

DRIVING DEMAND IN THE DIGITAL SUPPLY CHAIN:

Algorithms and the Untapped Power of Applying Real-Time Big Data and AI/ML



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“Companies that will successfully compete globally must have a Digital Supply Chain that captures a wealth of new data, analyzes it, and rigorously applies it to decision-making. The secret is to develop smart algorithms and harness the power of AI/ML to make it all work.”

**Sam Palmisano, former Chairman, and CEO, IBM and Chairman,
The Center for Global Enterprise (CGE)**

Chapter 1: Executive Summary

The results uncovered by this research call for companies to make rapid changes in their supply chains. They require companies to change the data they collect to make decisions, change the technology used to collect and analyze that data, and finally change, the focal point for decision-making. Companies that do this will significantly outdistance their competition, and companies that don't will lose ground. Modifying the four core DSC factors of Demand, People, Technology and Risk is not easy. However, the rewards are great.

Companies have begun creating Digital Supply Chains that make a difference, but progress is slow. They know the data they have, and are collecting from an array of sensors, which could be helpful. They understand that the Internet of Things (IoT) is in operation with everything from electric toothbrushes to automobiles to credit cards contributing data to it. Moreover, they are aware of the tremendous power of social media and its profound influence on society and business. However, the truth is that they are unable to craft a process to capture this data, clean it, analyze it and use it to drive supply chain decisions.

The good news is that there is a clear path forward. It involves heavy use of Artificial Intelligence (AI) and Machine Learning (ML) driven by specific algorithms. Fundamentally, the effective use of AI/ML and the enormous amount of data available will unlock the potential for your company to evolve from reactive to predictive. Companies will be able to anticipate future demand and predict the likelihood of future risks. However, effective use of AI/ML will require a cross-functional team of people to manage it. People to ask the right questions, define the right problems and perhaps, most important, use their judgement. We call this team the “Algorithm Council.” Companies that have this Council will create the algorithms that get smarter every day, and those that use AI/ML to manage the massive amounts of data will have winning supply chains.

In the following sections you will discover how the Digital Supply Chain manages demand, not just supply, a description of the research methodology, and a collection of the top insights that were derived from the work. Taken together, you will have a foundation upon which to inform the management decisions you have to make and the actions you have to take to create success with a leading-edge Digital Supply Chain.

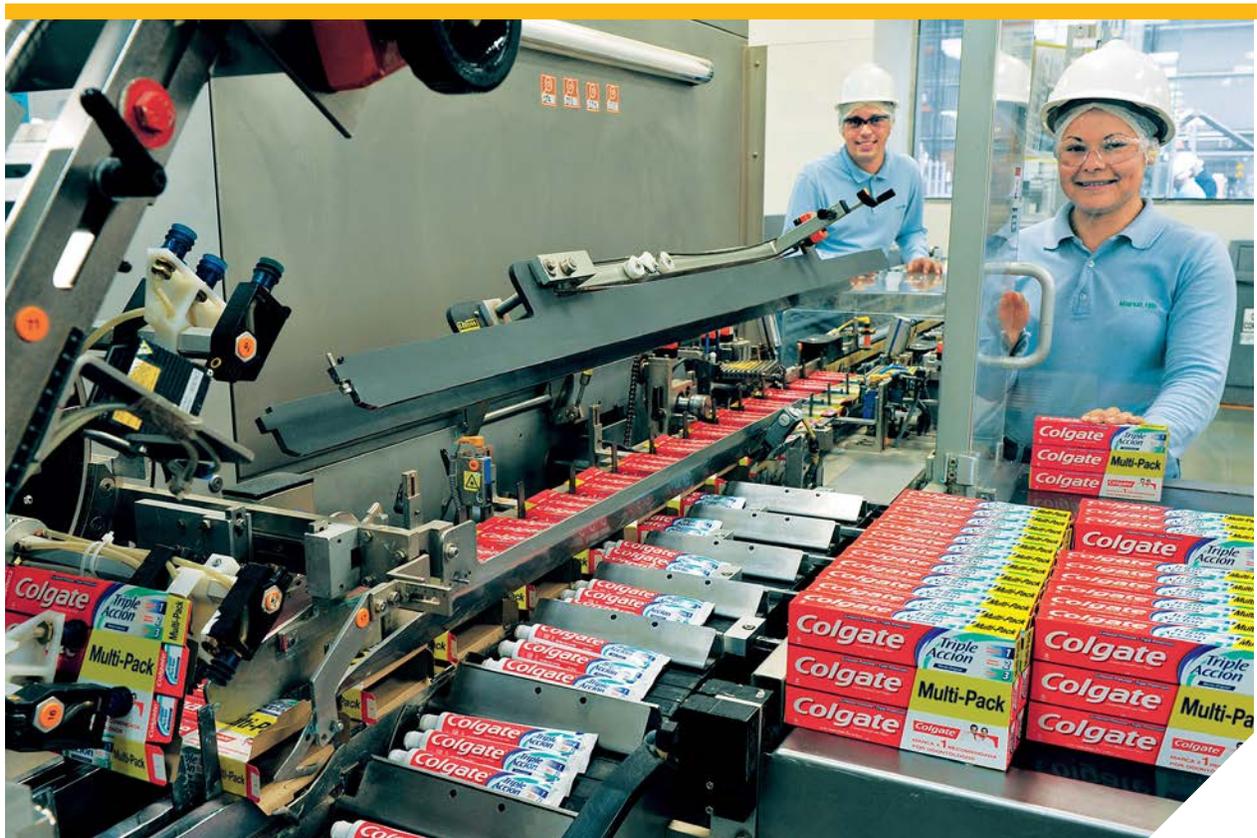


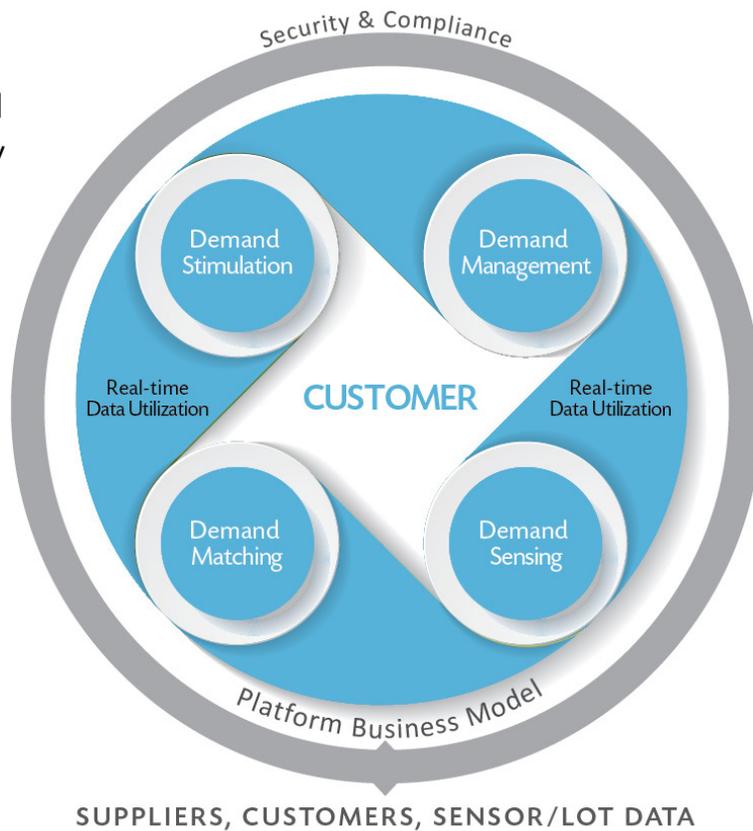
Photo credit: Richard Alcorn

2 Chapter 2: Unlocking the Power to Manage Demand

The release of the **Frontside Flip** in 2016, introduced the idea of using the Digital Supply Chain (DSC) to stimulate and manage demand. This was a completely new idea for many companies; for others, not so much. Some leading companies around the world had already started working on the **Frontside Flip**. In those cases, we recorded their insights and held multi-company sessions to crystalize their thinking and plans. We defined the Digital Supply Chain as something far different than today's Traditional Supply Chain.

A Digital Supply Chain is a customer-centric platform model that captures and maximizes utilization of real-time data coming from a variety of sources. It enables demand stimulation, matching, sensing, and management to optimize performance and minimize risk.

