companies that rely on stainless steel 318, an industry standard material that contains nickel. Companies

that manufacture vehicles to carry food products were hit especially hard. Fortunately, material engineers at some of those tank trailer manufacturers were able to shift quickly to lean duplex, a type of stainless steel that offers material properties that are 30 percent to 200 percent better than traditional alloys with only a fraction of the nickel contained in other stainless steels. Lean duplex also offers higher yield strength, making it less susceptible to cracking and corrosion, Denise Rondini writes in *Transport Topics*.

EXHIBIT 1

Different Types of Supply Chain Flexibility

Type of Flexibility	The Ability to...	Supply Chain Tactics
Volume Flexibility	Adjust order volumes internally and with suppliers in response to changes	• Overtime and weekend production • Access to temporary labor • Contract manufacturers and secondary suppliers • Safety inventory
Order Lead Time Flexibility	Have variable rather than fixed lead times with suppliers as required by customer demands	• Ask for shorter lead times from suppliers • Negotiate variable lead time requirements with suppliers • Select suppliers that have lead-time flexibility capabilities
Scheduling Flexibility	Adjust production and delivery dates internally and with suppliers as conditions change	• Real-time data visibility and dynamic scheduling • Work to secure preferential scheduling treatment from suppliers
Product Configuration and Variety Flexibility	Modify the design of a base product, including adding new varieties or features	• Develop platform products that allow re-configurability and modification • Practice mass customization
Physical Flexibility	Change the structure or layout of physical processes or sites	• Use modular facilities that can be modified for new uses • Build in future expansion and re-configurability capabilities during facility design
Capacity Flexibility	Modify the internal and external capacity levels of supply chain members	• Reconfigure work cells to shift according to product mix requirements • Use overtime and weekend production • Approve secondary supply sources and contract manufacturers • Reserved capacity slots with suppliers
Design Flexibility	Modify product designs quickly	• Computer aided product designs • Virtual simulation and testing • Use standard components wherever possible
Internal Routing Flexibility	Alter how a product flows through a facility	• General rather than specialized workers and equipment • Preapproved alternate routing
Logistics Flexibility	Reroute or adjust movement through logistical networks; shift modes of transportation or carriers	• Pre-approved secondary carriers • Have multiple port options • Have pre-approved multiple modal choices • Control title to goods to enable rerouting
Source/Location Flexibility	Shift production from one internal or external supplier or site to another supplier or site	• Qualify multiple internal production sites • Qualify alternate suppliers • Use suppliers with multiple production sites
Workforce Flexibility	Assign and reassign workers as needed	• Simplify labor work rules and job classifications • Utilize temporary labor
Energy Flexibility	Shift seamlessly between energy sources	• Purchase flex-fuel vehicles and equipment • Consider energy flexibility as a decision variable when specifying new equipment and facilities
Material Flexibility	Shift from one material to another with relative ease	• Test and pre-approve material substitutes • Qualify substitute material suppliers or distributors
Supply Chain Design Flexibility	Adjust or tailor supply chains to satisfy specific requirements	• Create multiple supply chains to match product and customer segment requirements

Source: Robert J. Trent, Ph.D.

Embedding Flexibility in the Supply Chain

Our discussion so far has opened up the view of what supply chain flexibility can mean. (Exhibit 1 provides other views that we don't have time or space to explore in this article.) However, it's one thing to develop a clearer conceptual understanding of the concept and another thing to make it an embedded part of the organization's thinking and culture. Where should supply chain managers start?

There are many ways to answer that question, but in our experience, the three most important areas where flexibility should be embedded are: during the development of business continuity plans; during the development of new products and services; and during the development of commodity strategies. Let's examine each in turn.

Incorporate Flexibility into Business Continuity Plans. The objective of a business continuity plan is to assure the availability, reliability, and recoverability of business processes that service a company's customers, partners, and stakeholders. Business continuity formalizes a company's overall approach to effective risk management, and should be aligned closely to its procedures for incident management, emergency response management, and information technology disaster recovery. Investor Warren Buffett once observed that risk comes from not knowing what you are doing. Business continuity planning helps ensure that we know what we are doing when bad things happen.

A key part of a business continuity plan involves the recovery strategies put in place to mitigate specific risks identified during a risk assessment. This is where various kinds of flexibility will come into play. Data gathered from business impact analysis and risk assessment (two important parts of continuity planning) will lay the groundwork for recovery strategies that mitigate potential risks. Recovery strategies and the associated estimated costs for implementation are then developed and presented for review to a business continuity governance board (such as the executive management board). Increasingly, different kinds of flexibility should be considered when developing risk strategies.

Integrate Product Development and Risk Management. In typical new product development projects, particularly at technology companies, engineering teams work as fast as possible to develop new products or technologies. Then, at some later point, supply chain professionals become involved and suppliers are selected to support the design. This sequential approach limits a company's ability to anticipate and perhaps even prevent supply chain risks. Unfortunately, this model is the norm; there are few companies that address product development and supply chain risk simultaneously. Although integrated product and process development is well understood, the integration of supply chain risk and new product development is not.

So what are the characteristics of a process that brings together product developers and supply chain risk managers? First, supplier selection must happen early in the design process, so that those responsible for supplier risk management have time to identify and address any supply concerns. Next, each cross-functional team involved in product development, with the help of supply chain managers, will have responsibility for identifying a set of supply chain risks, including logistical risks that may affect their part of the project. Those risks are then collected and categorized for easy access. Development team members will meet regularly to review product development progress and also the actions taken to address potential risks. Increasingly, these actions will

A Basic Plan for Assessing Commodity Risk

Here is a simplified five-part framework for a risk assessment plan that should become part of any commodity sourcing strategy.

Section 1. This section includes an external intelligence report that describes in detail the supply market for the commodity/material. Who are the major suppliers and where are they located? Who are the major customers? What are the supply trends? Are there specific supply and demand price drivers? What is the overall competitive environment of the market for this commodity?

Section 2. This section identifies and categorizes risk(s), including a detailed description of each risk (i.e., not a generalization such as "potential supply disruption" or "bad weather").

Section 3. This section requires the development of a risk scenario map with each risk plotted on the map. The dimensions of the map can include the probability of a risk occurring and its expected impact if it were to occur.

Section 4. This section contains a comprehensive risk management plan that identifies risk management actions that describe how to manage the risks identified in Section 2. This section should also include a timeline that shows how and when to carry out risk management actions.

Section 5. This section includes a listing of objective references and information sources about the demand and supply market for that item and supplier(s). It should identify why each information source is valuable. Particular emphasis should be given to information sources that are updated on a regular basis.

focus on supply chain flexibility.

Taking this a step further, a team will estimate the probability of each risk occurring and the impact on product launch if the risk occurs. Priority is then given to evaluating the higher risks to determine what action can be taken to reduce their probability and impact, including the development of approaches that support supply chain flexibility.

Make Risk Plans Part of Commodity Strategies. One indicator of an organization's maturity is the presence of well thought-out strategies, which in supply chain management includes commodity or category strategies. A purchase commodity or category is simply a grouping of like items or services. Something that should increasingly be required is for commodity or sourcing teams to include risk assessment plans as part of their formal commodity strategies. That will encourage commodity teams to assume the responsibility for risk management rather than shifting it to another party. It will also help embed risk management thinking into the corporate culture. A risk assessment plan is an extension of a risk analysis. The plan documents known risks and includes descriptions, causes, likelihood of risk occurrences, costs, and proposed risk management responses. It can easily be included as part of a formal commodity strategy. Again, many of the risk management responses proposed in the plan may relate directly to actions that enhance supply chain flexibility.

The sidebar, A Basic Plan for Assessing Commodity Risk, provides a template for developing a risk assessment plan. Section 4 of the template will include the flexible capabilities that help manage the risks identified in Section 2. Executive management should not accept a proposed commodity strategy unless it includes a fully developed risk assessment plan.

A Culture Attuned to Risk

Companies that are effective at managing supply chain risk will have created a corporate culture that constantly considers risk implications. A culture that emphasizes risk will benefit from a set of action plans, capabilities, tools and techniques, skilled personnel, and the ability to quantify the value of risk management efforts. When these capabilities are present, a company can engage in thoughtful risk taking that is supported by supply chain flexibility rather than being paralyzed by an irrational fear of risk. Within the domain of risk management, supply chain flexibility might just be your next source of competitive advantage.

3 State of Disruption: Technologies May Management in

Every so often, new technologies come along that threaten to upend the world as we know it. Such was the case in 2003 when Walmart announced its famous RFID mandate that required its top suppliers to put RFID tags on shipping crates and pallets. As RFID startups proliferated like convenience stores, many predicted the end of barcodes and a new level of real time supply chain visibility.

Despite the hype, Walmart abandoned the initiative a few years later. Yet that wasn't the end of the story. Twelve years after the mandate, RFID is alive and well in the retail supply chain. But instead of tracking pallets in a distribution center, the technology is used inside the retail store to ensure that the right assortment of sizes and styles are on the shelves. RFID isn't so much a disruption as a complement to existing solutions.

Fast forward, and supply chain managers are hearing about the wonders of robots, 3D printing, and wearable data collection technologies. Many are predicting that our supply chains will never be the same once these disruptive technologies take hold.

Is it all hype? That's a question I put to the authors of the following articles on robotics, additive manufacturing, and the state of mobility. Based on their findings, I think the answer is mixed: Robotics, 3D printing, and wearable heads up displays all have niche applications today, but aren't yet ready for prime time. At the same time, all three are advancing quickly and price points are destined to decline. It doesn't feel like a repeat of the Walmart RFID mandate. Or, as Suraj M. Alexander, co-author of the piece on additive manufacturing, wrote to me: "The future is going to be amazing. I wish I was going to be young again." *—Bob Trebilcock*

Change Supply Chain the Coming Years

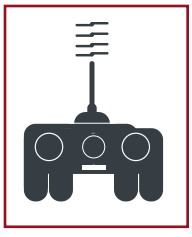
Robots at a Tipping the Supply Chain

As the needs of manufacturing and logistics grow exponentially, the supply chain industry will be one of the first to reap the benefits of the robotic revolution.

By Tom Galluzzo

Editor's note: In a February 2015 article on robotics, the *Wall Street Journal* reported that researchers from Gartner Inc. and Oxford University are forecasting that "a third of all jobs will be lost to automation within a decade. And within two decades… nearly half of the current jobs will be performed with machine technology." What might that evolution mean to the supply chain? That's a question I put to Tom Galluzzo from Iam Robotics. While *SCMR* does not typically publish articles from solution providers, in this instance, I purposely reached out to the founder of a robotics startup to get a view of why our industry is attracting interest from young robotic engineers like Galluzzo and how and when robotic technology might address challenges in manufacturing, distribution, and transportation in the future.

—Bob Trebilcock, Editorial Director



"If man ever flies, it will not be within our lifetime, not within a thousand years."
—Wilbur Wright, 1901

Just two years after making the above comment to his brother Orville, the Wrights made the world's first powered aircraft flight. How could someone so close to the tipping point, arguably the most influential person in aeronautical history, not know that success was within reach?

I experienced a similar phenomenon in my own career in robotics when I was a graduate student at the University of Florida. In 2004, the Defense Advanced Research Projects Agency (DARPA), the government group best known for fostering the Internet, challenged the robotics world to race unmanned vehicles 150 miles through the Mojave Desert. No one had ever built a robot that could drive by itself through that much off-road terrain. It was called the DARPA Grand Challenge.

My professor decided that our research lab would

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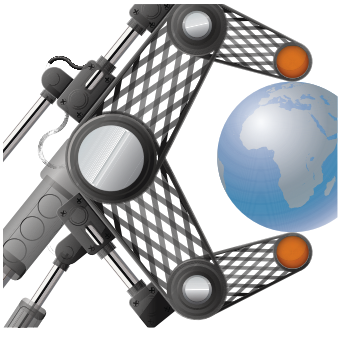
Point in

compete in the race. Over 100 teams attempted the challenge; only 15 were able to get robots to the starting line, and none made it through more than five percent of the course. It was a complete failure. Most robots veered off track and crashed, some got stuck and ran their engines until catching fire. Ours plowed itself through barbed wire until it tangled itself to death. We made the most of the experience, but we couldn't help but feel defeated that day. I remember saying to my teammates that it would be many years before anyone would complete the challenge. No one disagreed.

The next year, just 19 months after the first challenge, robots from five different teams completed in the 132 mile race. Unfortunately our robot was not one of them. Our software still had a few shortcomings. One issue with the GPS caused it to go off course after 14 miles and we never recovered. That day I learned another great lesson: When the world decides to meet a challenge, success can happen much faster than expected. I believe that is the same tipping point phenomenon the Wright brothers experienced in 1903.

