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Editorial

Preparing for the Era of the Digitally Transparent Supply Chain: A Call to Research in a New Kind of Journal

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We are commencing a new era in global trade: the era of the digitized supply chain. In the 25 years I have taught students and conducted research in the field of supply chain management, I have never seen such a magnitude of change as is occurring today. These changes are unparalleled in their scope, the implications for revision of the way humans work is completely new, and the impacts they will have will be both business-transformative and life-changing. This is the era of the transparent, real-time supply chain, which is being enabled by the rapid digitization of the communication infrastructure, cloud-based computing, mobile technology, and the rise of the digital ecosystem. Interestingly, these changes have less to do with technology, but rather our mindset and thinking on how to deal with them. In this essay, I argue that we need a new type of journal to advance the discipline, as the current ones simply aren't keeping up.

1. New Realties Call for New Research Inquiry Outlets

As we move towards thinking through what the new era of digital and transparent supply chains holds in store for us, both industry and academia are woefully unprepared for what is happening here. Multiple challenges exist as they relate to the capability of people, systems, and most importantly, management paradigms and thinking around the concept of transparency and digitization. In this inaugural essay, I begin by identifying why I believe this type of journal is needed now. I will follow this by identifying a set of issues that are not being addressed in current journals, issues for this journal (*Logistics*) to take on as it rolls out in the coming years. I hope to encourage researchers to work directly with industry experts to drive inquiry into how the digital supply chain will drive activities.

I am not the only senior SCM researcher that is recognizing that as a discipline, we have missed the boat. The Production and Operations Management Society announced a new theme of becoming more relevant to the world outside of academia. In a recent issue, Toffel (2016) [1] opines that researchers should be able to answer "yes" to all three criteria of whether a research question is novel to academics, relevant to practice, and can be answered rigorously. Roth et al. (2016) [2] suggest that interdisciplinary research is needed to revitalize our field and expand our influence. And Marshall et al. (2016) [3] suggest that significant changes are needed in the culture of the operations management (OM) research community, including the methodological blinders that fail to capture the importance of culture as a dynamic variable.

In the end, all of these researchers suggest that undue emphasis on methodological rigor is throttling the flow of interesting and relevant research in our field. Though fundamental principles of good scientific inquiry must remain, too many of our current academic journals are bogged down by statistical or methodological concerns that sacrifice content due to overemphasis on rigor. Their contribution to conceptual development and new content is minimal, and in many cases, adds nothing at all. Worse yet are the lengthy pages devoted to mathematical optimization and modeling

solutions to problems whose boundary conditions have been made so tight that they would never exist in the real world of living supply chains. These models provide little or no new insight and are established to meet the standards of the people who try to pass them off as being "academically rigorous", but who have lost sight of the objective of bringing novel insight to management thinking and decision-making.

So as we launch the inaugural issue of *Logistics*, we have done so with this perspective in mind.

First, as other academics noted here have called for "interactions with practitioners" ([1,2]), we are doing just that, and inviting leading practitioners who I personally believe are demonstrated thought leaders—individuals who are truly pushing the boundaries of supply chain practice—to become part of our board. We have selected practitioners who have several characteristics in common. First, they are senior executives who have worked in a number of different supply chains, and have risen to senior executive levels based on their proven track record. All of these practitioners are intellectually curious. They challenge the status quo, and are pushing the boundaries of what we know works and doesn't work in today's global business environment. Most of them have worked globally in different organizations and understand the importance of culture and change management as a key differentiator of success. And finally, they are all excited to contribute to the growth of knowledge in the field. As such, we believe their contribution is invaluable to the growth and insights of this journal.

Second, we are moving to an open source journal. Articles will be reviewed, but unlike journals that act as "gate keepers", we are focused on ensuring that timely research makes it to press as quickly as possible, so that it will get to the forefront of practice. We recognize that there will be errors, methodological assumptions that are not validated beyond a doubt, and even non-replication in quantitative results that later research may demonstrate. Our review process will seek to minimize such potential errors. But, the emphasis here is on innovation and idea speed to market, since we believe that the content created therein will provide greater value than an overbearing emphasis on methodological scrutiny, under these circumstances. Authors will be assured that their insights will move quickly to dissemination through our open source architecture, and will be featured in blogs, social media, and other modern approaches to knowledge creation beyond the published journal article. We will also encourage podcasts of research summaries, links to other real-time analytics websites, and other virtual accompaniments to supplement articles published in *Logistics*. We believe that knowledge creation is a fluid activity that requires a broader and more novel approach than lengthy conventional academic peer-reviewed formats where results are often dated by the time publication occurs.

Third, we are focused on research that is not only relevant, but also *interesting*! A very small proportion of what we see published today in traditional peer-reviewed academic journals is truly interesting, and rarely makes its way into any type of practitioner view. In many cases, presentations by academics of their research to practitioners is almost always deemed as "obvious", or even "irrelevant" as the problem assumes any vestige of reality from the problem at hand. We intend to apply a criterion of "interesting relevant research" as the primary filter for *Logistics*, with methodological rigor serving as a secondary filter. Authors who submit papers that do not offer any new insights or which model activities that are not realistic will be advised to submit to other publication outlets. The rationale for this approach is that there are many journals that are methodological "gatekeepers" for the field, but few that truly apply the criteria of weighting interesting ideas and innovative research as significant factors for publication. To state this plainly, the editorial team values research and scholarship that creates new insights into the major challenges of adapting to our emerging era of digitally transparent supply chains. We would rather identify research and substantive writings that are provocative, that challenge existing paradigms, and that introduce creative ways of thinking about supply chains or advance novel data collection analysis methods (even if in experimental form) to current problems.