Digital Supply Chain



We spent 2017 working with senior executives from 72 companies from around the world on developing the tools and insights to begin executing the Digital Supply Chain **Frontside Flip** vision. Successful execution requires fundamental transformation of the supply chain mission, and capabilities. The senior executives who are running major supply chains agreed on two important requirements. The first requirement is to change measurement systems to reflect the new supply chain role as demand generators. We completed our work and published **Digital Supply Chain Transformation Guide: Essential Metrics**. In this document we provide a “pick list” of Essential Metrics and a DSC Transformation Maturity Assessment tool. The second requirement is to find ways to more easily collect, clean, analyze, and make decisions with big data. That is the focus of this work.

As we moved through our research, what we discovered was surprising. Companies are already collecting a substantial amount of data. In fact, the data that they collect overwhelms their ability to clean it, analyze and use it effectively. As a result, many companies still rely on sales forecasts based on historical data and do not expect their supply chain organization to have much additional insight. The sales forecasts are based on last year’s sales, market knowledge and the desire of the sales team to maximize their incentive plans. All of this is shaped by the pressure to make certain revenue numbers that

are dictated by the CFO. This process inevitably leads to reduced forecast accuracy, excess inventories or stock outs, and subsequently, higher costs. It also means that the supply chain organization is forced into a reactive role and is less able to stimulate or manage demand.

Data analytics offers a pathway to gathering and using new types of data; some that have been traditionally used and some that are brand new. For example, data from the Internet of Things (IoT) and its 1 trillion sensors and the massive amounts of social media information can be collected, integrated and analyzed to better predict and manage customer buying behavior. That's right, we said 'manage customer buying behavior.' The radical transparency between your company, your customers and the end-consumer allow you to manage consumer behavior through mechanisms like dynamic pricing.

The DSC offers the potential to efficiently incorporate new information, and thereby, improve forecast accuracy and reduce information latency. AI/ML and the development and continuous improvement of algorithms will unlock the true power of the DSC. They will enable the DSC to create opportunities to not only sense demand but to also more effectively manage and stimulate it. More importantly, the timing of data collection and interpretation is now approaching the possibility of near real-time. AI/ML is essential to capitalizing on the flood of data instead of drowning in it.

Direct financial benefits include revenue increases and cost reductions across several categories:

- Reduction in manual processes
- Reduced stock amplification
- Reduced human intervention
- Reduced Bull Whip Effect (BWE)
- Lower inventory holding costs and write-offs
- Lower risk of supply disruption due to business performance or compliance issues

By analogy, in the 1980's IBM had created computers that could play chess at a high level. However, they could not beat a Grandmaster. After a decade of building and learning the increasingly sophisticated algorithms, the IBM computers now beat every Grandmaster. All the wisdom of the world's greatest players has been added to new ideas developed by the computer itself. Your company must start on this learning path and develop a DSC that utilizes existing and new data sources and captures the wisdom of your team to eventually make even better decisions than your best supply chain planners. The algorithms that create this winning play will take time to develop and refine. Starting to develop them now is the only way to ensure that you will win in the future.

The Bull Whip Effect is the term used to describe distorted demand information from one end of the supply chain to the other, which leads to inefficiencies such as excess inventories, poor customer service, ineffective transportation, and missed production schedules. The phenomena is caused by demand order variabilities that become amplified as they move up the supply chain. (Lee, Padmanabhn, Whang 1997) The modern Digital Supply Chain reality is that Artificial Intelligence (AI) and Machine Learning (ML) must be applied to collect and analyze this high volume of new and existing data. And high-quality algorithms are required to collect, clean, analyze and execute decisions using this data. The companies that do this first will win in the marketplace.

This paper summarizes the insights that we have gained from 12 months of looking at the challenge of positioning the DSC to manage demand using real-time big data and AI/ML. It is worth noting that we believe all industries should march toward a DSC, even industries that market services, software or financial products. Some companies are well down the right path towards utilizing real-time big data that helps the DSC manage demand.

Perhaps the pre-eminent example of an organization that illustrates the power of the DSC and its ability to manage demand is a company that millions of people use probably every week: Amazon. They have done a superb job of using their supply chain to capture customers. The power of suggesting other things to buy, of using customer reviews to assist choice and two-day (or shorter) delivery is unbeatable. Moreover, Amazon is pushing for new data, new elements of the supply chain to own (e.g. Whole Foods) and new ways to deliver goods to its customers such as driverless vehicles and drones.

Your DSC should help you dominate your industry by better meeting the needs of your customer and customer's customer.

“Data is the new steel. Companies that harness it in the right way will be able to create a powerful digital supply chain, handing them a significant advantage over their competitors.”

Bill McDermott, SAP CEO

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Chapter 3: Research Methodology

The Digital Supply Chain Institute (DSCI) regularly convenes a council of industry leaders from around the world. These leaders are typically the Chief Supply Chain Officer, the CIO or a senior operating executive. We intentionally limit competing companies' involvement in this group to encourage the free flow of ideas. We call this team the Global Experts Group (GEG). (See exhibit A)

The GEG, through a protocol-driven qualitative interview process, provided their best ideas on our topic of managing demand in the DSC using real-time big data and AI/ML. We also held three Executive Leadership Forums in 2017. One meeting in Hong Kong, Zurich, and Baltimore, each sponsored by one or more of our key Institute member companies. These sessions were comprised of 70 plus executives from some of the world's most important global companies. (See Exhibit B)

The DSCI surveyed another 150 supply chain professionals in collaboration with colleagues at the American Productivity and Quality Center.

Additionally, we conducted an extensive literature review of hundreds of existing research documents and writings on the topics utilizing academic, industry, and journal sources. Themes and insights were generated from the literature, which guided our interview protocol, as well as helped us shape the research findings. Appendix A lists the published sources that we found most valuable.

All findings were reviewed with the GEG and are broadly supported.

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EXHIBIT A

DSCI GLOBAL EXPERTS GROUP



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ZTE

EXHIBIT A

GLOBAL SUPPLY CHAIN COMMUNITY



EXHIBIT B

“At ZTE we are pressing hard to become a company that leads through a strong Digital Supply Chain and powerful customer service. There are so many things to do to make this happen. We start with a focus on a few of these actions, get them done, and then move to the next actions. Execution is the most important thing.”

Anders Karlborg, Assistant CEO, ZTE

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Chapter 4: Top Ten Insights

There are many actions that companies can take to accelerate progress towards a powerful Digital Supply Chain. We made a list of the Top Ten Insights that we think will be essential ways for companies to utilize AI/ML to make rapid progress. Consider which of the Top Ten are priorities for you and your organization. The insight is framed and supported by information that covers:

- Current Situation (what we see now)
- What Will Happen and How (our forecast)
- Quote (from a company that is making strong progress)
- Survey Results (where applicable from our survey of 119 companies)
- Literature review (from the academics who work in this area)

The Data “80-20” – Getting it Right

CURRENT SITUATION

Our research showed that most companies are overwhelmed with the data they already have and manage. We found that IT budgets are already stretched to collect, store and provide analytics to help supply chain planners and managers make quality decisions. Getting data from customers and customer’s customers, a vital component of the frontside flip strategy, is much more difficult than we would like. If customer data is obtained, it is often controlled by Sales and Marketing and not always freely shared with the supply chain function. Supply chain managers may lack confidence in the quality of the data, and many decisions are made based largely on intuition and gut feel. Evidence suggests that on average, 80% of supply chain data handling and review time is spent collecting and cleaning data, leaving only 20% of the time to analyze and use it.