I also believe we are approaching a similar tipping point where robots will become useful for everyday tasks. Much like cell phones or computers, robots will soon be everywhere and we won't remember life without them. These machines will drive our vehicles, pick up our orders, make our food, and do countless other things. But much like computers in the 1950s and 1960s, autonomous robots will find more use in industry before use in our day-to-day lives.

Unlike manufacturing labor, supply chain labor adds more cost to products than value. This inherently makes supply optimization a priority. Robots will make a compelling business case to do that.



The supply chain industry will be one of the first to reap the benefits of this revolution. While robots have been ubiquitous on the plant floor for decades, they have been slow to make inroads in distribution and logistics. However, their needs are growing exponentially, demanding new forms of automation to meet new demands. Unlike manufacturing labor, supply chain labor adds more cost to products than value. This inherently makes supply optimization a priority. Robots will make a compelling business case to do that. Shortly after robots cross the tipping point, we'll see a many of them in the warehouse.

Why Robots are Important

The supply chain is filled with challenges. Moving all of the materials important to our lives from the producer to the consumer takes a lot of hard work. Truck drivers spend tedious hours on the road while order fulfillment pickers walk miles a day. The jobs are dull, repetitive, and exhausting. Turnover is a huge headache for supply chain managers. That is why labor management is perhaps the biggest supply chain challenge of all. How do you find the right employees? How do you keep them working and keep them happy at the same time? Companies spend a lot of time and effort trying to answer these questions—and it's only going to get harder. The industry should be ready for some major trends that may make automation a requirement to survival.

One trend is the aging population. In general, we will have more non-working-age consumers demanding goods through our supply chain. This has a disproportionate effect. The ability to meet increasing demand will be harder because relatively fewer working age people will be available to do the work.

Another trend is the resurgence of domestic manufacturing. Rising labor prices overseas and a need to have agile control over production has caused manufacturers to grow operations at home. To succeed, manufacturing companies will have to offer supply chain workers better wages and provide more engaging work. Again, this will have a double effect on the supply chain. As manufacturing increases demand on logistics, it will simultaneously reduce the relative availability of labor.

Finally, e-commerce will continue to be a major trend. It has become so ubiquitous that it's easy to overlook how its exponential growth is changing the supply chain. Since 2000, the number of warehouse jobs has grown from around 100,000 to over 700,000—a trend that is both disruptive and unsustainable.

Over the past few decades, the supply chain has met growth challenges and managed costs by optimization with computer technology. Things like Enterprise Resource Planning (ERP) and Warehouse Management Systems (WMS) have allowed us to amp up supply chain efficiency, but the world of logistics is a physical world. It can't scale beyond material limitations, and in that sense, physical automation is the next logical step.

Robots and autonomous vehicles enable a new kind of automation. The biggest difference between autonomous robots and traditional automation is infrastructure. Robots will work within our infrastructure in the same way people do. Driverless trucks and convoys will drive on existing roads and highways. Automated lift trucks and picking robots will use the same pallets, totes, and racks that are in warehouses today. There are several advantages to this. We won't need to build new facilities or floor space to take advantage of robots, and the level of flexibility will be on par with manual labor. Manual labor

and automation will effectively become interchangeable.

The question is why aren't robots able to work within our infrastructure today? Robots have been working on assembly lines for decades. What allows them to enter the supply chain now? In order to answer that, let's look at recent progress in the world of robotics.

The Ingredients for Autonomous Robots

With any technological breakthrough there are invariably a set of final ingredients that make it possible. These ingredients themselves are other recently created technologies and tools. In the case of the Wright Brothers, for example, high power-to-weight internal combustion engines and an improved understanding of aerodynamics gave them the ability to create powered aircraft. In the world of autonomous robots, there are newly available technologies that are pulling us to a tipping point.

Since 2000, the number of warehouse jobs has grown from around 100,000 to over 700,000—a trend that is both disruptive and unsustainable.

Some of the biggest recent changes are in sensors. We now have low-cost commodity sensors that can see the world in full 3D. Their development is largely owed to the video game market, where they are used for interactive gesture control. Previously robots were dependent upon 2D color cameras or laser range scanners. The problem with these older sensors is that they either require too much processing with unreliable algorithms or the sensors are too expensive. Now, sensors do much of the processing themselves while they provide robust data at speeds comparable to human vision.

Another technical ingredient is the availability of exponentially growing processing power at low cost and low power consumption. This advancement has largely gone by unnoticed by the general public because new achievements from Silicon Valley are somewhat old news. These days we just expect cell phones and computers to do everything at crazy speeds. In reality, the recent computing innovations are more astonishing than ever. As a result, we basically have supercomputers in our pockets that can operate on a battery all day long.

What that means is that mobile robots now have the ability to see with their own eyes. What's more, improved 3D vision algorithms enable them to operate in less structured environments. By comparison, the robots that have been on factory floors for the past 40 years are completely blind, or if they do use vision, they are typically limited to highly controlled 2D scenes. Past robots have therefore relied on precise structured environments to do their job. They are programmed to move through a series of exact positions and the objects they manipulate must be precisely placed by automated infrastructure and tooling.

The ability for a robot to see and make sense of its surroundings means that things no longer have to be precisely positioned and the machines can handle other objects in the environment dynamically. This is the environment of the supply chain. It's a world with a fairly well organized and well-defined set of objects, so that machines can be programmed to work within and recognize those specific things.

What we're really talking about is the kind of structure (or infrastructure) required for a robot to operate. You may hear other experts talking about unstructured environments and how robots cannot operate within them. That is largely true: but the logistics world is not unstructured. Nature is unstructured; a child's bedroom is unstructured, but warehouses are *not* unstructured. They have a fixed set of SKUs, racks, and containers, all kept in an ordered scheme. It's true that not everything in the supply chain is positioned perfectly or kept in perfect shape, but new robot vision can dynamically measure where things are in the moment and adjust accordingly. These are loose-structured environments, and the recent advancements in sensors and computer vision is making it possible for robots to do something useful within them.

Emerging Solutions

Much of my confidence in robots' ability to operate in loosely structured environments comes from another

recent DARPA project called Autonomous Robotic Manipulation (ARM). I worked on this project at Carnegie Mellon University. For the ARM project, DARPA wanted robots to see and manipulate objects with minimal human instruction. The program was a fair success. We were able to get a robot with a head, two arms, and two hands to see and grasp dozens of different every day things. We were also able to get the robot to perform basic tasks, such as opening a door or hanging up a phone.

The ARM program fell short of truly unstructured manipulation, but it proved that simple tasks (ones that have only a few steps) are possible to do with autonomous robots. For me, this inspired real-world applications for autonomous manipulation. The problem is that the applications are seemingly limitless. So we needed to find ones that could be solved with robots, but ones that could also bring significant economic benefit to customers. It turns out that the supply chain has just those applications.

In 2012, I founded a company called Iam Robotics to solve warehouse problems with next generation robotics. We started by studying various operations to determine the viability of using autonomous manipulation. After spending almost a year in primary market research, we found that piece picking was the best application. Picking is a relatively simple manipulation task (when compared to say, changing a tire). Additionally, the speed at which picking is typically done is achievable by an autonomous robot. Most picking operations require a lot of walking and grasping. AS/RS solutions take away most of the walking, but they inherently require costly installation and infrastructure. Iam Robotics is building mobile robots that can do both the travel and picking and it's all enabled by new sensor technologies that allow robots to see products stocked in existing infrastructure.

This is not meant to be a promotion for our company. Rather, it is meant to illustrate the growing interest among robotic engineers in supply chain applications. Indeed, other competitors are addressing similar issues, creating an emerging and robust group of suppliers focused on this industry. For instance, vision enabled robots are now entering the supply chain to solve many old problems in new ways. Companies like Seegrid and Balyo are creating AGVs that use sensors to navigate a warehouse without any modifications to flooring or hardware installation. Wynright has robotic solutions for case packing, palletizing, and truck loading, and they recently demonstrated a robotic truck unloading system that used vision to see and pick boxes. We're even starting to see robots working side by side people. GENCO recently deployed a set of Baxter robots from Rethink Robotics that can work next to people on a production line.

In addition to these great applications, almost every major automation integrator has a robotic AS/RS product or a robotic case palletizing product. These types of robotic machines are still blind. I wouldn't consider them fully autonomous because they really don't sense the world around them, but they do integrate beautifully with other important supply chain automation tools like conveyors and the many WMS systems available on the market. For any automation solution of the future to be successful, I think it will need to work nicely with all of the existing optimization tools that the supply chain depends on. We are starting to see more robotic systems do just that.

Are We There Yet?

All of these advancements are great, but just how close are we to that real tipping point? Most supply chain operations don't use all of these new technologies. When are we going to see robots used everywhere?

This is the same problem that Wilbur Wright had in 1901. You can be on the brink but not know it. There is no way to tell exactly when, because you don't know what you don't know.

It is often the case in science and engineering that the margin between a breakthrough and countless previous failures is incredibly thin. When you approach a tipping point though, something is different. The steps toward your goal become easier and more pronounced. You surprise yourself. That is exactly what our recent experience has been like with the picking robots we're working on. We didn't know for sure how well they could work, but as we tried the newest technologies, tweaked the latest algorithms, and thought up some new tricks, we found that the results were far better than we expected.

Based on our experience, and that of many of our competitors, it's clear to me now that robotics technology has arrived and we need to be willing to try it in new ways and foster new applications. The evolution will happen rapidly in this stage: Expect to see lots of new robots in all kinds of new applications. Some will thrive, some will adapt, and some will fail. Those willing to take a chance early will reap the most benefits and have a chance to disrupt their competition. Ultimately, I think this will make some form of robotic automation required to survive in the supply chain business—and that is when they will become ubiquitous.

Is Your Supply Chain Additive

Additive manufacturing and 3D printing promise to simplify manufacturing, reduce inventories, and streamline operations. But, to determine when and how to apply additive manufacturing, organizations need a decision model that assesses it's market strategy, supply chain performance, and complexity.

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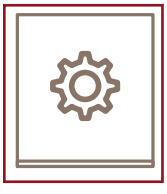
By André Kieviet and Suraj M. Alexander



Long before manufacturers talked about custom manufacturing and batch runs of one, there was orthodontics. Orthodontics treatments are customized by nature. Orthodontists meet one-on-one with every patient to take X-rays and make molds of their teeth and then create a unique treatment plan to correct a patient's misalignments. That custom approach spawned an industry of decentralized dentists, orthodontists, and dental laboratories who each have a role in the treatment plan. Think of it as a complex and expensive dental supply chain. For a long time, the question was: Well, what is the alternative?

Enter Align Technology, Inc., a global medical device company that disrupted the rules of the orthodontics game. Align Technology produces clear aligners—sold under the Invisalign brand—as a malocclusion treatment. Made of a nearly transparent plastic material, clear aligners work on the same principle as metal braces: They put soft pressure on individual teeth to move the denture into the desired position. However, instead of adjusting metal arch wires and brackets throughout the treatment, Align Technology provides a customized,

Ready for **Manufacturing?**

transparent plastic rack for each phase of the plan. Clear aligners have the added benefit of being much more discrete than a mouth full of metal.

The treatment itself is not new. Align Technologies' innovation is its production method. The traditional approach to producing clear aligners is to cast teeth molds that are altered manually by orthodontists for each phase of the treatment. Every two to four weeks a new cast is used to produce the aligner using plastic thermoforming machines that work either with pressure or with vacuum. In this method, up to 48 molds are created during a course of treatment. Each mold requires 10 to 20 different steps, or a total 480 to 960 labor-intensive steps for a treatment.

Align Technology did away with the traditional supply chain for orthodontics by centralizing the production of Invisalign in Mexico. Gone are the decentralized dentists and dental labs involved in a treatment plan, along with the hundreds of labor-intensive production steps. Instead, Align Technology utilizes stereolithography, an additive manufacturing (AM) technology, to produce all the required aligners for a one-year treatment plan in one run. The process creates 48 fully customized molds depicting the simulated future position of a patient's denture. Then, using the molds, all of the aligners are vacuum-formed in one step and shipped to customers around the globe.

Successful applications of additive manufacturing like Aligner Technology are among the reasons some companies are looking to additive manufacturing and 3D printing to gain a competitive advantage.

Centralizing the production does result in higher transportation costs and longer lead times, which negatively affects the overall supply chain performance. In spite of the expected increase in transportation costs, the reduction in supply chain complexity significantly reduces Aligner Technology's overall costs.

Disrupt Traditional Manufacturing

Successful applications of additive manufacturing like Aligner Technology are among the reasons some companies are looking to AM and 3D printing to gain a competitive advantage. In traditional manufacturing, regionalization and customization increase supply chain complexity. The result is a decline in supply chain performance, including long lead times, high stock levels, inefficient utilization of production capacity, and low degrees of automation. Until now, there have been few alternatives to produce a fully customized product that meets the needs of the marketplace.