So what are the issues that are truly interesting? While the following issues described in this essay are far from exclusive, here are some that I believe require greater exploration and development.

2. Issue 1: Re-Thinking the Objective of "World Class Supply Chains"

As a young assistant professor at Michigan State University in 1992, I was part of a group called the Global Procurement Benchmarking Initiative. This initiative benchmarked over 300 global companies, and set forth many of the principles for what we called "World Class Supply Chains". Many of these principles became the foundation for consulting practices at Accenture, Deloitte, Booz Allen, and others. The principles at the time were certainly appropriate, and were considered ground-breaking at the time, and many were documented in our short book "Introduction to Supply Chain Management" [4].

Many of these principles were based on the theme that supply chain managers could move beyond being a "buyer and shipper of stuff", but as a centralized function that combine spending across both direct and indirect categories of spending, leveraged this volume through purchase power, and sought to achieve significant cost improvements and efficiencies. An automotive executive recalls how difficult this was given the technology limitations that existed in the early 1970s.

"To drive centralized buying, I had to dive down into the Bill of Materials and do a cross-tab. Fortunately, we had a decent commodity coding system for each part number with a prefix that described the car the part was attached to, the function of the item and the suffix that described engineering levels, color, and material to a certain degree. This was the first intelligent database system at the time that allowed me to look at a "deck" of the current buy for a commodity group for our production buy. I started by looking at no more than 10 commodity groups, and looked at the production buy across these commodity groups. With the data organized this way, I was able to see that I could consolidate the number of suppliers by commodity, the value of the buy for the group, using data that no one had ever seen before! This was really exciting! Then I created a matrix of around 35 existing buyers, pulled all the heavy truck stuff out of it, and ran summaries of the data. I could then start to see how many commodities I was dealing with, and was able to reload the commodities to a smaller group of buyers with broader responsibilities that might cover more than one commodity."

Over time, executives also began to understand and realize the critical role that suppliers and distributors played in driving revenue and controlling costs. They began to establish systems for measuring supply chain participants' performance, improving performance through development activities when they could not do so on their own, and acknowledged that not all relationships with these third parties were the same, with some needing more attention because they were more strategic than others. Over time, the terms "strategic sourcing" and "logistics integration" were coined, which largely involved combining volumes of requirements from across the business, grouping them into large bids, and driving down costs due to larger quantity discounts achieved. This also led to the use of "reverse auctions", where suppliers would bid on these quantities online. In logistics, the focus became on centralization of distribution centers and warehouses to drive optimization in transportation routing, reduce inventory carrying and handling costs across the system.

Many of the traditional concepts that evolved from this perspective of "driving down costs" focused on driving efficient operations in the supply chain from supplier through to end customer. Many of these principles also coincided with the introduction of "lean manufacturing", based on the "just-in-time" thinking pioneered by the likes of Toyota. For example, the "Theory of Constraints" [5] emphasized that to optimize the end-to-end system, the "bottleneck" operation had to be addressed by adding capacity at this operation. The concept of "just-in-time" and "lean manufacturing" focused on standardization of products, improving coordination between different enterprises to reduce inventory, and only delivering the exact amount needed in small quantities that could be immediately consumed by the follow-on operation.

Another group at MSU under the leadership of Dr. Donald Bowersox led the concept of the "Logistics Renaissance", proclaiming that logistics was a value-added function that could drive market penetration through technology adoption. All of the work going on during this period highlighted many important issues, that were encapsulated in a "maturity model" that identified how organizations could develop these capabilities over time towards a truly "world class supply chain" organization.

However, "world class" still emphasized distinctions between the functional areas of purchasing, operations, and logistics, which were still viewed as disparate functions. Arguments broke out internally and in academic debates over which area had dominance over the others. The three groups involved in these activities (purchasing, operations, and logistics) were lumped together as "supply chain" functions, but never really stopped working independently from one another. Professional disputes emerged among the logistics, operations, and purchasing trade associations over who was really in control of the supply chain; purchasing felt they are calling the shots, while logistics professionals claim that they have oversight over all movement of material in the chain! All the while, they claim to be driving "world class procurement" or "world class logistics" practices, implying that these practices are the best of the best. In fact, "technology integration" was supposed to bring all these groups together, but in fact there still exists lingering tensions, discontinuities, and waste in the end-to-end supply chain of many organizations. Sure, they could buy things more efficiently, and ship things more efficiently, but were they really linked? Hardly.

One executive I interviewed emphasized this succinctly:

"We get hung up on World Class too much. World Class is simply a set of tools on a tool belt—but the real wave of change is on understanding the business well enough to apply the tools that will drive a total cost model, that spans the end to end value stream. Leveraging and strategic sourcing has gotten in the way of that. And a centralized world-class solution is not always appropriate in every operation globally, because a single model may not work for every small, medium, and large operation. And so we need to approach the problem with a different toolbelt, and be ready to use a number of different tools depending on the different business drivers and geographic components that are in play. World Class is focused on ticking the box around completion of the tools. We are too focused on getting an answer, rather than focusing on an outcome. We want to create nice two by two's with a label for a supplier, rather than generating and delivering a coherent strategy. I see supply chain practitioners using the tools incorrectly, and should be spending more time instead understanding what a performance specification looks like before going to the supply chain. There needs to be much more focus on the pre-award phase of the business, and the competence of the people doing this. And the total cost concept goes well beyond that."