WHAT WILL HAPPEN AND HOW

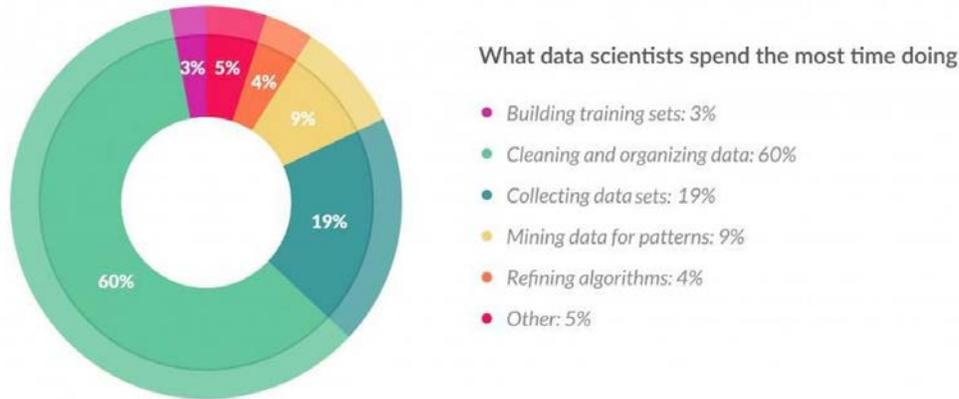
In the future, we expect the inverse of the current state - 80% of the time will be spent on analyzing and using the data and only 20% on collecting, cleaning and maintaining it. In the near term, companies will need to acquire data analyst and data scientist talent who know how to collect, manage, and analyze data, big and small. At the same time, companies will need to educate many of their line and staff people on the skills needed for data-driven decision-making. AI/ML skills and talent will also be needed in greater volume. Algorithms will be developed to clean, map and analyze structured and unstructured data. Furthermore, top management must make sure that the Digital Supply Chain has access to the best data available from customers and customer’s customers. This means that data that is currently owned by the Sales and Marketing team must be shared with the supply chain team. Analytics will be fine-tuned, and only less-common operational decision-making will require human intervention.

“While the use of external demand signal data is becoming increasingly important as we advance our Digital Supply Chain initiative, the preparation of the data remains a pain point. Mapping and cleaning data is labor intensive. We are adding machine learning capability to the process of mapping and cleaning data to increase automation and improve speed.”

Michael Crowe, CIO, Colgate-Palmolive

SURVEY RESULTS

Survey Question: *What do data scientists spend their time on?*



Source Link: <https://www.forbes.com/sites/gilpress/2016/03/23/data-preparation-most-time-consuming-least-enjoyable-data-science-task-survey-says/#252447f66f63>

LITERATURE REVIEW

Our literature research found the consensus view that educating leaders and managers about the potential of AI/ML technologies and techniques would pay off. Educated managers and the team will be able to steer the company to the best 80-20 rule. The literature also suggested the best way to fully extract value quickly and accurately is to combine data analysis-skilled talent with supply chain domain experts. The more aware leaders are about the opportunities afforded by these technologies and processes, the better they will be able to take advantage of them utilizing and managing scarce data science resources. Supply chain management (SCM) domain experts are needed to ensure that the right problems are being analyzed and any derived results are relevant (Waller and Fawcett, 2013). Rozados and Tjahjono describe Big Data Analytics as the process of applying advanced analytics techniques in combination with SCM theory to datasets whose volume, velocity or variety require information technology tools from a big data technology tool kit. They emphasize the need and challenge of leveraging supply chain professionals with the ability to continually sense and respond to SCM relevant problems utilizing big data analytics to provide increasingly accurate and timely business insights. (Rozados, Tjahjono 2014)

Real-Time Demand Shaping: Beyond Forecast Accuracy

CURRENT SITUATION

Demand Forecasts are notoriously difficult to improve regarding both speed and accuracy. Every company would like to improve their demand forecast process as the benefits to doing so are substantial. Reducing demand data latency and enhancing its quality can both reduce bullwhip effects, as well as allow us to better meet customer needs.

Of course, some companies have made progress using customer demand data such as Point of Sale data and social media data. Demand forecasts, however, are often inflated by sales force aspirations, especially for new product or service introductions. A surprising number of demand forecasts for new products/services are based on the VP of Sales saying, "I think I could sell 50,000 of those things!" This is not to say that aspirational goals shouldn't be part of the sales and fulfillment process. However, the leap in performance will occur when a company can use a wealth of data, analyze it, and interpret the results using algorithms that get better as experience is gained. When this is possible, the company is not just forecasting demand; it is shaping demand and the company can begin stimulating new demand and move it to non-peak periods.

WHAT WILL HAPPEN AND HOW

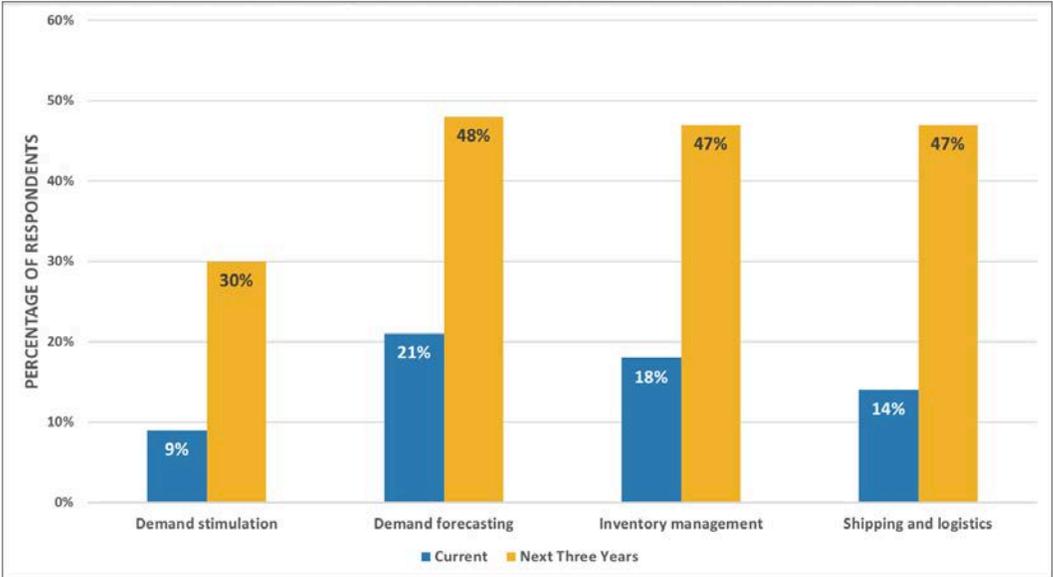
Real-time demand shaping will require new data, new technology, and new people. In the late 1990's companies had to pay a premium for SAP skills. In fact, they often had to pay an exorbitant amount for contractors who had the right mix of skills, knowledge and talent. A few years later, SAP skills were readily available, and the market corrected. People with these skills were available and reasonably priced. A similar pattern will play out concerning Data Science and analytic decision-making talent. These new people will drive the implementation of technology required to collect and analyze data. Of course, this is only possible if top management changes the roles that people play, re-define the silos and incent people to collaborate to make things happen. Also, top management must invest in the technology to capture that data, develop algorithms and use it to make decisions. The demand forecast will be developed by new cross-functional teams that include Sales, Marketing, Product Development, DSC, and Finance. The new demand forecast will be based on large volumes of unstructured and structured data that illuminates customer buying behavior in near real-time. Most importantly, algorithms will improve as experience is gained and enable all of this to happen. The ultimate goal is to take the new knowledge derived from all the new data and use it not to predict demand but to stimulate it. A supply chain that can stimulate and shape demand will contribute revenue to the enterprise and experience other benefits.

“In determining what data we need, we start with the problem and then select the relevant data. Right now, forecast and planning maturity is one of our top priorities.”

Betty Parston, VP Supply Chain Transformation, Schneider Electric

SURVEY RESULTS

Survey Question: From the following supply chain applications, describe your use of AI/ML?



LITERATURE REVIEW

Research has supported the strategy of AI/ML being applied to large quantities of structured and unstructured data stored in flexible “data lakes.” This will have the effect of reducing data latency (helping with bull whip effects) and will give us the ability to explore data relationships in new ways. This new data architecture will offer the best chance of gaining competitive insights while improving decision making quality and speed. Most academics feel that there are stronger ways to collect and analyze data than those methods that are currently being deployed in business.

Here are some examples Chen Mao and Liu (2014) provided to illustrate a few of the opportunities that Big Data Analytics (BDA) - AI/ML might provide to help drive and manage demand:

- ability to monitor and predict low in-stock items in advance
- significantly reduce impact of late and incomplete shipments
- predict how profitable special quantity deals really are
- forecast the optimal inventory needed for promotions and what the best times are to ship the inventory
- provide retailers with the ability to suggest pricing and allocation strategies when no historical data is available

Battle of the Algorithms

CURRENT SITUATION

AI/ML is currently being used most often in supply chain manufacturing. Our research highlighted that AI/ML should also be applied to developing demand for new products and services, and in the management of the flow of goods and services to the consumer. Sales force intuition has not proven to be an accurate indicator of high value and demand for products and services. Algorithm-based approaches that can learn, improve, and eventually reveal hidden patterns in large volumes of data are within our grasp. By uncovering hidden patterns and unlocking predictive power in information, supply chains will have the best chance of competitively satisfying customers. Simply put: Companies that develop better demand algorithms, supported by AI/ML, will win. Companies relying on human intuition and weak algorithms will lose.