The promise—or the hype—of advanced manufacturing is that AM will simplify the supply chain. It will eliminate manufacturing process constraints, such as machining, that were implicitly introduced on designers owing to the limitations of traditional (mainly subtractive) manufacturing processes. Done right, AM facilitates more innovative and functional designs, along with the capability to manufacture customized products on demand, in lots as small as one. It also offers the potential to combine process steps required in traditional manufacturing with the added advantage of requiring no specialized tooling. This enables the reduction of operational and logistics costs.

AM has scale and scope advantages over traditional manufacturing. Many organizations believe they can create a decentralized production network with small, fully flexible production centers close to the point of demand that would allow them to manufacture small lots of highly customized products. That model would reduce complexity, eliminate the need for large batch runs and high stock levels, and take time and cost out of transportation. Industries such as commercial aviation are already successfully using AM technologies to manufacture parts on the shop floor that have intermittent demand and are required in very small quantities.

Despite the hype, as the Aligner Technology case study shows, the assumption that adopting AM will utilize a decentralized network of small- to medium-sized production centers is not necessarily true. What's more, AM may add some costs to the supply chain, such as transportation, that must be off-set in other ways—or may not be off-set at all. Until now, there has been no framework to help organizations decide when they should adopt this technology—or whether it is even economical to do so. Based on our research at the University of Louisville, this paper presents such a decision framework (Exhibit 1).

The framework is based on three assessment dimensions, listed below.

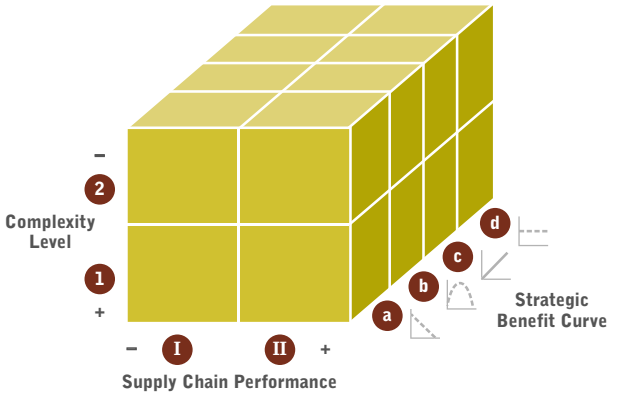
1. Strategic Customer Benefit
2. Supply Chain Performance
3. Complexity Level

Let's look at each in detail.

The *Strategic Customer Benefit* dimension is a strategic reflection on how customers value an extended

EXHIBIT 1

Decision Model for Additive Manufacturing Application



Source: University of Louisville

range of product variety and customized products. Every organization could be classified as having one of four different strategic benefit curves, which define the relationship between perceived customer value and product variety. This concept, derived from the optimum variety concept, or Vopt, developed by Peter J. Rathnow in 1993, is extended to define a complexity management strategy, as illustrated in Exhibit 2.

The *Supply Chain Performance* dimension considers the implications of adopting a technology such as AM on the performance of the supply chain. The assessment considers the key performance indicators of service, quality, lead time, and costs. A comprehensive cost model has been developed that covers all stages of the supply chain and includes AM processing costs, such as post processing requirements.

EXHIBIT 2

Strategic Benefit Curves and Complexity Management Strategies

f_{BEN} and f_{Costs}	Description	Likely V_{opt}	Complex Management Stategy
a	Variety reduces overall benefits	1	Avoidance
b	Variety increase benefits to an turning point and decreases benefits afterward	$1 < V_{opt} < \infty$	$V > V_{opt}$:Avoidance $V < V_{opt}$:Control
c	Variety increases overall benefits indefinitely	∞	Control
d	Variety does not impact benefits curve	Min (f_{Costs})	Avoidance

Source: University of Louisville

The third dimension pertains to *Supply Chain Complexity*. Complexity relates to transparency across the supply chain. Enhancing transparency results in better management and better performance across the supply chain. The elements that effect complexity include mass, diversity, connectivity, and overall transparency. Measures of these elements assist in quantifying complexity. A subset of measures specifically focuses on the production driven complexity, which allows an assessment of the complexity introduced by the production technology. AM's potential to eliminate fabrication and assembly steps by manufacturing complex designs in a single process step, as was the case at Aligner Technology, has the potential to reduce overall supply chain complexity.

Step By Step

The input factors for the decision model are generated in a structured five step modeling process (Exhibit 3 on the following page).

Step one represents the strategy definition stage, where the organization defines its long-term direction and scope to create an advantage for the organization. The achievement of the strategic objectives is dependent on the supply chain management and related complexity management strategy. The latter defines if the organization should avoid or control the level of complexity in its supply chain. In this context, the avoidance strategy would aim to reduce the level of complexity, while control would be an acceptance of a potential increase in complexity. To avoid complexity, additive manufacturing could be used to simplify and consolidate production steps, while for the control strategy, the focus would be on adjusting product variety and design.

Steps two and three assess complexity across the existing supply chain, including that resulting from the production technology adopted. This assessment defines the baseline complexity measure. The levels of the four elements of mass, variety, connectivity, and transparency are calculated to assess the complexity of the overall system. The mass is quantified using a metric that enumerates all elements in the supply chain, which include

EXHIBIT 3

Five Step Modeling Approach

Source: University of Louisville

interacting companies, people, processes, and other factors. The variety metric provides a measure of the diversity in the supply chain by measuring how many different types of elements are involved. The connectivity metric is a measure of the number of relationships in the supply chain, and the transparency of the supply chain will be defined by an opacity metric.

These measures are not used to pass a judgment on the level of complexity; rather they are used to assess implications of any change in processes and design on supply chain complexity.

All four measures have a complement for assessing production complexity. Its evaluation in step 3 provides a perspective on the implications of the adopted production technology on the overall supply chain complexity.

Besides complexity measures, other relevant supply chain performance measures should be considered to develop a baseline. This would include measures related to quality, cost, and service, such as, on-time delivery, lead time, and return rate statistics. The measures should be tailored to each organization as the market requirements vary from market to market. Overall supply chain costs are affected by the production technology adopted. Hence, a comprehensive cost model has been developed which covers all relevant cost drivers in logistics, transportation, and production. The costs characteristics as well as the costs curves depend on the quantity produced. Because traditional production technology costs are significantly influenced by expenditures for set-up and tooling, the unit costs depend significantly on the lot size produced. In contrast, unit costs for additive manufacturing parts are more constant as set-up is often not significant and tooling is not required.

In step four, remodeling of the supply chain is considered to reduce costs and improve performance. An organization should consider improvements over the entire supply chain, including the impact on customers, and not just their own production facilities. Here, adopting alternate production technologies, such as AM, can be assessed.

In order to select the appropriate AM technology, it is important to know the key customer requirements, such as color, strength, and surface roughness. This is important as a decision might be required if customer specifications cannot be met through AM.

As expected, AM technology is rapidly progressing. Available materials and processes for AM are also increasing. Once limited to processing plastics, AM technology has evolved to include metals and other materials. Also, the way materials are joined in the layer by layer production process varies, for example, from using gluing material in binding jetting processes to melting the building material itself as in direct energy deposition, material extrusion, material jetting, or powder bed fusion processes. Additionally new coloring options are also increasing which are, in a business-to-customer environment, an important decision variable. These parameters and processes determine the selection of the AM technology.

After the technology selection, the remodeling should be driven by two themes. Production steps should be consolidated, as additive manufacturing has the ability to produce complex designs in one step. This would reduce buffer inventories and increase flexibility. The second theme should be moving the point where complexity occurs to the latest stage possible in the supply chain. By applying these basic themes, it should be possible to positively answer the following simple questions:

- Can stock keeping be reduced or eliminated?
- Can assembly work be reduced or eliminated through combining productions steps?
- Can transport be reduced or eliminated through consolidation of production processes?

In Step 5, an assessment of the supply chain in terms of complexity and supply chain performance is conducted by comparing the baseline developed in steps three and four with the remodeled state. All defined measures should be considered for evaluation. Because not all measures have the same importance for an organization, a company specific evaluation scheme needs to be developed. The decision model will provide guidance on whether an organization should adopt AM technology immediately, or wait for further improvements in technol-

ogy and cost. A high-level output of the decision framework illustrated in Exhibit 3.

If adopting AM technology and remodeling the supply chain is recommended by the Decision Model, then it would be prudent to evaluate the technology on a pilot scale first.

To AM or Not To AM

So, is your supply chain ready for AM? Let's look at how a home appliance manufacturer applied the Decision Model to evaluate the potential application of AM in a production facility producing approximately 520,000 washers per year. In this example, one major part, the control panel, was considered a candidate for the new technology.

The mass is quantified using a metric that enumerates all elements in the supply chain, which include interacting companies, people, processes, and other factors.

One of the key drivers for this analysis was the complexity associated with this part. At first glance, the control panel seems like a simple part; it is comprised of a plastic panel shield, keys, a display, and related electronics with its connected wire harness. In addition, the control panel has tampon-printed language legends and signs. On a closer look, the part is any thing but simple. That is because in the battle for market share, home appliance manufacturers have fostered new design variants on a regular basis. Based on the number of options and variations in design and printing available to consumers, there was a permutation of 258 variants in the part in an average year.

In the existing process, the injection molding and the electronics behind the panel were supplied by two different suppliers. One supplier assembled the control panel including the display, keys, electronics, wire harness, and the panel body and delivered it to the washing machine production line in the scheduled sequence. If AM technology could be adopted, the panel could be produced at the point of use on the washer assembly without the electronics. That would allow the manufacturer to save on logistics and assembly efforts. In addition, it would enable on demand production of small lot sizes of different designs without high investments in tooling.

Using the Decision Model framework, the manufacturer considered each of the assessment dimensions. Based on two of the three assessment dimensions—Supply Chain Performance and Complexity Level—AM appeared to be a winning alternative to injection molding. For starts, the overall number of supply chain elements and the related complexity level in this example would be reduced by 17 percent. This would result in improved supply chain performance, reflected in lower inventory levels and increased flexibility. What's more, if the material costs in this application were comparable to the injection molding process currently in use, the additive manufacturing approach would be approximately 30 percent more cost effective than the traditional approach over the whole supply chain.

However, when the analysis applied the third assessment dimension—Strategic Customer Benefit—the picture began to change. For instance, the material costs to meet the more stringent requirements for AM were 16 times higher than those required for injection molding. At those price levels, the current process was more economically viable for lot sizes greater than six.

Further, an in-depth quality analysis found that the strength and surface roughness of the control panels were much better with injection molding than with additive manufacturing processes; even post processing of the parts could not deliver a quality level equal to the conventional process. These features were important to the customer. When all three assessment dimensions were considered, the Decision Model recommended against the adoption of AM because the strategic customer benefits of cost and quality trumped the elements of transparency and flexibility.

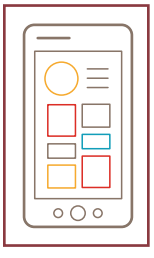
While this example provides some insight into the challenges that remain for widespread industrial adoption of AM technology today, it is not the end of the story. Already, there are moves afoot to improve quality and bring down the cost of the technology. For instance, some 3D printer suppliers have tried to copy the traditional office printer business model and earn the money on the toner and not the printer. Increased implementations of AM processes will drive down material costs owing to efficiencies of scale and competition. With these inevitable advancements, we believe AM will be a disruptive technology that eliminates scale and scope barriers for new competitors. For those reasons, it will be important to reassess whether or not to apply AM as conditions change.

Supply Chain Agility:
New Levels of Visibility through Mobile &

Omni-channel retailing is changing customer expectations and putting pressure on supply chains to develop fast, accurate, and efficient order fulfillment solutions. Here's a look at the mobile and wireless technologies and services that will enable those processes—and how they stack up today.

David Krebs is Executive Vice President, Enterprise Mobility and Connected Devices at VDC Research, a Natick, Mass.-based firm focused on technologies that enable a connected world. He can be reached at davidk@vdcresearch.com. For more information, visit www.vdcresearch.com.

By David Krebs



As anyone who oversees order fulfillment and distribution operations (or, who has been delighted by next day delivery of an order placed with Amazon Prime) realizes, e-commerce has raised customer expectations for product availability, delivery times, and costs. As if they weren't already high enough, these expectations reached new heights last year when Amazon announced the introduction of same-day delivery within certain parts of the United States.

The response by traditional brick-and-mortar retailers seeking to hang on to their customers has been significant investments in omni-channel retail experiences to counter the competition from pure e-tailers. Predictably, these changes are having a profound impact on supply chain and warehousing practices. Scaling e-commerce and omni-channel sourcing for more traditional brick-and-mortar businesses has stepped up the pressure on supply chain processes. Outside the four walls of the warehouse and distribution center, small last, mile delivery carriers—and not the large road fleets—are expected to satisfy the demand for moving smaller orders between forward distribution points and retail stores, introducing a new wrinkle or layer to existing distribution practices. Inside those four walls, there is greater pressure to ensure speedier and more accurate order fulfillment processes than ever before. And, don't underestimate the additional cost of the labor intensive picking methodologies required to fill thousands of single and multi-line orders compared to picking full cases or pallets of product.