In the end, there are some real problems with the "World Class" view of the supply chain. Although transactional excellence and efficiency is certainly an operative element that forms the basis for excellence, there is a shift away from the idea that "World Class" is something that applies to every situation.

3. Issue 2: Real-Time Transparency and Velocity: The Next Frontier

So if "world-class supply chain management" is no longer the objective, then what is the next generation of supply chains going to look like? In considering this question, it is important to recognize that managing supply chains is no longer about just cost optimization, but about deep understanding of the components of customer value, and making pre-emptive strategic plans that can better respond to sudden shifts in customer requirements and market conditions. This capability to respond quickly will be enabled by a series of dramatic shifts in the way we monitor the explicit needs of customers for materials, information, services, knowledge, and capability, but also to the intangible elements that drive the cost to provide this level of service. We are moving to the era of real-time supply chains, which involve understanding and predicting what internal users and customers will need right now, even before they themselves recognize that they need it. Response velocity is becoming the next capability that will define competitive survival.

The next competitive capability in the supply chain will be visibility, real-time response, and digitization as the ingredients for driving rapid growth in a flat economy. Visibility requires transparency, which in turn can be leveraged through the new technological capabilities of inexpensive cloud-based computing, distributed computing "at the edge", and the growth of a digital ecosystem.

Those who harness these technologies through collective innovation with their supply chain partners will win. In a single-digit growth world, velocity will become the only thing that matters.

Two key concepts reflect the core elements of real-time supply chains. Velocity is the ability of an organization to flow working capital rapidly from suppliers through end customers. Working capital is generally in the form of inventory, which is an asset that doesn't produce any revenue or cash. Thus, the object of the real-time supply chain is to achieve velocity in every aspect of how companies run their business. This includes how inventory is tracked and monitored, how much is produced, how quickly material and service suppliers respond, what modes of transportation are the most efficient and responsive, how to organize distribution and warehouse operations, how to move product through logistics systems, and most importantly, how quickly people in all aspects of the supply chain (suppliers, distributors, customers) are able to react and make decisions related to unexpected events and disruptions that impact the supply chain.

The key to enabling the ability to have velocity is through visibility—defined as the relative transparency of events, material, and flows to all key decision-makers in the extended supply chain. Visibility allows individuals to see what is going on, and in an empowered ways, allows these individuals to interpret information and rapidly make decisions in response to data. The opposite of visibility is opaqueness, which refers to a complete lack of visibility regarding what is happening in one's upstream and downstream network. When individuals have visibility that results in velocity of decisions, the system becomes frictionless. Speed of decisions increases not just the flow of information, but also the flow of materials, shipments, production, and all activities in the chain. This reduces friction, which in turn increases flow. Friction includes all of the typical delays and problems that slow down flow and cause inventory to build up. This includes multiple layers of approvals, delays in decisions until more information becomes available, or even operating as normal when a major disruption has occurred unbeknownst to you. It can produce bottlenecks in production systems and shipments, which delays material and causes inventory to build.

These principles are not new. Many of the concepts around "lean production systems" have emphasized flow and visibility. However, in the context of the digitization of the supply chain, these concepts have a new meaning and impact. It is also the case that many organizations have invested in very expensive systems called "control towers". In a control tower, information from all of an organization's logistics systems, production facilities, inbound shipments, outbound shipments, and inventory levels are dumped into a massive data warehouse. The information is then centralized into a "control tower", where individuals are scanning what is going on, and senior executives are "calling the shots", sometimes using complicated algorithms and automated ordering systems. The fundamental assumption behind control towers is that the people at the top have the best knowledge of how to optimize the entire supply chain, because they are the only ones who have access to all of the data. Much of the data is "integrated" (e.g., lumped together) from ERP systems, transportation management systems (TMS's), warehouse management systems (WMS's), distribution requirement systems (DRP;s) and material requirement planning systems (MRP's). Because many of these systems are in a "batch mode, which means they are updated on a weekly, or perhaps daily basis, the information being viewed in the control tower is always lagging. As a result, decision-makers in the control tower are making decisions based on what happened a few days ago, and are determining what to do next based on what they think will happen next. This scenario embodies the "old" themes of "supply chain integration": batch processing, information updates, "control-tower" thinking where only some people see the information, and decisions requiring signoffs by senior executives. An executive I interviewed stated this as follows:

"Real time supply chains are the anti-control tower. "Think about visibility in the context of driving your car. If you are watching your speedometer, you don't want information on your vehicle's velocity from a week ago, an hour ago, or even a minute ago! You want to know how fast you are moving right now! The same principle applies to the supply chain. To make informed decisions based on insight pulled from data, we need the data to be as fresh and as current as possible!"

Traditional enterprise software accumulates silos of data. This data is then called upon by managers and pulled up in reports that can be used to make decisions. It provides information in chunks or batches, which by definition is historical. In fact, almost all decisions in current supply chain systems are based on information about things that happened in the past. Just like the car speedometer telling you how fast you were going yesterday . . . this is our current scenario. We know how much we quoted, sourced, contracted and paid yesterday. What if we could make all our decisions in real time? What would happen to our performance if we had data in real time?