WHAT WILL HAPPEN AND HOW

Companies that develop better demand algorithms, and continuously improve them, will gain a competitive advantage. Our research team has highlighted the need for a fundamental shift in supply chain decision-making approaches. In the past, decisions have been made on intuition, relationships, experience, and executive orders. Evidence now suggests that well-designed algorithms can make better and faster decisions if we trust them. This has been demonstrated across industries. Amazon has seen its supply chain generate customer loyalty and increased sales through its recommendation engine algorithms. Goldman Sachs has had great success with its trading algorithms. Trusting them is not as easy as flipping a switch. Leadership will be required to guide the organization to new data-driven ways of decision-making. The key to success is developing

an algorithm, a formula, that produces the best guidance on what a customer wants, when and at what price. The best algorithms get better over time based on experience.

Some basic shifts inherent in using algorithms:

- From descriptive information to prescriptive action
- From human bias to machine learned actions
- From no algorithms for demand in the supply chain to at least four algorithms (one for each element of the demand stack)
- From siloed thinking to collaborative cross-functional consensus
- From individual initiative to algorithms for every product/service

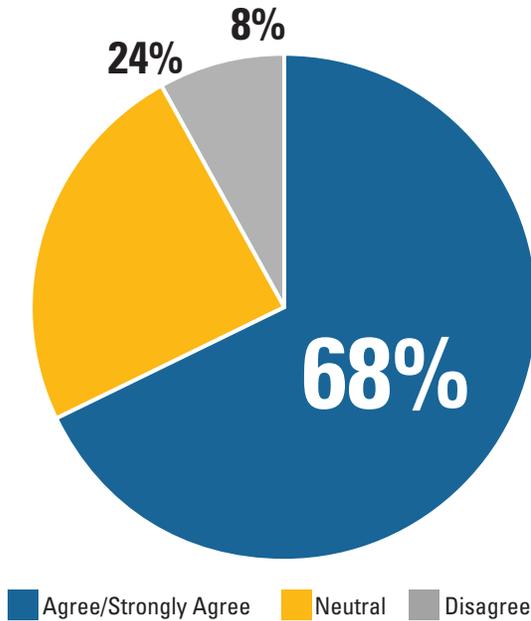
As we have often stated, the best way to affect change is to manage the elements of Demand, People, Technology, and Risk. Demand data must be gathered, and include non-traditional sources (e.g. sensor-based usage data). People must be skilled in analytics and have to be teamed up and incentivized across organizational barriers. As always, Risk must also be managed. Finally, Technology investments will be required to make everything work. Working these factors will result in algorithms that win.

“Supply chains used to be about coordinating operations and managing transactions, and much of this was manual. Technology and the digital economy have changed this irreversibly. Today transactions are automated, and supply chain management is about aggregating and analyzing data end-to-end to drive operational efficiencies and create intelligence about markets and players. We are investing in AI and Machine Learning in order to build supply chains of the future that will probably surpass what we can possibly conceive of today.”

Robert Sinclair, President, Supply Chain Solutions, Li & Fung

SURVEY RESULTS

Survey Question: In three years, the effective use of real-time big data and AI/ML in our supply chain will be a core part of our competitive advantage.



68% respondents agree or strongly agree that use of real-time big data and AI/ML in our supply chain will be a core part of their competitive advantage.

LITERATURE REVIEW

Artificial neural networks (ANNs) are computing systems inspired by the biological neural networks found in animal or human brains. These systems learn tasks by considering provided examples, generally without task-specific programming. ANNs are designed to enable progressive improvements to their own task performance.

Our research of literature told us that AI/ML is, by definition, evolving and learning algorithms created by humans. It is further developed by iterative processing. By executing these algorithmic processes, machines can discover opportunities previously hidden by more linear programming logic. Testing and learning in this environment are essential. The most important property of Artificial neural networks (ANN) is their capability to learn from examples. AI/ML algorithms can therefore be trained by using carefully selected historical data records of complex systems (Singh, Challa 2016). The literature suggests that becoming more algorithm-oriented is a strategy and a mindset supply chains must adopt to remain competitive.

The following is an example of image recognition. A system might learn to identify broken seals on packaging by analyzing example images that have been pre-identified by designers as “broken seal” or “no broken seal”. These systems do not have any pre-existing information about packaging or seals, instead they develop their own set of characteristics from the learning material they have been provided with to process and take action on.

Visibility Reduces Risk

CURRENT SITUATION

We found in our research that companies frequently do not have a clear view of their customer’s current and future needs. This is especially true of the needs of their customer’s customer. Similarly, we found that most companies lack a clear view of their suppliers and their supplier’s supplier. As a result, market opportunities are often missed, and inventory problems may occur. Supply chain disruptions occur due to business performance issues, compliance problems, weather and political situations. The lack of visibility into the end-to-end supply chain forces companies into a reactive mode. It is a source of both frustration and risk for supply chain leaders. The risk of disruptions that cause companies to not meet demand is greater than it should be, and the risk of over supply is always present. Visibility into the true emerging needs of customers and visibility into the capacity and performance of suppliers and supplier’s suppliers is needed to transform from a reactive to a predictive approach to supply chain risk.

WHAT WILL HAPPEN AND HOW

AI/ML and the increased visibility from data sources will enable companies to shift to a mode where exposure to risk can be minimized and risk mitigation improved. Using predictive analytics, companies will be able to anticipate possible risks in meeting demand and take earlier actions. Imagine having visibility into available capacity at suppliers, or real-time data on delays at tier 2 or 3, or being able to know at the last possible moment a product specification could be changed without causing a delay.

Developments in tracking and analytics will enable a true, transparent, end-to-end supply chain. Many software vendors have stepped up (e.g. SAP) to make this possible for everything from container monitoring to GPS connected assets to IoT devices. Potentially, this new transparent and secure system will be enabled by Blockchain, allowing for trust and increased visibility. Tough conversations will need to be held with trading partners when potential capacity issues become more visible. Clear guidelines will be developed for both performance risk and compliance risk. Improved visibility will yield

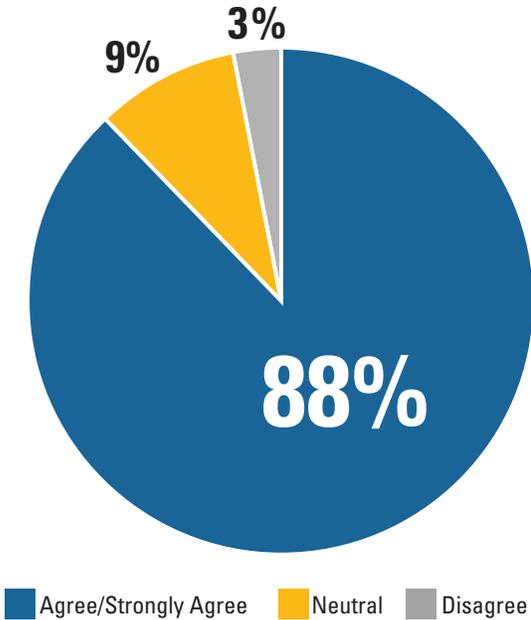
fewer stock-outs, fewer compliance issues, and support gains in market value as company reputation is enhanced.

“We are exploring how Machine Learning can improve our understanding of risk in our supply chain, especially when we look beyond our 16,000 tier-one suppliers. The question is how can we use data and Machine Learning to gain better visibility, which enables enhanced risk prediction and mitigation strategies, and improved reaction speed when disruptions are anticipated or occur anywhere in supply chain.”

Kurt Ravenfeld, Director Global Supply Chain Ops, Lockheed Martin

SURVEY RESULTS

Survey Question: One of the most valuable uses of real-time big data and AI/ML will be improving our supply chain risk management programs to become more predictive and preventative in managing demand.