With labor representing the single highest cost for

Wireless Investments

these businesses, retailers and industrial distributors alike have been making significant investments in automation and mobile technologies. What's more, the right investments have the potential to deliver real benefits: VDC research across a range of companies shows a strong connection between investments in mobile and wireless solutions and improvements to workflow optimization, worker productivity, and task accuracy. At the same time, given the hype around innovations such as wearable devices and Google Glass, supply chain operators are struggling to identify where to invest in order to leverage the advances in mobile computing and communications solutions to address these pressing issues. Based on our survey findings, we'll examine the three key areas we believe are important to the supply chain operator seeking to leverage the advances in mobile computing and communications solutions. They include: mobile device requirements for next generation investments; the value of voice and wearable technology for warehouse optimization; and the growing need for more advanced mobile services to support tomorrow's investments.

Omni-channel trends are driving investments to optimize warehouses and distribution centers as single facilities designed to support fulfillment through multiple sales channels.

Supply Chain Modernization: Aligning Mobility Investments with Tomorrow's Supply Chain Challenges

Omni-channel retailing and fulfillment represents the evolution of multi-channel retailing. Think of it as a seamless approach to the consumer experience through all available shopping channels. According to VDC's research, omni-channel is among those meta trends reshaping operations. With the increasing requirements for collaboration, cross-functional data integration, and data sharing, the role of retailers, wholesalers, and others across the supply chain is changing.

Omni-channel trends are driving investments to optimize warehouses and distribution centers as single facilities designed to support fulfillment through multiple sales channels. The catalyst behind these modernization efforts is customer service, as customers expect faster and faster delivery of their orders. A growing issue, according to many warehouse and distribution center operators, is the inability of their existing solutions to keep up with the volume and speed of orders.

Consequently, many retail organizations remain challenged by how to implement an omni-channel strategy with over one in two organizations (59 percent) telling VDC that they have no omni-channel retail capabilities or only an inconsistent approach to omni-channel retailing. Systemic to many of these omni-channel challenges are the requirements to support a greater degree of order flexibility, improve inventory accuracy and visibility, and support cross-functional data integration and sharing across numerous trading partners.

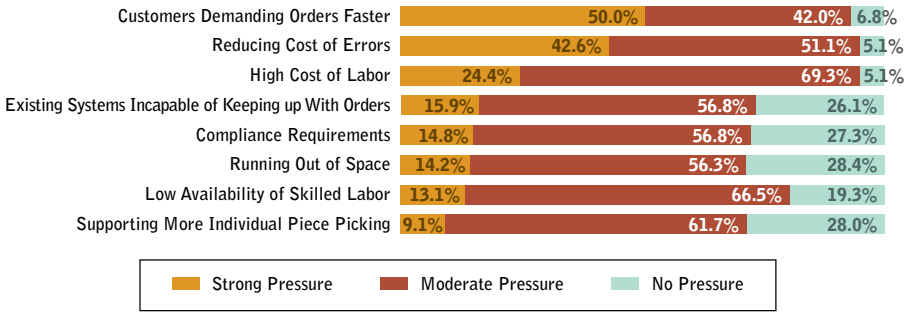
Targeted investments in automation solutions, especially in mobile computing and data capture technologies, are essential to addressing these operational challenges. Indeed, mobile devices have been a mainstay in most supply chain environments to support various material management workflows within warehouses and distribution centers and among delivery drivers. While purpose-built rugged handheld or vehicle mounted devices have traditionally supported these applications, changes to the broad mobile market are influencing and affecting investment decisions for supply chain applications.

According to our research, one major motivating factor driving these investments is that nearly all warehouse systems are facing moderate to strong pressure to support more individual piece picking. Existing physical and technological limitations are another major motivating factor to optimize: 56 percent of those surveyed reported that lack of space exerts moderate pressure on their operations, and 57 percent noted similar pressures from the inability of existing systems to keep up with order volumes. However, the pressure to meet customer demands for faster order delivery and the associated cost of errors are firmly at the top of the list driving investment decisions. A full 50 percent of companies we surveyed reported that increased customer demands exerted strong pressure on their operations, while 43 percent acknowledged similar levels of pressure in reducing the cost of errors (Exhibit 1). As a result, there is an ever-increasing need for process efficiencies to boost both productivity and accuracy.

Traditionally, the wireless data collection terminal has been the device of choice for supply chain applications. Although demand for this functionality is not expected to change, the devices used in these environments have largely been unchanged over the years. For example, the majority of mobile devices still

EXHIBIT 1

Services Most Influencing a Successful Deployment



Source: VDC

in use today resemble a "brick on a stick" form factor (pistol grip design), with a full keyboard and the same green screen/terminal emulation solution they have been running for over 10 years. These are the environments where enterprises first made meaningful investments in mobile and wireless solutions and led to the ratification of market moving standards such as 802.11b (WiFi).

Only now are decision makers beginning to evaluate alternatives that mimic the touch-centric focus of consumer devices as well as the adoption of more modern operating systems such as Android with intuitive user interfaces. With the end of extended support deadlines for legacy platforms looming in 2022, change is inevitable.

The question is whether next generation devices are ready for deployment in industrial settings. Given the business critical operations tied to many of these mobile solutions, more than anything, end users want reliability. So far, the report card is mixed. While organizations have experimented with consumer devices in warehouse and distribution center environments—including mounting iPads on forklift trucks—many of these devices are ill equipped to withstand the harsh environments and user cases common to supply chain operations; the cold chain being the extreme case in point. Based on survey results, VDC believes there are several critical requirements that consumer devices, like smartphones and pads, will need to meet before they see widespread adoption in supply chain applications. They include:

• **Durability and reliability.** The impact of mobile device failure, especially for highly optimized mobile applications, includes a significant disruption to workflows and lost productivity and the potential for customer service erosion and employee fatigue. At the same time, based on their design and portable use cases, the risk of damaging a mobile device is great, increasing the premium for durability. Consequently, it is not surprising that reliability and rugged design are among the most highly rated selection criteria for mobile devices by manufacturing decision-makers. That is important when evaluating the deployment of smartphones on the shop and distribution center floor, where the annual failure rates of consumer smartphones supporting supply chain applications was recently measured by VDC Research at 19 percent, substantially higher than the 4.5 percent of rugged handheld devices.

• **Connectivity options.** Mobile supply chain solutions rely on access to networks to be most successful. However, mobile workers frequently find themselves in highly remote environments with no network access, or they operate in environments with a high degree of interference. Therefore, it is critical that applications are designed with occasional connectivity in mind and remain functional even in the absence of network connectivity. Moreover, the ability for devices to seamlessly roam across access points in large facilities is an often overlooked yet critical requirement.

• **Battery life and management.** A major requirement for enterprise mobile solutions is strong, all-shift battery performance without significant design implications. The desired target is between eight to 10 continuous hours of operation. According to VDC's research, 65 percent of enterprise mobile users today indicate that their batteries "frequently" or "occasionally" do not last the full shift. Mobile devices designed for enterprise use—including rugged devices—fared better than consumer devices in battery performance. Moreover, the ability to replace batteries in the field, including hot swappable batteries, is a critical feature for field applications.

• **Ease of use and support.** Leveraging consumer design styles to deliver greater ease of use and user experience is critical when considering next generation mobile devices. However, beyond ease of use, ease of support is of equal importance. Key support requirements include mobile device and application management; help desk services; and advanced maintenance and repair services. In addition to application design consideration, many use

cases for field mobile applications expose the worker to direct sunlight conditions; making sunlight viewable displays a commonly required feature.

• **Security.** A critical requirement for any enterprise mobile solution, security becomes even more important with the adoption of increasingly sophisticated customer-facing and engaging mobile applications. Today, enterprises are mixed in their impression of mobile security, with only 50 percent stating that their organization has installed effective mobile security policies to address the potential risks mobile devices pose to corporate networks. Nevertheless, as far as mobile investment barriers are concerned, respondents cited security as only the fifth-highest barrier, behind other concerns such as application integration complexity, budget pressures, and lack of resources to support mobility initiatives.

• **Accessory management.** The need for a strong accessory eco-system, including charging docks, holsters, vehicle mount options, and others is critical for many supply chain applications. In addition, specialized data capture capabilities provide critical application specific functionality.

Realizing Voice and Wearable Technology Opportunities in Supply Chain Workflows

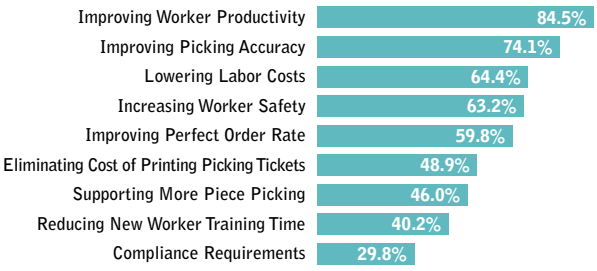
The promise of wearable computing and communications devices for enterprise and government applications is immense. They combine the benefits of hands-free operations and real-time situational intelligence at the point of interaction. The most common wearable technologies are the belt worn voice solutions and wrist worn computers with ring scanners.

Voice-based warehousing, in particular, provides a tangible benefit to companies looking to optimize warehousing operations and provides an exceptionally strong ROI. Research conducted by VDC has validated many of these benefits, including tangible increases in accuracy accompanied by improvements in overall speed and productivity for many warehouse workflows. For example, organizations deploying wearable solutions for voice-directed picking applications in warehouses are recording at least a 10 percent improvement in worker productivity and a 10 percent improvement in picking accuracy (Exhibit 2).

However, there have been barriers to the adoption of voice due to the long deployment times, high implementation costs, and relative inflexibility of many proprietary legacy solutions. VDC research shows that while firms are generally satisfied with their existing solutions, particularly in regards to accuracy, support, and ease of use, they cite costs of implementation and maintenance, limited compatibility with non-proprietary hardware, and training times as the top weaknesses of the current technology.

EXHIBIT 2

Voice Technology Adoption Drivers



Source: VDC

Next generation voice solutions are breaking some of those barriers down. For instance, next generation voice technology's modular design enables a heightened level of flexibility that is increasingly critical in today's market. Moreover, a more modular approach to technology allows for a more fluid labor force that is not constrained by a single area. Still, the chief barrier often lies in explaining the value proposition of voice-based warehousing technology to supply chain executives.

The dynamics affecting warehouse and supply chain operations mean that it is no longer an either/or decision, where a facility chooses between voice and barcode scanning or RFID. Many enterprises are looking to a more multi-modal approach with devices that have the capability to capture data in several different ways using the same device. Those might include the ability to speak a product identification number, scan a barcode, and read an RFID tag. These technologies are pervasive in most modern warehouses and have contributed significantly to the performance gains experienced over the past decade.

Beyond voice solutions and ring scanners, there is increased interest in other wearable form factors for use in logistics and supply chain environments, especially smart glasses and heads up displays. The concept received a huge boost with the hype around Google Glass, which was once named one of the best inventions of the year by Time magazine. Although Google Glass has since been written off as a commercial failure, its impact on evolving and advancing this form factor has spawned R&D investments from other solution providers. For example, the Vuzix M100, KNAPP's KiSoft Vision, and XOEye's current prototypes integrate camera, display, and conference functionality with the eventual goal of adding augmented reality capabilities.

Several prominent and well designed demonstra-

tions have shown the potential of smart glasses and AR overlays in areas such as warehousing and logistics supporting a variety of applications including warehouse picking, load management, and last mile support. However, in part to avoid potential privacy issues with customer-facing applications, most of the initial trials have focused on workflows in the warehouse. While the smartglass and Augmented Reality (AR) overlap technology has been easy to use and employees have taken to it fairly quickly, key challenges surrounding scanning functionality and snappiness (i.e. using a scanner integrated with the glasses), severe battery life limitations (less than two hours), unstable connectivity, and the high price point of some of the options expose the relative immaturity of some of these technologies. In this context, it's not surprising that the top two concerns among enterprise decision makers regarding the adoption of wearable technology are "lack of clear ROI" and "budget."

Managed Services for Mobile Supply Chain Solutions: Maximizing High Availability Solutions

Mobility management is rising as a chief priority for CIOs and CTOs worldwide. More than 85 percent of IT decision-makers expect steady or increased year-over-year mobility budgets, according to VDC survey results. Challenged to manage increasingly sophisticated mobile technology strategies and deployments, these organizations are procuring third-party technology support through a mobile managed services model.

We describe the managed services model as the function of outsourcing the day-to-day management responsibilities of IT disciplines and applications as a strategic method to improve operations and lower costs while enabling IT to focus efforts on more business-critical activities. Enterprises benefit from outsourcing functions as far-ranging as network services, data storage and backup, hosted enterprise applications, security services, and business continuity. Managed services are typically provided on a subscription model with key performance service level agreements (SLAs) in place.