Visibility is only possible to the extent today because of the evolution of technology. Clearly the establishment of the Internet led to the explosion of information and the subsequent supply chain tools and applications that are now harvesting data, and leading to the evolution of "cognitive" computing. But the disruption has not yet fully matured; in fact, it is really only just beginning. As organizations begin to operate an entities that mediate impacts that are upstream and downstream, the power of this force will become evident as those companies who understand the deploy this approach survive and thrive.

4. Issue 3: Product Traceability of Food and Products through Product Genomes

The popular press is rife with stories about the is increasing globalization of modern supply chain networks that span multiple regions, cultures, and regulatory environments, and which produce an added dimension involving *complexity*, *social responsibility* and *sustainability*. Many SCM studies of the past assumed a static, rational set of managers making decisions without the interference of these elements in their decision process. Cost optimization was the primary objective of interest, and other factors did not enter into the value proposition or equation. In addition, many studies was focused on a bilateral relationships in a single tier supply chain relationship involving a retailer and customer, or buyer and seller. However, an increasing number of practitioners and scholars recognize that complexity is "one of the most pressing problems in modern supply chains and a key impediment to performance" [6]. Indeed, even for relatively simple products, modern management has created supply chains that involve a large number of direct and indirect buyers and suppliers, propagated across a broad network of stages (i.e., tiers) and dispersed over several continents [7]. The 2013 horsemeat scandal across Europe—whereby horsemeat was illegally contained in products that were declared to contain beef—reveals how complex supply chains have become. In this case, the supply chain network consisted of a Romanian slaughterhouse, a Cypriot meat trader operating in the Netherlands, who was owned by a holding company from the Virgin Islands, sourced by a French meat processing company, a French ready meal producer, its subsidiary in Luxembourg, a cold storage company in the Netherlands, retailers in various European countries and, finally, European consumers buying their dinner in a grocery store! Another example involved apparel designers, pursuing ever cheaper manufacturing labor costs, were scandalized by the 2013 Rana Plaza building collapse, which killed more than 1100 workers in a textile plant [8]. Due to the lack of transparency across many apparel supply chains, it comes as no surprise that several Western retail companies initially denied that the products they ordered were even produced in these conditions. Observed purely in the context of cost minimization, such network designs may appear rational, but, in light of the more complex criteria embodied in a holistic view of sustainable and ethical supply chain design, such events require a new way of research and pedagogical theoretical constructs. Theories that are unable to involve a new set of challenges encountered by decision-makers in a global supply chain network are doomed to fail covering relevant phenomena.

Digital technologies hold the promise here of being able to shed greater light on the origin and working conditions behind the apparel products, electronics, and consumer goods products we purchase. The idea of having "product genomes" that provide the historical origins of a product is one that is coming to light. Product genomes are analogous to a living thing's genetic material. The genome includes the entire set of hereditary instructions for building, running, and maintaining an organism, and passing life on to the next generation. [9]. In most living things, the genome is made

of a chemical called DNA. The genome contains genes, which are packaged in chromosomes and which affect specific characteristics of the organism. A genome map helps scientists navigate around the genome. Like a road map, a genome map contains a set of landmarks that tells people where they are, and helps them get where they want to go. In a similar fashion, digitization is driving us to better map product genomes. Tracking products and pinpointing not only where they are today, but their entire history through the chain, is emerging as a key enabler of transparency and visibility in the supply chain. Consider this: Can you connect the essential leverage points in your network through cloud, mobile, and other media that provide a platform for analytics? Can you track the DNA of your global supply chain at a part number level? Today, the answer to both these questions is no. Very soon, however, new technology will permit anyone, whether a consumer, a manager, or a supplier, to do this. As supply chains evolve, we need a structure for mapping their genome. This means establish part number tracking and coding in the end-to-end supply chain. A big opportunity is to think about a vehicle for encoding the genome, to help us understand where products come from and where they go, a critical element for combating counterfeit and fraud. Supply chain scholars rarely discuss waste due to counterfeit and fraud, even though it is a large area of lost global profits and revenues. The importance of tracking and measuring all goods, including the possibility of counterfeit goods, must be estimated using data tracking. But unlike the calls for "Big Data", we must de-mystify the view that Big Data is the answer to improving supply chains. Big Data is static and useless in itself; *it's the questions you ask of the data that change supply chain outcomes*.

5. Issue 4: Trusting the Data behind the Machine

Another set of phenomena that are duly noted to be absent in our current theories-in-use involve the integration of psychological and social phenomena, including *human behavior*, *relationships between individuals in supply chains*, and the role of *culture*. Traditionally, SCM has considered all actors to be rational, and of a like-minded, often Western, view of contracting behavior. The unit of analysis has often assumed rational actors making decisions within a black box, involving decisions made at an (inter)functional or (inter)organizational levels. This view completely overlooks the fact that supply chains are, in fact, systems involving the complex motives, desires, wishes, or interactions of and between individual people. Contracting behaviors in Eastern cultures are often not well-explained in the context of buyer–seller relationships. For example, Donohue and Siemsen (2011) [10] provide examples of questions that cannot be well explained when behavioral phenomena are ignored:

- "How do trust and fairness factor into supply chain relationships?"
- "Why do supply chain professionals often place orders that do not correspond to the recommendations made by normative models?";
- "When does a stock-out upset customers and what impact should this have on supply chain execution?"
- "Under conditions of stress, do humans trust machines or analytics?"