In the recent survey conducted by DSCI, 88% of respondents agree or strongly agree that use of real-time big data and AI/ML in our supply chain will improve risk management programs to be more predictive and preventative in managing demand.

LITERATURE REVIEW

Our literature searches pointed us to numerous examples of IoT and sensor-based data, unlocking knowledge of the actual uses of products by consumers in the field. This kind of customer data has been well out of reach until recently. By reducing the reliance on business partners for key information, supply chain leaders will be able to optimize and manage demand and customer satisfaction in new ways. The literature warns of the challenges this increased transparency will open up regarding trust, collaboration, and the pressures for adopting “mutual gains” negotiation. Chase, in his 2013 book, ***Demand Driven Forecasting*** writes that “Supply processes continue to mature faster than demand. As a result, there is a larger gap to fill in the redefinition of demand forecasting processes to become demand driven than in any other area of the supply chain. This redefinition of demand forecasting will require new data (downstream point-of-sales [POS] data), processes, analytics, and enabling technologies. To become demand driven, companies need to identify the right market signals, build demand-sensing capabilities, define demand-shaping processes, and effectively translate demand signals to create a more effective response.” (Chase 2013)

New Talent Management for Supply Chain Talent

CURRENT SITUATION

Supply chain professionals are talented, process knowledgeable, operators. They know the business and understand suppliers and know how to get a good deal. They understand the importance of perfect orders and know the pain of a stock-out or a high inventory level. However, comparatively few understand the following:

- Artificial intelligence and Machine Learning applications in supply chain
- Data governance, acquisition, alignment and curation
- Advanced analytics and data-driven decision making
- Interpretation of customer needs and buying behaviors based on quantitative analysis

These knowledge gaps make the adoption of a data-driven DSC slow and difficult. They also prevent the vital application of AI/ML to core supply chain processes, especially as it relates to demand. Currently, at many companies, a very small percentage of people have the skills needed to effectively utilize big data/ML. Highly skilled data scientists are only a part of what is needed. Companies need to develop new skills among their supply chain personnel as well as in the people that are the data-users. The need to make data-driven decisions is becoming a critical success factor for excellent supply chain performance.

WHAT WILL HAPPEN AND HOW

Companies will develop a new talent management strategy and plan for the DSC. The plan will have three components. First, an entirely new set of people who are data scientists and analytical decision-makers will need to be hired. These people will form the core of a unit that develops algorithms that better predict and manage customer demand. These people may be shared with other departments or the function may potentially be contracted to 3rd party providers. It is important that the DSC leadership have ownership and control over some critical number of these people or their project work hours.

Second, the overall level of data-driven decision-making skills will need to be improved across the workforce. Our research indicated that the level of data-based decision makers would increase three-fold to eight-fold.

Third, companies will have to change job descriptions and hiring profiles, and develop compensation plans that are sufficient to attract and retain people with the right skills, knowledge, and experience. One challenge we expect is that many of the most sought-after skills will be resident within younger people. Moreover, some HR functions might balk at paying what is needed for these inexperienced hires.



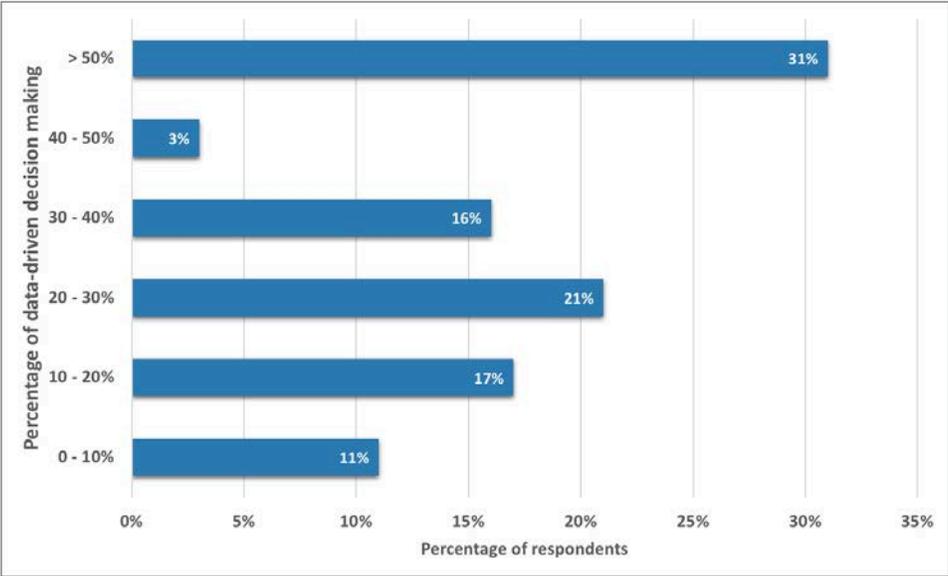
Photo credit: UNder ARMOUR

“Companies have to be action-oriented to see the benefits of Machine Learning algorithms –they absolutely have to act as if the future is today. That starts by asking “what problem am I trying to solve?” and bringing together a cross functional team that learns by doing.”

Walid Negm, CTO, Aricent

SURVEY RESULTS

Survey Question: In three years, the following percent of our supply chain employees will have training in data-driven decision-making.



In the recent survey conducted by the DSCI, 31% of respondents think that more than 50% of supply chain employees will have training in data-driven decision-making.

LITERATURE REVIEW

In Nadia Saunder’s recent book on **Big Data Driven Supply Chain Management**, she writes “only senior leadership can spearhead the transformational change required to build, apply analytical capabilities across their organizations. This transformational change will not happen if the responsibility is abdicated to middle managers, professional analysts, or external consultants” p 235 (Sauders 2014). We couldn’t agree more. The complexity of the technology and concepts in data analytics should not become a barrier to understanding their use and application in supply chain digital transformation. Digital transformation is a leadership opportunity, and problem, first and foremost.

The literature also discusses strategies for educating leaders and managers about the potential of these technologies and techniques at length. Articles from data science education feel that business managers need to better understand and support data scientists to take advantage of these scarce resources. Also, there is a need to join together data technology skilled talent with supply chain domain expertise to fully extract analytic value quickly and accurately.

The literature showed that this unique and competitive talent market also creates a need to creatively recruit talent through other means than simply reviewing CVs. Some forward-thinking firms are identifying and acquiring talent in data science through “hackathons” for example. The best data science talent is rare and once recruited must be taken care of to retain these unique and valuable individuals.

However, the marketplace seems to be responding. New startups are forming to train and supply data scientists. For example, Databreed is an Africa-based firm launched specifically to expand the pool of credentialed data scientists for employers around the world.

Additionally, to support its focus on people and emerging skill requirements for digital supply chains, the DSCI has created a course to train supply chain personnel on the vision of the **Frontside Flip** and DSC transformation.

The talent for using AI/ML and determining winning algorithms is just now emerging. Companies will need to find and bring it on board.

New Business Models We Can't Anticipate

CURRENT SITUATION

We were surprised to have found that very few companies are actively integrating new sources of big data across their supply chain. More specifically, very few companies have an active plan for acquiring new sources of customer data and applying it to their demand management challenge. Most, however, do believe that they need to develop this plan, and together with their CIOs, determine how the new data will be gathered, stored, accessed, analyzed and applied. Once these new data sources are brought online, and new forms of analytics are enabled, companies will be able to develop and test new business models. This is especially true for the Digital Supply Chain and the new data and analytics that will drive discovery of demand and new ways to meet it. It is fine that we cannot anticipate the new business model. We just can't overlook it when the data shows us that it is there!

“Digital Native” companies are the best examples of how the DSC can create new business models. As we mentioned in the **Frontside Flip**, Uber is a perfect example of a company that used digital technology to put the transportation supply chain into the hands of the consumer. The new model delivers superior service for significantly less cost. A major tire maker is planning to put sensors in tires and run their supply chain based on actual tires usage. They will anticipate when a consumer needs new tires, contact them directly and make an on-line sale of exactly the right tire size and type.

WHAT WILL HAPPEN AND HOW

We believe there are two important ways that companies will begin to address their data and analytics challenge. First, they will define critical business problems and determine what new data sources should be identified and gathered to help address them.