The value proposition for mobility is not dissimilar. Although enterprise mobile solutions are critical to support business operations—such as warehouse automation—it is often not a key business differentiator. Moreover, mobility often only represents a small portion of an IT staff's day-to-day responsibilities. Put another way, poorly managed and supported mobile warehouse solutions can negatively affect key operational metrics. From a warehouse mobile investment perspective, what organizations care about the most is continuity and decreasing risk. Availability and uptime and compliance with IT policies trump other end user considerations, making managed services for warehouse mobile solutions a good fit. And, in contrast to traditional professional services, mobile managed services facilitate broader outsourcing of the day-to-day IT operations and processes required to support mobile technology deployments.

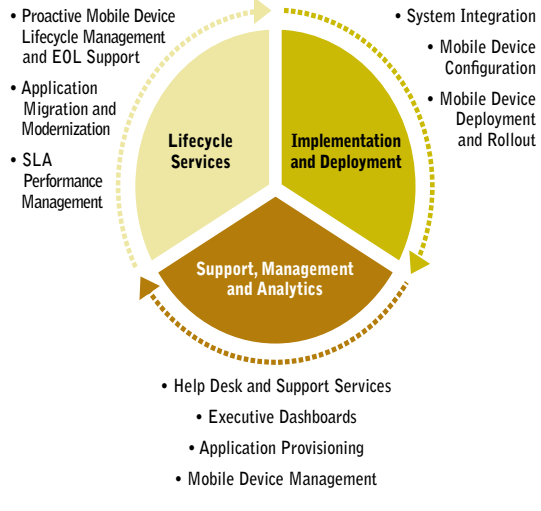
At its core, mobile managed services comprise three disciplines: implementation and deployment; support management and analytics; and lifecycle services. Combined, these capabilities offer enterprises a comprehensive suite of services to support mobile requirements from deployment to upgrade (see Exhibit 3). Key capabilities include the following:

Implementation and deployment. Whether an organization is deploying 50 or 5,000 mobile devices, critical decisions relating to device configuration, kitting, profile management, and business process integration need to be made. According to our research, staging/kitting, post deployment testing services, and device provisioning were identified as the services with the greatest impact on a successful mobile deployment (Exhibit 4).

Issues such as not managing profiles efficiently or poor configuration control have represented key process pain points for organizations that can be overcome with better device management. In addition, with a mobile warehouse workforce that turns over rapidly—especially considering temporary support required during peak sea-

EXHIBIT 3

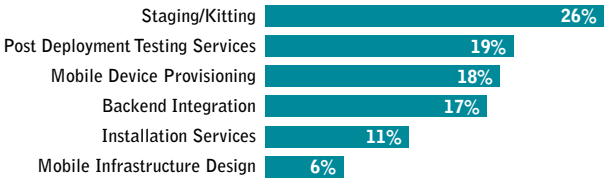
Enterprise Mobility Managed Services



Source: VDC

EXHIBIT 4

Services Most Influencing a Successful Deployment



Source: VDC

sons—the ability to seamlessly and efficiently get these workers live is critical to these businesses.

Support, management, and analytics. Once mobile devices have been deployed, the ability to manage them and provide support services aligns well with the managed services value proposition. This includes everything from ensuring that when a device does fail, the impact on operations is minimal to providing a controlled release process for mobile OS updates and application provisioning. The scarcity of IT resources within organizations today is resulting in major inefficiencies, often leading to cost disadvantages when compared to third-party service organizations.

Lifecycle services. Often overlooked, lifecycle services provide the business continuity required for business-critical mobile solutions such as those supporting warehouse operations. Ensuring that organizations are proactively managing their installed base of mobile devices with clear upgrade goals and the flexibility to adapt to business and technology changes is essential—especially in the more conservative mobile line of business segments such as warehouse automation.

Moving to a Next Generation Mobile World

There is little question that the pressures facing supply chains from omni-channel fulfillment to improved service levels and accuracy while controlling costs will only increase. As VDC research shows, mobile technologies deliver a tangible ROI today and will play an even more important role tomorrow. While smartphones and iPads, wearable computers and smart glasses have a future role to play, they are still emerging technologies when it comes to supply chain applications. The winners will be those organizations that apply the right technology to the right application to align their mobility investments with tomorrow's supply chain needs.

Innovation: It's Not Art; It's a Capability

Innovation is a repeatable process that can be studied, learned, and practiced—one that will sustain a company's profitable growth for decades.

By Violetka Dirlea, Kai Engle, and Jochen Graff

Editor's note: *The A.T. Kearney Best Innovator competition began in Germany in 2003, partly in response to rising concern among Western European companies that more sophisticated—and lower-cost competitors—from emerging nations were threatening their long-term profitability and perhaps their survival. Contest organizers wanted to spotlight great innovators to show how innovation is done.*

Now held in 20 countries around the globe, the competition has yielded a wealth of insights into how companies can excel in innovation management. This annual benchmarking against the best innovators focuses on the how-to of innovation and takes a deep look at what leading companies are doing to achieve better yield with their innovation strategies.

In *Masters of Innovation: Building the Perpetually Innovative Company,* a new book from A.T. Kearney, the authors highlight real experiences of the world's Best Innovators from 10 years of results from the Best Innovator competition. Masters of Innovation is a manual for creating a permanently innovative organization, deriving lessons for best practices from the experiences of the Best Innovators—members of a select team of companies that come in all sizes and from all industries around the world. The excerpt below shows that being innovative is a repeatable process that can be studied, learned, and practiced—one that will sustain a company's profitable growth for decades.

Common Virtues of Best Innovators

Best Innovators are often companies under pressure. Sometimes they face a threat of commoditization to a core product, or they might be contending with new entrants or an upstart technology. Yet what is remarkable is that their innovation strategies are not reactive. Their strategies are forward-looking and constant, open to course correction but clear in their destinations, through good times and bad.

Best innovators share common virtues. For all of them, integration of process and deep-rooted innovation cultures are character traits. Best Innovators are always in a state of future-mindedness, and they don't get blindsided by change.

Reviewing the metrics from the Best Innovators reveal that it's not how much you spend but how you spend it. For these organizations, innovation is not a factor of brute force—lots of budget, lots of time, lots of people—any more than it is the fruit of some eureka moment. Innovation for these companies is a management capability and a repeatable process.

To get their innovation strategies right, Best Innovators invest up front in understanding market, technology, and service dynamics. They are investing time more than money. Once they have their innovation strategy right, not just on paper but in the minds of all their most influential internal decision makers, they begin collecting

Violetka Dirlea, Kai Engel, and Jochen Graff are co-authors of *Masters of Innovation: Building the Perpetually Innovative Company*.

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the ideas that have potential into a managed portfolio. We call this portfolio search fields. These are the wellhead of the innovation flow.

Alignment in Support of the Innovation Portfolio

For Best Innovators, the job of prioritizing the possibilities in their innovation portfolios is never finished. At every point along the way to market, the business case for an idea is tested to see if it still holds up.

This would seem to be an obvious best practice for any company, and yet it is frequently overlooked, usually because of poor communication norms. Markets move, planning premises change, variability in the cost of raw materials alters pricing dynamics even before a product launches. All of these have direct effects on profitability. A regular update of planning premises is an institutional habit with Best Innovators. A change in those premises might mean one idea needs to be killed or delayed while another is bought forward in the portfolio's list of priorities.

An innovation portfolio is like a funnel. But the Best Innovator funnel has an odd shape. It does not taper steadily to product launch. Instead, the funnel abruptly pinches near the middle, around the time search fields begin to yield specific ideas that can be argued with a business case or, as the case may be, rejected.

At every stage in an idea's development, collaboration makes a concept stronger. The definition for collaboration is cross-functional cooperation within the organization. We find this sort of internal alignment typical of Best Innovators, but—sometimes to our surprise—it is not always the norm among their peers.

Internal alignment is a predictor for an innovation's long-term value to a company and its shareholders. We all know, for example, about Sony's failure in the mobile entertainment market. Often forgotten is that senior leadership didn't focus the attention of the whole organization on the meaning of mobile entertainment for growth. Eventually, the consequence was the surrender of Sony's early lead in smartphones and Apple's dominance of the market.

Best Innovators have all kinds of organizational structures, but overall, they integrate more internal functions in the innovation process than the average of all participants in the competition. All of them have well-considered processes to ensure continuous cross-functional involvement of pivotal internal functions—chief among them are R&D, production, sales, and tellingly, procurement.

The talent for cross-functional collaboration is true of Best Innovators when they engage in partnerships outside their own organizations. Best Innovators know that the best and brightest talents don't all work for them. To supplement their inventory of competencies, Best Innovators appear to step naturally into intimate collaborative relationships with an array of outside players—from customers and suppliers to universities, government agencies, and event competitors.

The world is a complex place with knowledge generated from every corner. Best Innovators see the world as a network of knowledge clusters, of which their organization is just one. For Best Innovators, knowledge management is more than a vogue phrase. It is an actively managed capability in support of alignment and creative flexibility. They link their cluster to others, transfusing capabilities into—and across—their organizations.

The KPIs to which Best Innovators are conspicuously attached help enormously in providing guidance. They let senior managers and members of an organization at large track the progress of the innovation portfolio with hard facts. When speaking to the senior leaders of Best Innovator winners, it is remarkable how many can rattle off KPIs for their innovation strategies, especially time to profit—a measure of how long a product needs to become profitable, measured from the moment it was decided to develop the product or service. It is the essential KPI of an innovation portfolio.

For Best Innovators, knowledge management is more than a vogue phrase. It is an actively managed capability in support of alignment and creative flexibility.

That clarity is essential to providing a creative structure to the overlapping networks described. Members of those networks—not all of them inside the organization—need to communicate with one another and make decisions quickly. With one collaboration tool or another, they talk to one another. Most of these conversations about commercializing ideas are not explicitly directed by senior management. But with clarity of vision and agreement on mission, the collective evaluation of ideas acquires structure that permits new ideas to be applied faster.

One of the key conclusions of Masters of Innovation is the importance of durability, or how the leaders are able to maintain their innovative concepts year after year. Substantial growth comes from delivering on durable innovation strategies, durable in their constancy and durable in their structured openness to change. This is, once again, a tension that Best Innovators manage well because they take great care in building their leadership teams.

A SPECIAL SUPPLEMENT TO:
SUPPLY CHAIN MANAGEMENT REVIEW

THE TOP 50: Great management, even better operations

Analysts say the annual listing reflects the management teams that are willing to get their hands dirty in order to compete in the cutthroat world of deregulated trucking. Here are the carriers that are leverage rolling assets and technology to post the most impressive financial numbers.

By John D. Schulz, Contributing Editor

They all operate basically the same trucks. They all haul similar trailers. They all hire from the same pool of driver candidates. They compete for the same shippers. And they all try to abide by the scores of federal and state regulations that control this economically deregulated, $720 billion industry we call "trucking."

So what sets apart the best from the rest? "To me, it's how senior management rolls up its sleeves and gets dirt under their nails," says Satish Jindel, principal of SJ Consulting, a research firm that keeps a close eye on the trucking industry. "If they're hands off and all they want to do is sit in fancy meetings and look at flip charts all day, they're not going to cut it. If you don't have depth of understanding in this industry, you're not going to do well."