As an example, based on their results of a review of inventory management models, Williams and Tokar (2008) [11] argue that behavioral issues are not adequately accounted for in many observed inventory planning models. While research on has often been made on the basis of assumed rules and interactions between rational decision-makers representing companies, our research neglects many aspects of human behavior, company culture, and cognitive biases that underlie the interorganizational relationships we seek to model and explain.

A study by Boettcher et al., 2016 [12] provides a clue as to the complex relationship between man and machine in the supply chain. They conducted a study that included both an automated tool that provides a map that contains information regarding past IED explosions and insurgent activity to illustrate one optimal route choice, and a second in which a human provides information that conflicts with the map and recommends a different route. The findings of the laboratory simulation using a group of young students was very revealing:

- Presentation order did not significantly affect reliance/trust in human and automated sources within risky decision-making tasks. In other words, there may be more critical design choices worth considering when designing systems to promote reliance for this type of scenario.
- When presented with conflicting information from automation and human sources in high workload scenarios, operators may increase trust in human sources. In other words, increased workload negatively affected trust in automation.
- When presented with conflicting information from automation and human sources in high risk scenarios, operators may decrease trust in automated sources. Increased risk positively affected trust in the human. This may be due to the added load of assessing automation's trustworthiness.

The implication of this research is that any real-time supply chain system must have the following characteristics to be successful:

- The system itself must produce data that is trustworthy. In other words, the data must represent the reality of the situation.
- The information provided by the system must be aligned with human perceptions of what is happening as well. It also suggests that combining human observations with system data can augment and increase the level of trust that others observing the information will have in the data.
- Under high-risk situations common in major disruptions, people will trust humans over system-produced data. This is a cultural artifact that should be considered, and an obstacle that may need to be directly addressed.
- Under a high level of workload stress, again operators may trust more in human dialogue. The need for human-to-human communication under these types of situations is important.

Because the emergence of real-time supply chain systems is so novel, there are many such cultural artifacts that may need to be overcome, even if the systems issues are addressed.

6. Issue 5: Innovation as an Outcome of SCM

Research is often directed towards improving the efficiency of processes rather than other goals, such as rewarding cross-enterprise *innovation* in the supply chains [13]. A recent exemplar that bucks this trend is research by Bellamy et al. (2014) [14] who explore the influence the structure of the supply network has on innovation. Still, much of research in our field is lagging when it comes to embracing innovative paradigms and technologies. Examples include the paucity of research that explores the impact of embedded product data flows, such as big data analytics, the impact of 3D printing on inventory models, and the ubiquity of smart phones as a method of material planning and risk management. Second, we have often sought to develop theories "that can explain as broad a range of phenomena as possible" (Tsang and Elsaesser, p. 409. [15]). However, this focus on generalized principles may have led us to neglect research that explains the peculiarities and context associated with innovation *industry-specific supply chains*. Some of the more unique types of supply chains include oil and gas, hospital and patient care, financial services, construction, and biopharmaceuticals.

Can service and manufacturing supply chains really be covered by the same supply chain principles? Can the power structure and long-term orientation of an automotive supply chain really be compared to relational structure and the goals of a food supply chain, or a call center system? And to what extent are actors that emerge in these spheres unique to those ecosystems, e.g., the donor or politician involved in a humanitarian supply chain, or can all of their behaviors be effectively explained by the same set of generalizable theories? We believe there are unique industry specific supply chains do have unique characteristics that merit a different set of research tools and paradigms. For instance, project procurement is an emerging field that requires how to manage and monitor third party contractors, and ensure that they are safe. Innovative technologies are emerging to help monitor and manage contractors, including wearable technology, body cameras, 3D visualization technology, and wearable glasses with instrumentation and guidelines for operations. These emerging fields are

ripe for further inquiry and research, as we explore how to manage people in service industries who are working in difficult and extraneous conditions.

7. Issue 6: Legal and Financial Transparency—Who Owns the Data?

One of the emerging issues in today's supply chain is how data and information is transmitted in real-time, and what information is suitable, versus those that could be completed in batch mode. In the words of one analyst, "Not all data gets a first class ticket!" There are significant challenges in thinking about what types of data should be created in real-time (natural disasters, financial issues, market shifts, capacity issues, operational breakdowns), versus those that can be communicated and transmitted in real-time. In addition to this question, there are issues around how people will be prepared to *get their heads around the issue of transparency*. There are also significant legal constraints around the concept of complete sharing of data up and down the supply chain. Legal counsels are likely to not only object, but forbid the open and real-time sharing of sensitive data, which is exactly why the concept of transparency reveals. There are also significant challenges around the idea of data ownership, as data is rapidly becoming the basis for creation of analytics. There may also be issues related to litigation around post-event data, and whether this information will be kept and for how long. Just like DNA cells are now used to open up old criminal cases and new evidence is introduced, the issue of how long data from supply chain events is kept around is sure to be a contractually complex issue going forward.

Supply chain financing is another emerging area that will rely on exchange and availability of key data. The complexity around how to transact complex exchanges in the supply chain, including currency denominations, the emergence of block chains as a vehicle for exchange, financial hedges, and other transactional components of the supply chain will become more critical. The preservation of supply chain transactional data will become an important component for tracking and auditing supply chains, and will also play an important part in the chain of custody of supply chains, and understanding the origins of many products and services. This is of particular interest to the intelligence community, which seeks to decipher and unravel the source of illicit goods and human trafficking in the supply chain.