For example, a company seeking to increase the sales and delivery performance of a product will be able to achieve this by optimizing the delivery of the product. New data sources that illuminate customer preferences on how they receive the product would be analyzed and new transportation and delivery processes would be adjusted and aligned with customer needs. This approach is to define the problem and decide what data and information are required to solve it. Moreover, be flexible in defining the problem to explore if there is a new business model that works for the customer and the company.

The second way that companies will change to a new business model is harder to describe but just as real. Once companies have identified, gathered, processed and aligned large “lakes” of data, they will start to discover that there are new ways to create value in the marketplace that were previously hidden. These insights come only after the data has been gathered and data scientists and analysts discover new relationships and patterns. For example, a comprehensive analysis of social media and buyer behavior data for a millennial market segment may uncover that for this population, car ownership is no longer desired, yet the flexibility to use a car when needed is valued. The company reacting strategically to this market insight might decide to stop marketing new cars to this segment and instead make cars available as needed on a subscription plan or through a usage fee. This new business model was not anticipated when the data was collected but became the source of a new business model when analyzed. This approach is “Gather the data, analyze it every-which-way-from-Sunday and discover a new business model that works for the customer and the company.”

One approach that is gaining momentum in the area of new business models that we cannot anticipate is the “digital twin.” This simply means that we create a digital twin of a certain physical asset. The digital twin enables us to experiment with changes that could lead to a new business model, a new way to make money that meets the needs of customers.

“We see digital tools and techniques not only helping us figure out how what has already happened in our business, but also helping us predict where it will go. Predictive insights, if acted upon quickly, can be a source of competitive advantage. Our business models need to be flexible enough to pivot to areas of opportunity as the invisible becomes visible.”

Dave Kurz, Research Fellow, DSCI

SURVEY RESULTS

Survey Question: Are business models disruptive enough in your company?

“79% of CEOs told us that their current business models are not disruptive enough.” It is clear that global leaders of successful businesses recognize that creating a customer centric, digitally-transformed business is a top priority.

Source Link: <https://assets.kpmg.com/content/dam/kpmg/au/pdf/2017/customer-first-digital-age.pdf>

LITERATURE REVIEW

Sophisticated DSC data analytics programs, implemented with good quality, and accessible data, will uncover new sources of customer value previously hidden from traditional views. Data analytics can better explain both what has happened in the past, as well as more accurately predict what will happen in the future. Most exciting for business strategy, however, will be the ability to uncover insights and hidden relationships. Trusting these insights and organizing to take action will be the source of new business models that change the industry and meet emerging customer needs.

Marketing and product development, along with product engineering, have often times led the way for using these predictive analytic techniques. DSC leaders can leverage and learn from them if the proper influence and collaboration strategies are used. Productive collaboration and partnering with these resources, especially in the near term, is a key DSC leadership development issue. Ittmann notes one of our key takeaways for this review, that “as data and analytics transform organizations, and the landscape within which they operate, it inevitably puts additional new demands on management. For any organization to achieve what has been outlined in this book it is necessary to take a whole range of steps and actions. These include aspects such as, working across functional areas, data capturing, ensuring data integrity, data management, tools and techniques to perform the necessary analytics analysis, and the human resources capability required to achieve all of this.” (Ittmann 2015)

New Product, New Win

CURRENT SITUATION

Supply chain functions have historically been on the back end of the product or service introduction process. Advanced companies often have key supply chain involvement in product development and engineering. Analytic insights that help organizations narrow their scope and laser in on critical customer needs and preferences gain a significant market advantage. Firms that integrate their Digital Supply Chain function into this front end of product development are reaping the rewards of more revenue from the customer and lower cost. They have the capability to create new wins with new products. A leading Japanese consumer electronics company launched a new mid-sized camera product that was an instant success. It was well priced because the supply chain team influenced the choice of parts and components. It was exactly what the market wanted and the supply chain team had picked that information up as they delivered other camera products to retailers.

WHAT WILL HAPPEN AND HOW

Winning companies will adopt a more integrated cross-functional view that includes their DSC to gather important customer insights and information. While the DSC team will not be responsible for directly developing new products, they will be closely involved in their creation. They will add value by being in touch with the customer and learning from them through delivery and in-field use. They will help develop algorithms that best predict the customer demand for the new product and analyze DSC availability to produce and deliver.

“Consumer driven data, applied appropriately, unlocks the supply chain allowing it to fulfil and even drive demand. This data helps us create – a single view of the customer – that allows us to design, manufacture, and deliver the product that they want and need before they know they need it.”

Colin Browne, President Global Sourcing, Under Armour

SURVEY INSIGHTS

Survey Question: Are business models disruptive enough in your company?

Forty-five percent of manufacturers report that the cloud is key in speeding new product introduction. And, it's not just cloud-based solutions: 80 percent say that technology in general has improved their ability to innovate. Industrial automation is another key to introducing new products with faster, more reliant and accurate processes. This is why 75 percent of respondents say they are using robotics and shop floor automation.

Source Link: <https://www.plex.com/blogs/optimizing-global-supply-chain-management-and-execution.html>

LITERATURE REVIEW

We found compelling literature review insights on new combinations of AI/ML techniques that have been tested favorably against traditional forecast methods. New techniques that quickly adapt to unpredictable demand signals are emerging that will help us with activities such as new product launches. It is plausible that AI will leapfrog the current Traditional Supply Chain planning function. We reviewed a respected text from 2013 that fails to mention AI at all, and discusses the implications of sensing and demand shaping, but without the benefits of the more non-linear AI/ML architectures and models. We noted that it is important to develop a series of methods and architectures that will be most appropriate based on the type of demand a product is seeking to fulfill. This could influence where AI forecasting models are initially deployed. High value product with low forecastability for instance makes sense. New product launch is certainly one such example. (Jaipuria Mahaoatra, 2014)

Dynamic Pricing

CURRENT SITUATION

Companies set prices and then adjust down, if necessary, to boost sales and lower inventory. In a period of high demand, prices will be increased. This market place-based behavior happens sporadically and reactively. But, it is a common occurrence. Companies have trained their B2B and B2C customers to expect this. A few industries have adopted a much more dynamic approach to this challenge. Airlines constantly change the price of each seat almost up until the time the plane takes off! Uber adjusts its pricing up during periods of high demand. Commodity prices are constantly adjusted based on supply and demand. Consumer electronics companies routinely hack their prices on Black Friday, especially if inventories are high. Moreover, big B2B companies routinely lower their prices at the end of a fiscal year.

WHAT WILL HAPPEN AND HOW

Almost everything that a business or consumer can buy will be dynamically priced. Pricing will fluctuate based on market demand and available inventory. Predictive analytics will be used to continually set and adjust pricing for more and more products and services. The concept of a List Price and a Sale Price will gradually disappear. Profit optimization will occur when a company correctly anticipates demand, knows supply and comes up with the optimal price and distribution plan. AI will guide companies on customer buying behavior, mega trends, and history. New production and delivery methods will enable companies to seamlessly integrate the speed of getting the product to the customer into their dynamic pricing.

“Dynamic pricing is rapidly spreading to new industries. As the use of AI/ML evolves, dynamic pricing will become commonplace in almost all products and services. The effectiveness of a company’s dynamic pricing algorithms will be a key performance indicator in managing the Digital Supply Chain.”

Craig Moss, Director, DSCI

SURVEY INSIGHTS

Survey Question: Can dynamic pricing improve profitability?

The profit potential due to dynamic pricing depends on the type of demand scenario as well as the amount of demand variability. Overall, our analysis indicates that additional profit potential due to dynamic pricing ranges from 1-7% over and above the optimal fixed pricing profit.

Source Link: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.93.9814&rep=rep1&type=pdf>

LITERATURE REVIEW

Dynamic pricing is not a new idea, it has been utilized effectively in many industries such as energy, airlines, online retailing, and others for many years. The real question this insight is addressing is what is new because of the Digital Supply Chain? When we look at the business models of the industries and companies most effectively utilizing dynamic pricing to optimize results now, they are largely able to access up to the minute, even instantaneous, information about both demand and supply. The research team feels that as the Digital Supply Chain tools and methods, fueled by real-time demand sensing and inventory visibility, become more ubiquitous, then dynamic pricing strategies will begin to

cascade to industries and business models that have traditionally not been able to take advantage of it. As traditional firms develop more sophisticated, algorithmic-driven decision support systems, new pricing strategies should be assessed and considered as they become more implementable.