Whether a trucking company has 300 or 3,000 employees, size shouldn't make much of difference at the end of the day, Jindel adds. His research shows that it's how trucking managers and employees interact with one another—and ultimately their customers—that

Top 25 less-than-truckload carriers: 2014 revenues

(Including fuel surcharges)

Rank	Carrier name	2013 Revenue ($ million)	2014 Revenue ($ million)	YoY % Change
1	FedEx Freight	$5,095	$5,672	11.3%
2	Con-way Freight	$3,466	$3,632	4.8%
3	YRC Freight	$3,127	$3,220	3.0%
4	Old Dominion Freight Line	$2,270	$2,710	19.4%
5	UPS Freight	$2,502	$2,633	5.2%
6	Estes Express Lines	$1,835	$2,043	11.3%
7	ABF Freight System	$1,720	$1,885	9.6%
8	YRC Regional	$1,730	$1,832	5.9%
9	R+L Carriers*	$1,298	$1,415	9.0%
10	Saia Motor Freight Line	$1,139	$1,272	11.7%
11	Southeastern Freight Lines*	$914	$1,006	10.0%
12	Averitt Express	$606	$674	11.2%
13	Central Transport Intl.	$488	$667	36.8%
14	Roadrunner Transportation	$559	$577	3.3%
15	AAA Cooper	$500	$508	1.7%
16	Dayton Freight Lines*	$386	$446	15.4%
17	Pitt-Ohio Express	$362	$393	8.5%
18	New England Motor Freight	$358	$372	3.9%
19	A. Duie Pyle	$259	$282	8.9%
20	Central Freight Lines*	$208	$218	4.8%
21	Daylight Transport	$183	$202	10.4%
22	Oak Harbor Freight Lines	$168	$184	9.3%
23	Ward Trucking Corporation	$140	$153	9.3%
24	Wilson Trucking	$147	$148	0.8%
25	Lakeville Motor Express	$121	$125	3.3%
Total Top 25 LTL carriers		**$29,581**	**$32,270**	**9.1%**

Note: Revenue for LTL operations only, unless otherwise indicated and include Canadian operations
Revenues primarily LTL and include less than 10 percent for truckload and other services
Source: Company reports and SJ Consulting Group estimates

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Top 25 truckload carriers: 2014 revenues
(Including fuel surcharges)

Rank	Carrier name	2013 Revenue ($ million)	2014 Revenue ($ million)	YoY % Change
1	Swift Transportation	$3,287	$3,611	9.9%
2	Schneider National	$2,320	$2,465	6.3%
3	Landstar System*	$1,606	$1,794	11.7%
4	J.B. Hunt Transport Services	$1,622	$1,779	9.7%
5	Werner Enterprises	$1,642	$1,683	2.5%
6	Prime**	$1,418	$1,601	12.9%
7	U.S. Xpress Enterprises	$1,480	$1,540	4.1%
8	CRST International	$1,070	$1,099	2.8%
9	C.R. England	$1,152	$1,071	-7.1%
10	Crete Carrier Corp.**	$1,008	$1,034	2.6%
12	Knight Transportation	$822	$892	8.5%
11	Heartland Express	$582	$871	49.7%
13	Ruan Transportation Management Services	$712	$757	6.3%
14	Ryder Systems	$709	$738	4.1%
15	Greatwide Logistics / Cardinal Logistics	$780	$734	-5.9%
16	Celadon Group**	$601	$697	16.0%
17	Roadrunner Transportation	$441	$689	56.4%
18	Covenant Transportation Group	$634	$649	2.5%
19	Stevens Transport	$621	$635	2.3%
20	Con-way Truckload	$637	$632	-0.8%
21	Anderson Trucking Service	$567	$583	2.8%
22	Universal Truckload Services*	$533	$580	8.8%
23	Mercer Transportation*	$483	$547	13.3%
24	Western Express	$463	$540	16.6%
25	NFI Industries	$512	$535	4.5%
Total Top 25 TL carriers		**$25,703**	**$27,757**	**8.0%**

*Light-asset carrier
**Results adjusted to closer resemble calendar year
Revenues primarily for truckload operations and may include less than 10 percent for non-truckload services
Source: Company reports and SJ Consulting Group estimates, prepared by SJ Consulting Group

matters when measuring success.

Experts and top executives agree that it's that tactical, day-to-day awareness of what's going on in a trucking operation that helps to set the top carriers apart. The "ins and outs" of the ever-changing trucking world change, sometimes rapidly, and top management needs to be nimble enough to answer those challenges daily.

The importance of having an active management team took on greater importance in the wake of the Motor Carrier Act of 1980, which deregulated interstate trucking. Donald Broughton, chief market analyst for Avondale Partners and a long-time trucking analyst, says that deregulation in 1980 created the "nimble" trucking industry that we know today.

Prior to deregulation, logistics costs amounted to nearly 19 percent of GDP. Today that figure is about 8.5 percent, or just about half what it was in 1980. "That's because they deregulated the industry," Broughton says. "This country has the lowest distribution costs in the world, which is a remarkable thing given our size."

The best motor carriers are the ones who have adapted to that changing landscape—and many haven't or couldn't. Of the Top 50 motor carriers in 1979, the last full year of economic regulation, only five remain today—YRC Worldwide, ABF Freight System, UPS Freight (then known as Overnite Transportation), Central Freight Lines, and Central Transport. The rest have either ceased operations, gone bankrupt, or have merged with other entities under different names.

Today, virtually every one of the Top 25 truckload (TL) companies didn't exist prior to deregulation—and most trucking veterans wouldn't recognize the operations of the surviving LTL carriers because of their technology, modern freight routing software, and other 21st Century advances necessary to keep pace in today's rapid paced delivery environment.

"What drives the trucking industry is variability of demand, variability of freight flows, weather, and a huge number of people and machines that help you deal with variability."

—Mark Rourke, Schneider National

"It boils down to management," says Broughton. "This is a tough business with very complex issues. With some brands, like Coca-Cola, any jockey could ride that horse. That's not the case in freight transportation. Management does matter. Operations do matter."

The importance of operations is underscored by the huge variables inherent every day in trucking—uneven demands due to seasonality and other factors, managing a huge capital- and labor-intensive business, and, of course, the unevenness of the overall national economy.

"What drives the trucking industry is

variability of demand, variability of freight flows, weather, and a huge number of people and machines that help you deal with variability," says Mark Rourke, president of truckload for Schneider National (No. 2 TL on our list). "Variability is the biggest cost driver in the industry."

And the Top 50 continue to do well, adds Rourke, because they have the ability to invest in the best technologies and latest equipment with enhanced safety features, enabling them to cope with that variability.

"To stay on top of this ever-changing environment, all the Top 50 carriers have progressive and talented management teams," says James Welch, CEO of YRC Worldwide. "Longevity in the marketplace is another characteristic of the Top 50 as are good operations, certainly. You have to be able to execute on what you say you can do."

So what internal moves are the best of the best making to stay on top? Let's take a deeper dive into what makes sister magazine *Logistics Management*'s Top 50 tick.

Staying on top

Welch, by all reports, inherited a nearly bankrupt operation when he assumed the chief executive post at YRC Worldwide in late 2011. The company had lost in excess of $2 billion when he decided to return to the company in which he had spent his formative years in middle management.

When he took over, nearly every YRC operating unit was losing money, its workers were demoralized and fearful of losing their jobs, and shippers were beginning to question YRC's staying power in the market place. And, of course, the company was struggling under the weight of approximately $1 billion in long-term debt.

"Getting our balance sheet right, getting equity back in our business, and extending our labor agreements through 2019 cleared up the murky waters and allowed us to reinvest in the companies and compete in the marketplace," Welch explains. "We now have a good amount of runway in front of us, and we're not focusing on the past six or

seven years."

Strategically, Welch has done an excellent job of separating YRC's operating companies from the holding company that has the large debt load. Holland, New Penn, and Reddaway run as independent companies in the regional marketplace, and he tweaked the Yellow and Roadway long-haul networks to operate profitably. With these moves service has improved, productivity is up, and employee engagement is back.

"Our employees have been through a lot," says Welch. "We renegotiated labor concessions in the middle of our contract, something we had to do to get the refinancing done. We knew we had to go through that. Our employees had lost a step or two, and it took some time to get that back."

Welch is also adjusting operations. YRC is asking the Teamsters for greater use of interline carriers—third-party transportation providers—in areas currently served by YRC drivers due to the lack of density in these remote areas.

YRC has also returned to buying new equipment for the first time in about six years. In the first six months of this year, YRC is on pace to acquire 600 new tractors and 2,000 new trailers. "We're not back to our normal standards, but we're making nice strides," says Welch.

Brian Balius, vice president of transportation for Saia (No. 10 LTL), a multi-regional LTL carrier with 167 locations and 7,500 employees operating in 34 states, says that the carrier is centered around improving the quality experience for shippers. "That means reducing defects, claims, and service failures," he says.

It must be working. Saia grew revenue by 11.7 percent last year, one of the top growth rates in the LTL sector. Balius says that the carrier is seeing this growth due to investments in retraining employees, raising standards, and making financial investments in rolling stock and equipment such as air bag inflators that go between pallets to optimize trailer space.

Virginia Tech institute to study HOS impacts

The Virginia Tech Transportation Institute will study impacts of restart breaks on commercial truck drivers' safety performance and fatigue levels as part of a $4 million study for the Federal Motor Carrier Safety Administration (FMCSA). It's the largest on-highway study of HOS and fatigue ever done, the group said.

Last December, motor carriers won a one-year suspension of two provisions of the current HOS rules. Trucking interests say the mandatory breaks are unnecessary and costly and that drivers themselves are the best judges of when they're tired or not.

Virginia Tech will compare truck driver fatigue and safety performance levels for drivers who take two nighttime rest periods during their 34-hour restart break to drivers who take less than two nighttime rest periods during their restart break. An estimated 250 drivers will take part in the study.

"A better understanding of how the new hours-of-service provisions are being implemented by drivers is an extremely important issue for highway safety," says Rich Hanowski, director for the Center of Truck and Bus Safety at Virginia Tech. "We have an opportunity to perform ground-breaking research that will have an impact for decades to come."

The study will compare five-month work schedules of drivers, assessing crashes, near-crashes, crash-relevant conflicts, operator fatigue/alertness, and short-term health outcomes for the two groups of commercial truck drivers.

Drivers are being recruited from small, medium, and large fleets across a variety of operations to help ensure statistically significant results. The research plan also involve including a variety of haul types in the study, including flat-bed, refrigerated, tanker, and dry-van trailers.

Hanowski's team will track driver road-time as well as resting/sleeping status through onboard truck electronic logging devices that track a driver's on-duty time and record and measure safety-critical events. The team also will measure and code fatigue levels of drivers using high-tech wrist watches.

The Virginia Tech Transportation Institute will issue its final study report subject to independent peer review panels with both medical and scientific expertise. The study findings will ultimately be delivered to the Department of Transportation and Congress.

—John D. Schulz, Contributing Editor

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Phil Pierce, executive vice president of sales and marketing for Averitt Express (No. 12 LTL), agrees that experienced management and operational teams are priceless. "I've been here 33 years, and we're still growing the business to assure our future," he says. "We have to bring new ideas to the table to improve and enhance our relationship with our customers."

Progressive LTL companies such as Averitt and Pitt Ohio (No. 17 LTL) have started offering transportation management systems (TMS) in order for customers to easily plan and track their transportation spend. A recent Peerless Research group survey shows that one third of shippers are currently using TMS while another third are looking into the prospect.

"We've started offering TMS to our smaller customers," Pierce explains. "We're trying to offer things that previously they couldn't afford on their own."

Saia and other trucking companies are also eagerly investing in technologies that provide a cost advantage, including telematics for tracking each customer's freight. The shift to electronic log books also adds efficiencies to operations such as payroll and driver compliance. And then there's greater use of TMS to help create all-important freight density by carriers eager to achieve as much efficiency on each load.

"Our incremental costs are dramatically less that way," says Saia's Balius. "Directionally, the whole magic of logistics is finding carriers that need freight in the direction that shippers have it. That's what we try to maximize."

Driver dilemma

According to industry analyst Broughton, attracting and retaining a sufficient supply of compliant truck drivers is the single largest inhibitor to growth in trucking. "I'm sure that there are many TL carriers that would love to grow, but can't find drivers," he says. "Money is not the sole answer, but it sure does help."

Schneider's Rourke says that the driver situation is as difficult as he can remember—and that's even with taking several proactive steps to stay ahead of the curve. "We get drivers home every week. Our pay is competitive, and we train drivers for 16 months into an aggressive student program and extend that program an additional five weeks on the road with experience drivers," he says.

Even so, Schneider says it's not considering expanding its fleet at this time because of the tightness in the driver supply. Other TL carriers say they are doing the same thing.

Averitt's Brad Brown says that one of the key components to its driver-training program is mentoring. "We pair younger drivers with older guys for several weeks," he says. "They get to learn not just driving but safety techniques and the day-to-day challenges of the road. We have finishing schools to teach them more driving skills, such as backing up, giving them a little more confidence."

There's no question that carriers are throwing money at the driver problem. Some 42 percent of trucking companies raised driver pay last year, according to the National Transportation Institute's survey of more than 300 carriers.

There's no question that carriers are throwing money at the driver problem. Some 42 percent of trucking companies raised driver pay last year, according to the National Transportation Institute's survey of more than 300 carriers—compared to the 11 percent of that offered raises in 2012.

YRC is recruiting drivers once again, a pleasant enough endeavor for a company struggling with layoffs as recently as 2009. "It's the first time we have driver recruiters," says Welch, noting historically that LTL carriers haven't had problems hiring sufficient drivers.

"We're really going hard after military," Welch adds, noting that YRC has joined the U.S. Chamber of Commerce's "Hiring our Heroes" program. "Vets have been trained well. They're disciplined, and they're good workers."

Capacity and rates

So even with hands-on management teams of the Top 50 trucking companies coping with

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an array of operational issues, their internal costs are rising at such a degree that rate increases are seen as inevitable for 2015.

In fact, shippers ought to brace for stiff rate increases in their contract renewals. Capacity is tight, and rates should reflect that tightness, carrier executives contend.

"If capacity stays where it is, we're putting pricing improvement ahead of volume," says Welch. "From 2008 through 2012, we didn't stay with the market from a pricing standpoint. We're taking this opportunity to get pricing and freight mix right, so that's our priority for 2015."