8. Issue 7: Supply Chains as Complex Adaptive Systems

The new era of the digital supply chain should explore Complex Systems Theory. For too long, organizations are managing based on transactional boundaries, using simple deterministic ways of thinking. However, the network of firms in the supply chain is more akin to the dynamics associated with Complex Systems. Complex Systems Theory grapples with how organizations adopt in the face of dynamic change and evolve over time, with those organizations best able to adopt ultimately surviving [16]. A further branch of thinking suggests that firms which survive essentially co-evolve with those entities around them. This line of thought, sometimes called the "resource based view", suggests that the changing relationship between a firm's activities and entities in its competitive environment creates whatever distinct capabilities it draws on for sustained competitive advantage. (Many scholars have contributed to this line of thought. A good summary of these references is provided by [17]. In simpler terms, the organizational processes that occur with other entities in the value chain together provide the "emergent" strategies that shape how the organization survives.

As with Darwinian theory, which states that living things evolve as their parts (organs, biomolecules, or genes) mutate, organization theorists would suggest that organizations adapt as each of the supply chain competencies (representing micro-agents—the individual activities that make up the entire organization) influence selective advantage for the firm as a whole [18]. Again, translating this into operational thinking, organizations that drive collaborative behavior with their key supply chain partners in their daily routines, contracting approaches, and relationships, co-evolve to a higher level of performance that allows all entities in the chain to not only survive, but adopt to the rapidly changing environment around it. More importantly, "in co-evolutionary processes, the

fitness of one organism or species depends on the characteristics of the other organisms or species with which it interacts, while all simultaneously adapt and change." [18]. This evolution occurs even in an environment that is characterized by rapid change, regulatory pressure, new technology, and other major challenges. As Kauffman notes, "A critical difference between evolution on a fixed landscape and coevolution is that the former can be roughly characterized as if it were an adapt search on a "potential surface" or "fitness surface", whose peaks are the positions sought. In coevolution, there may typically be no such potential surface, and the process is far more complex" [18].

The implication here is that organizations in the supply chain must begin to think of not only their local environments, but extend their strategies to consider all of the participants in the supply network. All organizations evolve based on the application of rules or based on following a certain set of performance metrics that indicate progress towards those rules. The problem, or course, is that adherence to these rules may lead to evolution, but not all evolutions lead to successful adaptations to the environment! [19] Many organizations may be following the wrong set of rules, or even if their intent is to improve, they are using the wrong set of performance metrics to indicate whether adequate! Progress is being made towards the right evolutionary outcome, but the ability to be agile is critical.

9. Issue 8: Identify the Strategic Fit of 3D Printing in Supply Chains

Perhaps no other technology has gotten as much press as 3D Printing. There have been some outlandish claims made about this technology in the popular press. For instance, some have claimed that the emergence of 3D printing will make it unnecessary to forecast demand since it is possible to have local manufacturing completed anywhere, anytime, and that products need not be made in advance. Similarly, a myth exists that companies will not need to maintain inventories for spare parts for products since products can be produced immediately on demand with the help of 3D printers.

While 3D printing does hold a lot of promise, there are indeed a number of myths that should be "clarified" regarding this technology. To begin with, 3D printing is not new; it has been around for more then 25 years, and is a fairly robust technology. The terms rapid prototyping, 3D printing, and additive manufacturing are all terms for the same process. Second, 3D printing is not as simple as the hype would have you believe. In fact, there are three stages of 3D Printing. First, design engineers need to design the parts for 3D printing. This is an important first step, there are certain products that are a good "fit" to consider when designing parts for 3D printing. For instance, 3D printing is NOT good for high volume, very large parts. The process takes very long, as much as several days, and is not cost effective compared to high volume production. The sweet spot for 3D printing are parts that are too complex for injection molding, as well as complex steel and aluminum parts that require a very smooth surface that won't work well for casting. 3D printing is also used to create parts that are then developed for casting production, especially for prototype development (such as aerospace components).

There are also several versions of 3D printing production technologies and materials. The most common of these is sintering. In sintering, layers of plastic, aluminum, or other materials are spread onto a plate, and are about 0.1 mm thick. Next, ultrasound lasers sinter or "melt" the layer of plastic or steel. The entire plate then moves down into a box, and the next layer is added. At the conclusion of the process, the entire box is full of plastic powder, with the components in them. Each box may have many parts that are layered geometrically into it like a 3D jigsaw puzzle, and this is done to maximize the productivity of the process.

I have visited world-class 3D printing companies with machines that may take one to three days to produce a single box of parts, which means the operation runs 24-7. 3D printing has been used to create customized furniture, customized insoles for Adidas, aerospace prototypes, and even takes orders from consumers who can submit their own design for 3D printing. The production is used to construct a customized hip implant component was being produced and custom fit for a patient, and then surgically implanted in the patient. The hospital would take an MRI to get the dimensions and detailed scans are used to then custom fit the hip implant. The bone will then grow into the

implant and integrated into the bone structure. They also can create models of hearts based on CT scans, so that surgeons can "simulate" a difficult operation prior to the occurrence using the model of the heart sintered into plastic. The risk is much lower as the physician has practiced on a model of the heart in a black box.

The primary benefits of 3D printing are to shorten product development time to market. The ability to rapidly and cheaply produce prototypes based on a design is instrumental and less cost then injection molding, and works best for low volume (e.g., one-off) products that are complex to produce. The technology is also ideal for mass customized, one-off products, where there is a custom design with variability, such as customized medical devices. For example, when a manufacturer of hearing aids began to use 3D printing to produce devices that were customized for people's different ear tube shapes, he set the standard for the industry. Today 99% of hearing aids are produced using 3D printing. Software scans the shape of the ear, and you can receive them in a very short time.