Hallberg and Hinterhuber, in articles on pricing strategy note that recent research confirms high levels of complexity and cost associated with product pricing, as well as high degrees of variability in the ability of firms to effectively implement pricing strategies (Hallberg 2015) (Hinterhuber 2017). The reasons for less effective implementation have to do with the role of individual judgment and lack of commercial experience (Hallberg 2015). We know from our DSCI research that AI/ML, and analytics strategies are well suited to help overcome business issues of complexity that outstrip individual capabilities. Digital techniques should therefore improve firms' abilities to implement more complex dynamic pricing strategies.

Own It or Clone It

CURRENT SITUATION

Companies face an important challenge when deciding whether to outsource or own manufacturing. They face similar challenges with other functions such as procurement. Outsourcing reduces capital cost and the associated risk. Insourcing gives greater control over product timing and price. However, outsourcing part of the supply chain means that providers must offer a low price competitive bid. Companies vary in their decision-making about their supply chain and what should be outsourced. Very few have developed sophisticated AI tools for keeping control whether out or in. The question is "Do I create an advantage for my customers and shareholders by owning a function? Alternatively, am I better off finding a contractor who can clone my capability?"

WHAT WILL HAPPEN AND HOW

More companies will insource production as 3D manufacturing lowers labor costs and permits operation near the target end customer. The DSC challenge will be to help make the right "in or out choice" and then make either choice work well. AI/ML will be used to gather and control production information either way. Moreover, often it will be Blockchain-based data that reduces the opportunity for incorrect data. Similarly, the Digital Supply Chain for some companies will seek contractors that have stronger capability or more capacity. Purchasing is a function that is increasingly cloned within another entity.

“Chain IQ is currently working with several clients to incorporate artificial intelligence and robotic processes into their supply chain. Clients are keen to deploy Machine Learning to enhance their operations and their level of maturity in digitalizing their supply chain.”

Dr. Urs. Dogwiler, Group CEO, Chain IQ

SURVEY RESULTS

Survey Question: How much outsourcing is going on in the supply chain?

90% of manufacturing companies report having some level of outsourcing. Thirty percent of them outsource 40% or more of their manufacturing.

Source Link: https://www.supplychain247.com/article/5_steps_of_supply_chain_outsourcing/supply_chain_insights

APQC’s Open Standards Benchmarking data in procurement indicates that just under 30 percent of responding organizations have initiated the outsourcing of non-strategic activities in their procurement functions.

Source Link: http://www.scmr.com/article/the_trade_offs_of_outsourcing_procurement1

LITERATURE REVIEW

The Digital Supply Chain, as we have discussed, will improve end-to-end visibility and reduce the latency of supply chain data. End-to-end truly means accessing more transparent data about our value stream partners, both upstream and down. Vendor managed raw material inventories, which reduce the needs for a large procurement function, become more viable as information sharing becomes more transparent, and instantaneous. Likewise, manufacturing by outsourcing partners becomes a different kind of decision as the barriers and access for data and information about production capacity and manufacturing pipeline, as well as costs, fall. The outsourcing decision regarding warehousing and transportation services will also transform as visibility, transparency and real-time access to data improves. The need to rely on value chain partners to provide strategic data and information will decline as digital sensor-based information, fed directly to a company’s cloud becomes the norm.

Hartman, Ogden and Hazen noted that insourcing and outsourcing decisions are not permanent, but instead require continuous evaluation in most organizations. “Firms that deliberately and continuously assess costs, firm capabilities, and the external environment will be able to capitalize on using the most advantageous location.” (Hartman, Ogden, Hazen 2016, p 216) The DSCI research team feels that Digital Supply Chain information enhanced in quality and speed by AI/ML, is a source of competitive advantage in this continuous in-sourcing/outsourcing assessment process.

Algorithm Council: The Secret Weapon

CURRENT SITUATION

Companies work hard to understand, predict, and manage customer demand. Yet, most companies are dissatisfied with two things. First, they feel that their ability to understand, predict and manage customer demand is limited. Second, they know that their ability to rapidly respond to changes in customer demand is inadequate. One of the causes for this is poor data; data that is either flawed or incomplete, or missing whole new categories of information. We covered the poor data issue in other sections of this white paper. The other reason that companies struggle is organizational. Companies are typically organized into silos that prevent effective data gathering, data sharing, data analytics, and data-based decision-making. For example, many supply chain organizations lack direct access to the customer data collected by their sales function. They simply rely on the sales forecasts produced in each region. Similarly, many sales teams have limited knowledge of customer preferences for logistics and service requirements. When a product or service becomes a big hit, the supply chain has a hard time catching up with demand. When a product or service does not sell, then supply chains tend to be slow to reduce cost.

WHAT WILL HAPPEN AND HOW

The secret to unlocking the power of the organization to manage demand and supply is to create an empowered cross-functional team to ask the right questions, collect the right data and build the right algorithms to make the right data-driven decisions. We call this team the “Algorithm Council.”

This team will include members from Sales and Marketing, Supply Chain, Information Systems, HR, Enterprise Risk Management and Finance. The primary purpose of the Algorithm Council is to build algorithms addressing the right issues that lead to market dominance and make decisions that increase sales while increasing margin and/or lowering cost. Imagine a team that had deep customer insight and understood the power and capabilities of the Digital Supply Chain. Companies have started to experiment

with Algorithm Council like committees, but few have incorporated the right skills and authorities to build market-winning algorithms and drive customer success. Creating a successful Algorithm Council will require leadership to drive organizational change that breaks down silos and fosters a new era of cross-functional collaboration where success is interdependent.

The Digital Supply Chain Institute is undertaking research to establish the right organizational structure, membership, skills, and technologies to make the Algorithm Council possible. The research will be complete in July 2018.

“Leading companies understand that algorithms are the key to using all the new data that is becoming available. Full speed ahead for algorithm development!”

George Bailey, Managing Director, DSCI

SURVEY RESULTS

Survey Question: How valuable is cross-functional communication?

By the fall of 2003, Leitax had attained dramatic improvements in forecasting accuracy as a result of cross-functional collaboration. Three-months-ahead forecast accuracy for sell-through (sell-in) had improved from 58% in the summer of 2002 to 88%.

Inventory turns increased from 12 the previous year to 26 in Q4 '03, average on-hand inventory decreased from \$55 million to \$23 million, and on-time delivery improved from 35% of orders to 75%. A final noteworthy result of this process was the level of agreement reached by the forecasting group and, through the members of the group, by all the functional areas involved in the process.

Source Link: <http://www.hbs.edu/faculty/Publication%20Files/07-001.pdf>

LITERATURE REVIEW

Councils managing supply chain planning, decisions, and execution have been at the center of forward thinking organizations for some time. These councils have been operated by aggregating batches of data and information generated monthly (rolling demand forecasts), quarterly (transportation networks), or longer term (capacity planning). Real time data that influences or drives decision making, as exemplified by control tower projects, has been historically limited and slow to expand. The concept of the Algorithm Council represents a fundamental shift away from making situational supply chain decisions based on slow

moving batch information, and instead pivots towards a machine-driven approach. Chen, Mao and Liu suggest that data science will gradually offer improvements over the hasty and subjective decisions made by “experts” (Chen, Mao, Liu 2014). The Algorithm Council will collaboratively develop the strategic principles that will be deployed in networked AI and Machine Learning environments. Sets of strategic algorithms, capable of improving their own performance over time will outperform more analog demand councils. These new complex networks require executive guidance to begin and maintain their processes as business conditions evolve. The essential difference is the shift to shaping decision parameters for the networks to execute and improve closer to real time than their human equivalents.