Most LTL carriers took a general rate increase of about 5 percent in January. Whether that will suffice for the year is difficult to say in this currently tight freight environment. "My crystal ball isn't any more pristine than the others," says Balius. "We're well prepared to take on additional growth, we've invested in sales resources, and we're optimistic that none of the macroeconomic things will adversely affect this."

"Our focus is on margins, not so much growing our driver count," says Schneider's Rourke. "We think transportation is cyclical, and we want to make sure that we're nimble and have the ability to adapt and adjust, but adding a bunch of people is a costly endeavor. We think we're sized in the right way to take advantage of market, whether it goes up or goes down."

Most executives say shippers should expect rate increases in the 3.5 percent to 5 percent range, perhaps slightly higher on some geographic lanes where capacity is tighter.

However, the strategies of the individual companies comprising the Top 50 may change depending on the specific operations and industry niche. But the message from the top senior management teams remains constant: They will be there when and where shippers need them at competitive rates, and they'll be telling their employees that they are valued members of the team.

John D. Schulz is a Contributing Editor to Supply Chain Management Review

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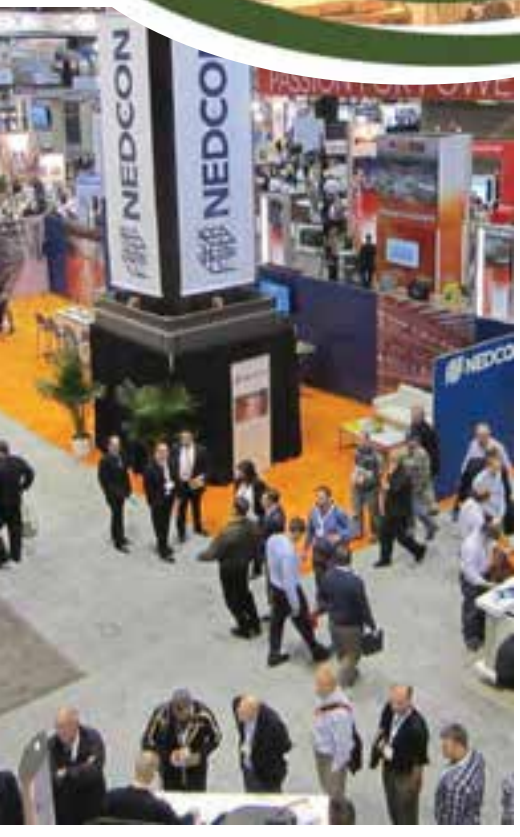

ProMat 2015 covered 340,000 net square feet of exhibit space in Chicago's McCormick Place in March with 802 exhibiting companies.

Record-breaking ProMat held in Chicago

ProMat hit new records this year, according to John Paxton, president of MHI, both in terms of numbers of exhibitors and of attendees. With registrations topping 37,091 attendees, show producer MHI announced a 8.8 percent attendance jump over 2013. The four-day event held in March, covered 340,000 net square feet of exhibit space in Chicago's McCormick Place with 802 exhibitors. ProMat was once again co-located with Automate.

"This year's show encompassed all of the products, solutions, and systems needed to drive manufacturing and supply chain optimization," said Paxton. Combined, the two show floors used 400,000 square feet of space dedicated to helping organizations improve the productivity of their manufacturing and supply chain operations.

ProMat 2015 featured 125 educational sessions, including four keynotes, a supply chain workforce summit, and more than 110 show floor seminars focused on the latest materials handling, logistics, and supply chain innovations and applications.

Here are some highlights from the show.

Dematic introduces suite of intra-logistics systems

At a press conference, Dematic featured a range of solutions for factories, warehouses, and distribution centers. The new suite, powered by performance-optimizing software, encompasses receiving, storage, order fulfillment, buffer staging, packing, and palletizing.

John Baysore, CEO Dematic North America, said the solutions can be tailored to a wide range of needs, from light- or voice-directed put walls capable of 200 to 400 picks per hour to robotic each-picking systems that achieve 1,200 picks per hour. "These operational improvement methods can be applied in many configurations and capacities, from small point solutions to large integrated systems," Baysore said. "Because these solutions are modular, flexible, and scalable, we can help small companies become big ones."

Each solution, including very narrow aisle automatic guided vehicles (AGVs), shuttles, and automated mixed case palletizing, is managed and controlled by Dematic iQ performance optimizing software. Baysore also emphasized Dematic's service presence in 67 cities, up from 55 last year. Dematic aftermarket service has achieved a first-time repair rate of 94 percent, he said.

John Baysore, CEO of Dematic North America

Buffer, sequence orders, and small parts with Kardex Remstar solution

Tom Coyne, president of Kardex Remstar

Used for compact, high-speed case and tote buffering and sequencing, Kardex Remstar highlighted the new sort2ship solution in a ProMat press conference

The system incorporates order lines from storage lifts, vertical carousels, and static shelving in a compact footprint. When connected to conveyors and an automatic load-handling device, the system automatically transports containers to a Megamat RS vertical carousel for buffer storage.

"Sort2ship can provide on-demand sequencing to meet customer-specific shipping requirements, automatically routing them to packaging or shipping," said Tom Coyne, president. "The system enables DCs and e-commerce suppliers with several thousand order lines per day to significantly increase their order picking productivity."

Other potential applications include automatic goods-to-person order picking for small parts inventory, delivering inventory to multiple workstations, and improving ergonomics, Coyne added.

Intelligrated showcases what's next for e-commerce

Chris Cole, CEO of Intelligrated

At a press conference, Intelligrated showcased a series of solutions to optimize order fulfillment processes for e-commerce and omni-channel fulfillment operations.

Featuring exhibitions of the company's software, picking technologies, put wall, automated storage and retrieval systems (AS/RS), conveyor solutions, and sortation systems, Intelligrated's booth was complemented by a booth at Automate highlighting the company's GoKart autonomous mobile robot.

A live demonstration of the company's shuttle technology featured the OLS (one-level shuttle) retrieving products from storage. Handling totes and cartons, the system supports goods-to-operator fulfillment, product sequencing and buffering, and just-in-time inventory management applications.

"The theme for our booth is: "What's next for e-commerce,'" said Chris Cole, CEO of Intelligrated. "Coordinated by integrated software solutions, our modular and scalable solutions can help manage the transition from pallet to case handling and from case handling to each picking. In all manners, distribution and warehousing are changing, and not just in retail."

After hiring 300 employees last year and a further 200 already this year, Intelligrated has also created a dedicated team of 15 individuals within the sales department to meet the increasing demand for aftermarket support.

VNA swing-reach truck unveiled by Raymond Corp.

The Raymond Corp. launched an extension of its existing swing-reach (turret) very narrow aisle (VNA) line of lift trucks.

The Model 9800 joins the 9600 and 9700, expanding the product family's capabilities to higher elevated lift heights and heavier capacities, explained Justin Byma, product manager for very narrow aisle products. "The vehicle has a 3,300-pound base capacity and standard lift heights up to 50 feet," he said. "It fits a nice slot before our existing Transtacker vehicle, which reaches up to 60 feet."

Ideal for any company struggling with warehouse floor space constraints, Byma said key markets include textile and apparel, e-commerce, durable goods, wholesalers, and manufacturers.

The vehicle was engineered for maximum energy efficiency, with an advanced lift system with electric regenerative lowering and a hydraulic counterbalance that reduces total system energy demand. Its articulated steering mechanism is unique, he added. "It supports better maneuverability in tight spaces."

Justin Byma, Raymond product manager for very narrow aisle products

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Scalable multi-level Navette shuttle offered by SSI Schaefer

In its automated systems and materials handling solutions exhibit, SSI Schaefer Systems International showcased the Navette scalable, multi-level shuttle. Flexible, the automated shuttle stores and picks trays, totes, or cartons stored within a steel framework of aisles. It is guided by travel and support rails and serves up to eight storage levels.

The system can be scaled precisely to fit the widest possible range of items in the storage aisles, explained Mark Dickinson, executive sales manager. "The Navette totally negates the need for SKU slotting, and can get product to and from any location very quickly."

Solutions based on the Navette can be tailored to order volume, required throughput and individual article structure, he added. "Our 3D-Matrix solution utilizes Navette lifts and vehicles in X-, Y-, and Z-axes, allowing it to send multiple products to any location with a throughput increase because products don't have to be sent to the end of an aisle. Instead they route to the nearest lift and then are on their way."

JBT debuts AGV with on-board intelligence to target mid-sized needs

With the aim of filling the gap between facilities that rely on automated guided carts (AGCs) or conventional lift trucks to move materials, and those that use traditional automatic guided vehicles (AGVs) with a central computer, JBT introduced the JayBot AGV.

JBT marketing manager Mark Longacre next to a JayBot, JBT's new AGV with on-board intelligence that eliminates the need for a central system manager

The new AGV is well suited to this mid-sized niche because it has on-board intelligence and navigation sensors for safety and traffic control, rather the requiring a central management computer, said Mark Longacre, JBT marketing manager.

The on-board smarts and sensors allow the JayBot to navigate without the installation of reflectors, wires, or magnets within a facility, which further holds down costs.

When the system is set up, the AGV is driven around the facility to create a baseline of the routes to take, and while in operation, it navigates by comparing what its sensors see to this baseline. "We call it the industry's smartest AGV because it takes all that intelligence for traffic control and safety and puts it right on the vehicle," says Longacre.

The lower cost from eliminating traditional guidance infrastructure and a system manager layer makes the JayBot well suited to middle segment applications where AGCs don't offer enough functionality and where traditional AGV systems are too complex or too costly. The JayBot is capable of precise maneuvering, including the type of positioning needed for servicing racks, stands, and other locations.

Yale rolls out a variety of new products and fuel sources

A walkie powered by lithium ion batteries, very narrow aisle products, an automated tow tractor, and fuel cell battery replacement packs were among the new products on display from Yale Materials Handling Corp.

With a 25 percent smaller battery compartment, the MPB045VG lithium-ion walkie pallet truck is more maneuverable inside delivery trucks and retail stores. The battery is UL certified and is backed by a five-year warranty.

As another battery alternative, Nuvera hydrogen fuel cells require no alterations to the standard lift truck, can be fully refueled in two minutes and always perform like a fully charged battery, according to David McNeill, manager of product strategy for Yale.

"Customers continue to have issues with lead-acid batteries," McNeill said. "Instead of dealing with extra equipment or the labor and costs associated with lead-acid, customers can break free of those constraints with our lithium ion and fuel cell options."

The new very narrow aisle offering can be supported by Yale Aware RFID technology, which uses chips embedded in the floor to inform the lift truck about its environment. No two applications or aisles are the same, and the system can help avoid collisions with overhead obstacles or control speed at the ends of aisles.

David McNeill, manager of product strategy for Yale

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Jungheinrich showcases new, 100 percent U.S.-made electric reach truck

Perry Ardito, general manager (left), and James Gully, sales manager, from Jungheinrich

Perry Ardito, general manager of MFCA's Jungheinrich brand, highlighted the newest model ETR electric reach truck. "The ETR is the first Jungheinrich model to be completely designed, engineered, and manufactured in Houston to meet the North American market demand for this type of vehicle," he said.

Since the release last summer, ETR sales have vastly outpaced the original forecast, Ardito added. Grocery, e-commerce, retail, and other high-throughput applications with higher lifting and heavier capacity requirements are ideal for the vehicle.

Ardito also pointed out a new automatic battery extraction system for the Jungheinrich line of electric counterbalanced trucks, and showed an exclusive warehouse navigation system that works with the brand's turret trucks and order pickers.

"The navigation system enables semi-automated picking. Once the operator drives the truck to an aisle, the system determines the most productive and efficient path to the pick locations in the racking," he said.

Honeywell focused on vehicle, operator productivity

Equipped with a 12-inch screen, Honeywell Scanning & Mobility's new Thor VM3 vehicle-mounted mobile computer gives operators an easy-to-read tool to improve productivity and task accuracy. It features a quick-mount smart dock and field-replaceable front panel screen, permitting easy swap outs for use on different vehicles.

Backwards compatible with legacy Windows software or upgradable to the latest releases, the device interfaces with Bluetooth-enabled voice-directed picking headsets to maximize efficiencies in activities such as case picking, truck loading, putaway, and replenishment, said Bruce Stubbs, director of industry marketing.

Bruce Stubbs, Honeywell's director of industry marketing

"We're working on ways to positively affect the interface between the worker and the devices to improve their user experience," he added.

For monitoring of operational performance and worker safety, Honeywell also released the Operational Acuity software portfolio. "It includes two solutions to measure vehicle and workflow performance," said Stubbs. "It helps identify areas for additional training by collecting data and applying analytics, then turning that info into simple, actionable, and measurable process improvements for cost reductions."