There is indeed a sweet spot for 3D printing that is growing. This is an area where further research is needed to explore the strategic decision processes around where and when to invest in a 3D printing technology. Injection molding is better for high volume products that are not complex, but the real benefit of 3D is that there is no additional incremental cost as complexity is increased in the design of the part. It makes no difference to the machine time. The only limits are material and technology and time. If you need the part in a day, it is not suitable, as it is a slow manufacturing technique.

Spare parts for machines are a potential growth area. The technology is attractive to oil and gas where down time costs millions of dollars. However, the technology is not yet able to produce titanium parts next to the equipment in minutes that would be able to be used. This is projected to be possible perhaps in a 5 to 10 year window. The future of 3D printing in the world of supply chain management is growing. While the potential for MRO and spare parts production is possible, there may be other areas where emerging applications will begin to pop up in the years ahead.

10. Issue 9: The Rise of "Good" Supply Chains

No one denies the need for sustainable business practices as a matter of the natural course of business. Fewer people, however, recognize the externalized costs of sustainability, both on the brand, and the long-term viability of the organization. Rather than focus on sustainability, I prefer to think of this as "transparency", which implies the ability to track the origins of products and services, thereby providing full disclosure of the "carbon footprint" and "human labor footprint" associated with products. This level of transparency will allow individual consumers to make the right decisions in their consumption patterns, and will also hold large corporations more accountable to understanding what is going on in their supply chains. And most importantly, whether their supply chains are "good".

Good supply chains balance performance, price, integrity, the environment, and social and political factors, allowing free and open trade while not transgressing the boundaries of integrity and human rights. This theme is most often called sustainability. It is interesting that the original concept of sustainability also has ecological roots: sustainability is the property of biological systems to remain diverse and productive indefinitely.

Sustainability can also be defined as a socio-ecological process characterized by the pursuit of a common ideal. Both concepts have an implicit reference to the idea of balance, endurance, and diversity of life.

Perhaps the closest equivalent to a trophic cascade in the supply chain sphere is the economic concept laid out by one of the earliest visionaries of our time: Adam Smith. Adam Smith wrote one of the most important and enduring set of business tomes of all time, *The Theory of Moral Sentiments* (1859) [20] more than 250 years ago. Smith recognized that the "invisible hand" of the market would create the right balance and outcomes for society in the long run, if it were allowed to operate freely. He notes:

"The rich ... are led by an invisible hand to make nearly the same distribution of the necessaries of life, which would have been made, had the earth been divided into equal portions among all its

inhabitants, and thus without intending it, without knowing it, advance the interest of the society and afford means to the multiplication of the species." [20].

In this manner, Smith makes a direct reference to the idea of diversity and balance in the natural order of civilization that maintains the sustainability of the system. The guidelines of the "invisible hand" apply here to the idea of natural competition in the supply chain. Open-source data and new cognitive technologies are enriching the invisible hand of the market and creating greater diversity of competition by the day. An emerging concept is that companies should go out and "mine" dark data, to "find" the market and the best suppliers, and in this manner explore markets to drive competition while establishing stronger relationships with the most competitive supply chain partners. Doing so makes the entire system healthier and more robust. Exploring vast quantities of market intelligence data on the Internet, the thinking goes, allows businesses to optimize cost and supply. This concept also prevails in the context of traditional "world class procurement" principles, which dictate that one should reduce the supply base to the "optimal" few. The assumption in many cases is, "We have too many suppliers. We should pare our supply base to the qualified and critical few."

This marketplace is the essence of creating balance in the supply network. The key to a "good" supply chain is balance among the following elements:

Integrity—Customers must believe a product's advertising and trust its label. They must be assured that no counterfeit elements or substitutions have been made.

Environmental health—At worst, do no net harm to natural or social systems while still producing a profit over an extended period of time; a truly sustainable supply chain could, customers willing, continue to do business forever. One emerging issue here is the bio-based economy [21]. As we move away from traditional petrochemical feedstock, the emergence of natural feedstock such as corn, cane sugar, and second generation natural sources will begin to drive the emergence of an entirely new set of supply chains [21]. The design and structure of these emerging supply chains will be an important and interesting development in the years ahead.

Products are produced in safe environments with fair wages, overtime, fair working conditions, and adult labor, that acknowledge the rights of workers to form unions, and that do not bully, coach, or force employees to do anything that is not within the normal requirements for humane working conditions. (Note that this can cause conflicting issues in some countries, for instance, India just passed a law allowing 15- to 18-year-olds to work in family businesses, in defiance of UN mandates). [22].

Politically and ethically sound policies—This includes appropriate governance over financial and social dealings, free of corruption, bribery, and fraud. Data is truthful, financial results are not overstated, and share price reflects the true value of the organization based on audited assessments of revenues and costs.

Good supply chains include all these characteristics. When they are all in balance, open and free competition flourishes, for all factors of labor, and all forms of free trade, allowing value to flow.

11. Issue 10: Reverse Supply Chains

Returns are a major problem for consumer packaged goods manufacturers in general. This is because 94% of all consumer product introductions fail to meet their projected sales targets. After a product is introduced, many companies have distribution channels stuffed full of product, retailers who have cleared out shelf space in the store, and have developed commercials, incentives to promote the product. When the product fails, the first thing they do is lower the price. And then when none of it sells, it comes back at full cost with transportation, handling charges, and no secondary market for it (no one wanted to buy it at the front end, why would they want to buy it on a secondary market?). And supply chain executives are realizing that they need to become more strategic in answering the question: how should we manage this asset now that we are stuck with it?