A SUMMARY OF THE TOP TEN INSIGHTS

The Data 80-20 – Getting it Right	Company spends 80% of effort on analyzing data and making decisions and 20% on collecting and cleaning the data
Real-Time Demand Shaping Beyond Forecast Accuracy	Forecast accuracy is important but Digital Supply Chains must do more; they must increase and manage demand
Battle of the Algorithms	Companies must collect more customer data and use AI/ML to develop algorithms that win in the market place
Visibility Reduces Risk	Visibility into suppliers and customers is an essential way to reduce the risk of supply chain disruption
New Talent Management for Supply Chain Talent	New people with data scientist skills and deep analytical skills must be found and current people must be trained in data-based decision making
New Business Models We Can't Anticipate	Get the data and use AI/ML to gain advantage and also use the data to discover new ways of adding value to customers
New Product, New Wins	Digital Supply Chain knowledge should be added to the process of deciding what to make or do and drive growth
Dynamic Pricing	Rapidly adjusting pricing as market conditions change will change the way that the supply chain is managed and drive profitability
Own It or Clone It and the Tools to Know	Decide what DSC functions should be outsourced and which should be revenue producers using new tools
Algorithm Council: The Secret Weapon	Form a cross-functional team to create algorithms that drive data collection, analysis, market focus, manufacturing, inventory and a host of other critical business decisions

Each of the ten insights requires a combination of changes to Demand, People, Technology and Risk. Each company should set out a strategy and execution plan for addressing these insights. Not all insights can be handled at once and so prioritization should occur based on the company’s specific characteristics. The table below shows the relative importance of Demand, People, Technology and Risk to addressing the insight. The evaluation is based on our discussions with companies around the world but may be different for your company. The filled circle illustrates how important each factor is.

INSIGHT	DEMAND	PEOPLE	TECHNOLOGY	RISK
The Data 80-20- Getting it Right	●	◐	●	◐
Real-Time Demand Shaping Beyond Forecast Accuracy	●	●	◐	○
Battle of the Algorithms	●	●	◐	○
Visibility Reduces Risk	◐	○	◐	●
New Talent Management for Supply Chain Talent	●	●	○	○
New Business Models We Can’t Anticipate	●	◐	●	◐
New Product, New Wins	●	◐	○	○
Dynamic Pricing	●	●	◐	◐
Own It or Clone It and the Tools to Know	◐	●	◐	●
Algorithm Council: The Secret Weapon	●	●	●	○

5

Chapter 5: Call to Action

There are two alternative strategies that companies may take. A company can decide to take measured steps in its supply chain transformation. It can wait until others have shown the way using new types of technologies such as AI/ML or Blockchain. Or, a company can decide to go “all-in” on Digital Supply Chain transformation. In our view, for most companies and in most industries only the second option is viable. Companies that stay the course and make only gradual changes will live in fear that a new digital entrant will offer to their customers a better supply chain. These companies should also worry that one of their traditional competitors is already building a data model that allows them to collect and use the wealth of data that customers are already generating.

Going “all-in” for DSC transformation starts with developing a strategy for collecting new data, using AI and ML to analyze it, and creating algorithms that capture the wisdom of the marketplace. Further, we call for the companies to create a new cross-functional team – the Algorithm Council. These are the people that will ask the right questions, define the right problems and use their judgement to better stimulate and meet demand through the development and continuous improvement of algorithms.

In Exhibit 1, we summarize our view of how Traditional Supply Chains gather data, create a sales forecast, and then hand the forecast off to the Supply Chain team who create a Demand Forecast Plan. This plan is then used to generate a whole set of plans for manufacturing, logistics, and others. For a variety of reasons, the Demand Forecast Plan is frequently wrong and sometimes very wrong. As a result, companies are working hard to improve demand forecast accuracy. We call the traditional approach a Sales and Finance

data model. Fine tuning this model and digitizing it will create some efficiency but will not likely be enough to win in the marketplace.

In Exhibit 2, we summarize our view of demand planning in the Digital Supply Chain. This data model is fundamentally different in approach, scope, and objectives. First, the center of the model has two elements: The Customer/Customer's Customer and the Algorithm Council. Second, the amount and type of data are greatly expanded. Third, the application of AI/ML is comprehensively used to collect, clean, analyze and decide. This is accomplished through algorithms that are designed to give deep insight into the customer's future behavior and requirements. The focus is on stimulating, sensing, matching and managing demand. In other words, working all elements of the demand stack. We call this the Customer and Algorithm-Driven data model.

Companies must move towards the Digital Supply Chain customer-driven data model. They must make the necessary investments in People, Technology, and Risk to manage demand. They should start by assessing where they are in their Digital Supply Chain Maturity. (potentially by using the Transformation Maturity Assessment tool that was developed by the Institute and is available on DSCInstitute.org). Companies should develop a Digital Supply Chain strategy (yes, we also have a tool to guide this!) and prioritize actions necessary to develop the Customer and Algorithm-driven data model. These actions should be supported by an investment plan and also clear revenue and productivity goals.

Revenue will increase, and overall costs will decrease. Most importantly, customers will love what they get and will soon insist that a company have a true Digital Supply Chain or they will move their business elsewhere.

“The technology needed to collect, clean and operate both structured and unstructured data to drive a smart Digital Supply Chain is not inconsequential. But the real change comes in how this data is leveraged through predictive analytics, Machine Learning and AI. Paybacks are enormous.”

Richard Howells, VP for Solution Management, SAP

TRADITIONAL SUPPLY CHAIN

Sales and Finance Driven Data Model

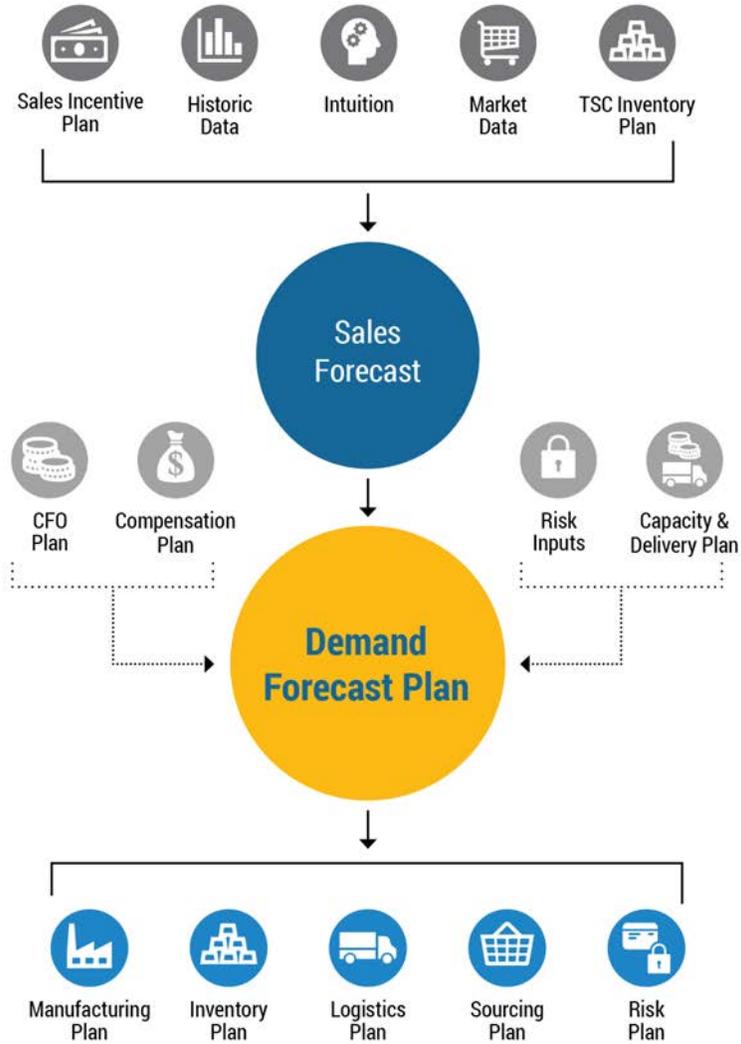


EXHIBIT 1



THE CENTER FOR
GLOBAL ENTERPRISE

About the Center for Global Enterprise (CGE)

The Center for Global Enterprise (CGE) is a nonprofit, nonpartisan research institution devoted to the study of global management best practices, the contemporary corporation, economic integration, and their impact on society.



About the Digital Supply Chain Institute (DSCI)

The CGE's Digital Supply Chain Institute (DSCI) is a leading-edge research institute focused on the evolution of enterprise supply chains in the digital economy and the creation and practical application of supply chain management best practices.

The DSCI's work is fielded by CGE and the Global Experts Group (GEG), a team comprised of top supply chain executives from companies around the world. The GEG acts as the DSCI's principle mechanism in developing the research and applied management learning.

Appendix A

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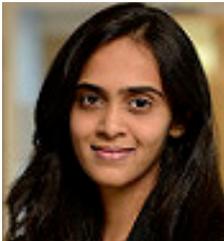
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