Hyster announces new engines with variable power technology

New IC engines by Hyster Company offer three performance modes for increased efficiency and productivity.

The booth's theme emphasized customizability of equipment to specific applications, and the new engines enable performance adjustments over the course of a day. For instance, if an application is typically busiest in the morning, the highest performance mode will maximize productivity. During a slower afternoon, a supervisor can switch equipment to the economy mode to consume almost 19 percent less fuel.

David LaDue, vice president of the west region for NACCO Materials Handling Group

Tested to withstand 30,000 hours of use, the new engines also produce 10 more horsepower, a 4 percent increase in acceleration, a 16 percent increase in performance on grades, 5 percent faster travel speed, 10 percent faster lift speed, and a 10 percent improvement in loads per hour.

"Variable power technology enables a balance of superior fuel economy or to maximize productivity during peak business periods when

moving more loads is critical to success," said David LaDue, vice president of the west region for NACCO Materials Handling Group, which also recently acquired Nuvera, a hydrogen fuel cell technology company. "Fuel cells, variable power engines, and more than 130 LPG, diesel and electric models allow us to provide a range of solutions tailored to each customer's needs."

Numina Group and Ferretto Group unveils VLM with integrated voice picking

At a press conference, Numina Group and Ferretto Group demonstrated a vertical lift module (VLM) with integrated voice picking technologies.

The result of a partnership between the two groups, the combination of Numina's RDS voice picking coupled with Ferretto's VLM delivers faster product picking and retrieval with improved storage density. Dan Hanrahan, president of Numina Group, said the system occupies 65 percent less floor space than conventional storage and the voice system can boost productivity by 40 percent over stand-alone VLMs.

Capable of heights beyond 50 feet, the VLM uses mechanically transportable storage shelves ranging in size up to 13 feet long by 3 feet deep with a weight capacity of up to 2,204 pounds. The system allows simultaneous picking and storage of parts, kits, finished product, and direct-to-consumer orders.

"Additionally, the control system uses off-the-shelf components available at hundreds of North American distributors," Hanrahan said. "This eliminates stocking of costly proprietary parts and allows customers to readily source spares and perform in-house maintenance."

Bob Hosier, senior vice president of design engineering for Numina Group

Close Relationships Lead to Superior Planning

Partner involvement in supply chain planning is beneficial, but now may be the time to take it to the next level.

By Becky Partida, Research Specialist–Supply Chain Management, APQC

Superior supply chain planning requires excellent insight into customer demand for products and the availability of materials from suppliers. Many organizations look to data collected internally to better understand these factors, but others collaborate with external supply chain partners as well. Collaboration with customers and suppliers can provide organizations with valuable perspectives on the supply chain that can result in benefits for all involved.

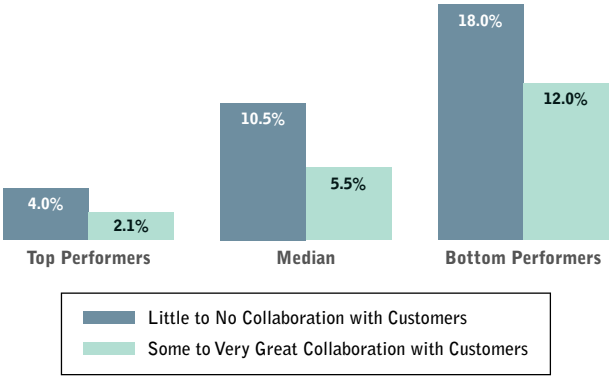
To determine the extent to which external collaboration can benefit supply chain planning efforts, APQC looked at data from its Open Standards Benchmarking in supply chain planning.* Participating organizations provided the extent to which their sales and operations planning processes involve external demand collaboration with customers, and the extent to which these processes involve external supply planning collaboration with suppliers. APQC grouped organizations based on the degree to which they engage in each type of external collaboration. The data indicates that organizations with more collaboration with either of these external groups have more accurate forecasts and more efficient planning operations.

Working with Customers Means Getting More

The data indicates that organizations collaborating more with their customers to determine demand more accurately predict the needs of their businesses with fewer staff and for a similar cost as organizations that conduct less collaboration with their customers. Those organizations collaborating more with their customers from some to a very great extent have a lower average monthly national forecast error than organizations that only collaborate with their customers to little or no extent. Those with more collaboration have a median error of 5.2 percent, whereas organizations with less collaboration have a median error of 13 percent. Organizations are clearly seeing benefits from greater collaboration with their customers to better determine demand for products. By getting the customer perspective on the market, organizations are able to more accurately determine how much product they should produce and keep on hand.

EXHIBIT 1

Collaboration with Customers and Inventory Carrying Cost



Source: APQC

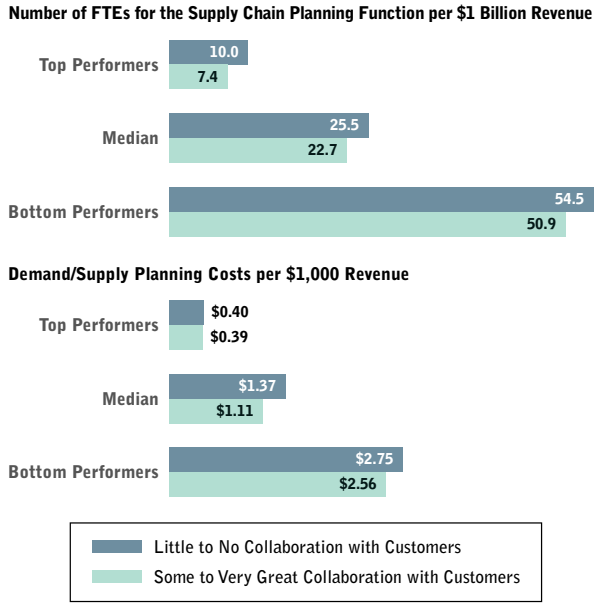
With improved forecasting comes better inventory management and thus lower inventory carrying cost. As shown in Exhibit 1, organizations that collaborate more with their customers for demand planning have an inventory carrying cost 5 percent lower than their counterparts that collaborate less with their customers. This further emphasizes the idea that collaboration enables organizations to better anticipate demand in the market and thus more accurately plan for needed stock. These organizations can then spend less on storing inventory.

APQC's data also shows that organizations collaborating more with their customers need fewer full-time equivalent employees (FTEs) for supply chain planning and spend less on the demand and supply planning process. At the median, organizations with more customer collaboration need about three fewer FTEs for supply chain planning per $1 billion in revenue (Exhibit 2). These organizations also spend $0.26 less on demand and supply planning per $1,000 in revenue than their counterparts with less customer collaboration. Although the cost difference may not seem significant, for an organization making $5 billion in revenue annually this difference would amount to $1.3 million more associated with demand and supply planning.

These results are interesting because they reveal that, despite additional tasks that may be associated with customer collaboration regarding demand planning, organizations engaged in more collaboration need fewer FTEs and dollars for the process. This hints that the insight organizations gain from collaboration enables them to streamline their demand and supply planning processes. The organizations are then able to dedicate less employee time to the planning process, thus reducing costs.

EXHIBIT 2

Collaboration with Customers and Supply Planning Operations



Source: APQC

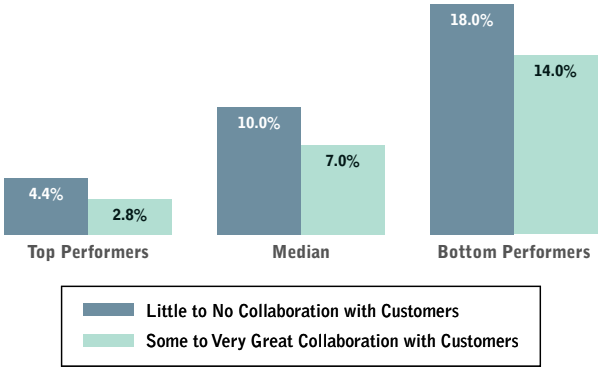
Additional Benefits with Supplier Collaboration

As with external collaboration with customers, organizations engaging in more external supply planning collaboration with their suppliers have clear advantages over organizations that engage less in this collaboration. Those that collaborate more with their suppliers have a much lower average monthly national forecast error than their counterparts that engage in less supplier collaboration. At the median, organizations collaborating more have an error of 5 percent, whereas organizations with little to no collaboration have an error of 27 percent. There is clearly a benefit to the forecasting process when organizations work with their suppliers to fine-tune which materials should be purchased and when so that they can best meet demand from customers.

As with customer collaboration, organizations collaborating more with suppliers also have a lower inventory carrying cost than organizations that engage in little to no collaboration with suppliers. At the median, those conducting more collaboration have a cost 3 percent lower than their counterparts with less collaboration. This indicates that the better forecasting achieved by organizations with more supplier collaboration can translate into less stock being

EXHIBIT 3

Collaboration with Suppliers and Inventory Carrying Cost



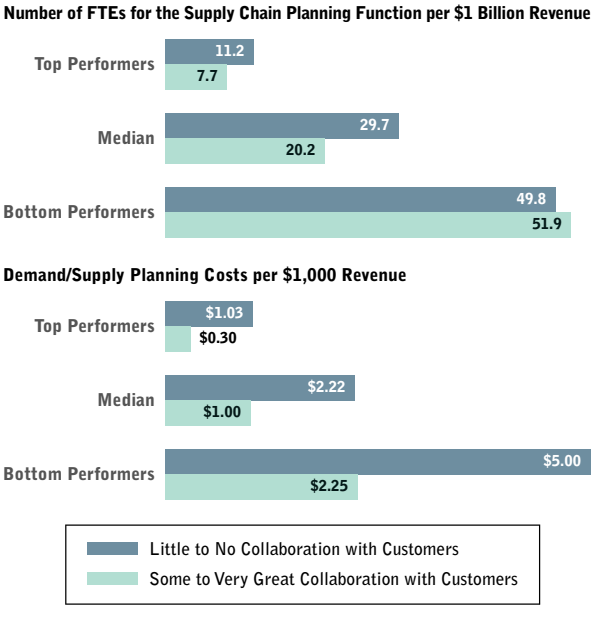
Source: APQC

carried at a given time and thus lower the cost of storing inventory.

APQC's data also shows large differences in performance for the two groups of organizations with regard to the number of FTEs for the supply chain planning function and demand and supply planning costs. At the median, organizations that collaborate more with their suppliers need nearly 10 fewer FTEs for supply chain planning per $1 billion in revenue than their counterparts that collaborate less. These organizations also spend $1.22 less per $1,000 in revenue at the median on demand and supply planning, resulting in the potential for $6.1 million in savings for an organization with $5 billion in annual revenue.

EXHIBIT 4

Collaboration with Suppliers and Supply Planning Operations



Source: APQC

The results from APQC's data again indicates that organizations collaborating with supply chain partners are more efficient in their supply chain planning efforts. It would seem from the data that the information obtained through collaboration with suppliers allows these organizations with more collaboration to make planning decisions that ultimately require fewer FTEs to complete and thus cost less.

Taking the Next Step

APQC's research indicates that organizations with higher amounts of supply chain planning collaboration with customers or suppliers are able to create better forecasts and can accomplish the planning process with fewer resources and at a lower cost. Many organizations collaborate with their supply chain partners to some degree during the planning process. This is often limited in the amount of collaboration as well as the types of partners that organizations look to collaborate with. Customer influence on the planning process may be limited because organizations often only estimate data on their trading partners that will be used during the demand planning process.

There are practices organizations can adopt to increase collaboration with their supply chain partners in an effort to improve forecasting and streamline the planning process. For collaboration with customers, this can involve identifying specific customers that can provide strategic benefit to the organization and then establishing relationships in which the organization obtains a majority of these customers' forecast sales volumes. This practice goes beyond simply estimating customer sales to creating truly collaborative relationships in which data is shared. Organizations can also consider working closely with customers to identify non-performing products and then generate markdowns or adopt other strategies to move this stock.

A basic level of supplier collaboration can mean working with first-tier suppliers to determine short- or long-term requirements for particular products and develop forecasts. To go beyond this, organizations can work with suppliers to obtain their inventory levels and capacities that can then be used in the demand planning process. Organizations can also consider adopting the formal Collaborative Planning, Forecasting and Replenishment (CPFR) model to facilitate information sharing with their suppliers through a shared information system. This can aid both buyers and suppliers in understanding the inventory needed to meet market demand.

* For more information on Open Standards Benchmarking for supply chain planning, visit www.apqc.org/benchmarking-portal/osb/supply-chain-planning.

About APQC

APQC is a member-based nonprofit and one of the leading proponents of benchmarking and best practice business research. Working with more than 500 organizations worldwide in all industries, APQC focuses on providing organizations with the information they need to work smarter, faster, and with confidence. Every day we uncover the processes and practices that push organizations from good to great. Visit www.apqc.org and learn how you can make best practices your practices.

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