Third party companies serve an important role in managing the relationship between the retailer and their suppliers. They act as an intermediary, receive the returned product, scan it, and provide the retailer with the reporting on returns. They then forward it along and bill it to their manufacturer.

All return departments in stores ship the products to these third parties to handle in a centralized manner. In theory, this sounds great. In the real world, it has problems. For instance in one major retailer, individual stores were responsible to handle damages—if they found a case of broken light bulbs, they created an invoice to the supplier for $30 for light bulbs. With 2000 stores, they need a person who is fluent at each store and aware to do it every month for all of the stuff that comes in to the returns counter. This does not always happen using a common process. As a result, there are millions of dollars lost for legitimate claims that haven't been processed properly. But the challenge is that individual retail locations have bad habits. Unless you really audit and account for what happens to returns, it ends up in many cases going into the dumpster. And in many cases, the product is still good. It can be refurbished, repaired, or re-sold to a secondary outlet, or donated for credit. Remarketing and Recycling is another important element of the returns process selling in different markets at a different price may often be an option. Until you tie that behavior back to the store, and tie the inventory responsibility for the stores, it is difficult to get behavior aligned. Part of the expertise is working on these challenges upfront.

Being "sustainable" is inherently associated with reverse logistics, but in the end it is really just good business management principles being applied. [23] People pursue reverse logistics because they want to tell people they want to do the right thing—and will spend $10M on a sustainability program, and then $3M telling them about it. Reverse logistics begins and ends with a business case, and the ability to execute on that business case to cover the cost of returns, which are an increasing cost in the retail environment.

12. Issue 11: Digital Computing at the Edge—the Internet of Things

A set of insights were shared by George Moakley, formerly the Enterprise Architect and Strategic Planner at Intel, now a founders of the new Intelligence at the Edge for Supply Chain Lab at Arizona State University. George spoke to a group of executives at the CAPS Roundtable at IBM in RTP on September 19, 2016.)

In considering the new technologies around the "internet of things" (IoT), researchers should adopt a different conceptual framework that considers the fact that technology is both evolutionary and revolutionary. Evolutionary technology is about doing things better; revolutionary technology is about doing better things. Doing things better is where most of the technology changes will occur, and this will come in the form of novel services which enable novel platforms. Many people think the IoT is about collecting data at the edge and throwing it into a data center and crunching it. But developers need to think differently about how the IoT will be used, because the true innovators will be computing at the edge of their supply chains, not at the center.

Consider the cell phone. When smart phones came out, people first discovered they could use a browser. But recall the first time you used a browser on a phone: it was awful! So we became smarter about designing websites so browsers could be used more easily, and that in turn led to Apps, which are a better way to use smart phones. So the evolution of the service platform led to revolution platforms, which is how technologies will enable platforms.

The digitization of the supply chain is coming, but no one is certain as to how it will unfold. Along with this evolution in how technology impacts our daily lives, one of the biggest changes will be in the "internet of things", which will drive "computing at the edge". This is also known as "distributed computing" and "distributed analytics", which involves computing data at the source of collection, which will increasingly be in machines and equipment. Smart sensors are emerging in the sub-$5 range that will capture data on shipments' temperature, location, and velocity.

A great example to consider is the collection of tire pressure on a moving truck. Sensors in the tires will capture tire pressure every millisecond—but there is no need to dump all of this data into a centralized data center! Smart sensors combined with distributed computing on the truck will collect first-pass data, and generate summary statistics, such as the fact that the tire will last 362 miles before a flat. Sensors combined with a local computer can provide key analytics, and when multiple sensors

interact, they can provide clues as to what is happening in the supply chain. For instance, vibration sensors combined with the tire sensors may have a strong correlation with theft, and analysts can determine that if they know what they are looking for. In another case, a truck pulling up to a loading dock in a distributed computing model will interact in the cloud with systems at the loading dock. A notification will be sent regarding the number of loads ahead of them at the dock, and the driver may be notified to slow down, burn less diesel, or take a break for a meal, as their slot at the dock has been pushed back. These types of interactions will require that cloud edges need the ability to discover each other and communicate. For this to occur, standard will need to be established, just like ethernet cables and internet protocol standards were agreed on for telecommunications.

Such technological evolutions will create service provider niches that will form the basis for commercial platform creation, ("evolution"), but also the potential for extinction of existing service providers through disintermediation and reintermediation. New technology has the potential to drive innovation and new platforms, but waves of digitization also can cause creative destruction of existing players that are too slow to keep up. In other cases, lawyers are quick to object with security concerns, just as they were with personal computers, personalized apps, and voicemail. Waves of digitization will continue to re-shape the environment we live in.

13. Conclusions

To summarize, these issues are not the only ones that are interesting and relevant, but they do seem to me to be issues that are not well understood, and which require some additional thinking and insight. We need academic researchers who are willing to engage with practitioners and recognize that the assumptions they are making are in many cases fallacious. And practitioners need to engage with academics who can provide a higher level of integrity and thought to these issues in an unbiased and more scientific manner. We both have a lot we can gain from each other. Hopefully, this journal is the beginning of a journey that will create insight and knowledge in these important areas affecting our global ecosystem.

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