THE APPLICATION OF ARTIFICIAL INTELLIGENCE TO GLOBAL TRADE:

A New Era for Supply "*ChAIn*" Management

by Daniel L. Gardner

Abstract

Artificial Intelligence is a branch of computer science that combines algorithms, software and hardware to build systems capable of replicating human thought and behavior. Within a subset of AI known as, “Machine Learning,” engineers design platforms that study data, learn from what is analyzed, and then apply those learnings to reveal data patterns, formulate predictions and/or make decisions. Much like a human, AI bases these cognitive processes on insights gleaned from historical and real-time data inputs. Because trade professionals use data to create sales forecasts that predict future outcomes, which in turn trigger operational and financial decisions that are influenced by recurring patterns of variances between actual and forecasted sales, supply chain management is fertile ground for AI. This paper sets out to identify the opportunities that abound in supply chain for AI, while pointing out the challenges inherent to such an ambitious undertaking.

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Introduction

The modern age of Artificial Intelligence (AI) began in November of 2022 with the release of ChatGPT. Created by the company OpenAI, this breakthrough technology uses Machine Learning to understand and respond to a user’s requests or questions. While ChatGPT gained notoriety as a Chatbot able to write papers on behalf of unscrupulous students, it has the versatility to translate languages, condense large documents into summary format, create charts and graphs from prose descriptions, and even write computer code.

Although Chatbots have captured the world’s imagination, other AI applications go beyond the generative capabilities of these “Large Language Models” to impact fields of human endeavor never thought possible. Whether it’s the use of Computer Vision to analyze thousands of MRIs and CAT scans to detect early cancer cases, or AI robots in factories that independently decide if a product passes a quality inspection, it seems that there is no limit to what Artificial Intelligence can do to improve nearly all aspects of the Human Experience.

While disciplines within the field of AI such as Computer Vision and Robotics have shown great promise for supply chain management (SCM), the area with the broadest and most impactful applications is Machine Learning (ML). There are many reasons for this, but one needs to look no further than the common ground that exists between ML’s core capabilities and the objectives of SCM to discern the mutually beneficial nature of the relationship. A comparison between what supply chain really is and what ML is designed to do, illustrates this point.

Futuristic by nature, tactical supply chain management comes down to predicting future outcomes in the form of a product sales forecast, and then executing against the forecast by making

decisions in functional areas that include procurement, logistics, manufacturing, sales, and accounting. Once supply chains are in motion and products are selling, executives then take measures to account for the inevitable variances that occur between forecasted and actual sales through the business activity known as Sales & Operations Planning (S&OP).

Since the late nineteen seventies supply chain professionals have used software-based technologies to carry out the aforementioned activities. Beginning with the automation of sales forecasting and moving on to operational functions like Material Requirements Planning (MRP), the developers of these single solution software packages evolved to create Enterprise Resource Planning (ERP) systems that not only integrated multiple supply chain functions, but that tied them to a “single version of the truth” accounting module.

While recognizing the phenomenal productivity gains born of these technologies, each was designed to automate business tasks. Basically, a system carries out what the code instructs it to do, without the ability to do anything other than the activities defined by the computer program. Machine Learning differs from traditional software to create platforms that mimic human thought and action, without explicit coding or human intervention.

Based on the premise that global SCM and Machine Learning share many parallels, this paper focuses on the ways in which ML-based Artificial Intelligence can augment a myriad of supply chain tasks and processes. Beginning with a depiction of how global supply chains work at a tactical level, the author then moves on to describe how ML supports and improves desired operational and financial outcomes. Key assertions are supported through the experiences of a fictionally named import company, “Serna Outdoor Living.”

Recognizing that technologies have flaws, limitations and downsides, the paper’s enthusiasm for AI is tempered by callouts on the role that data plays in allowing machines to apply what they have learned, what the limits to those learnings are and the talent shortages that exist in trade-centric solutions development. On a grander human scale, the likelihood of job loss is confronted, as well as the legitimate concerns about the amounts of energy and water needed to run AI data centers when Climate Change is already wreaking havoc on the planet.

Author's Note

As of the publication of this paper (March 2025), the terminology used to explain the various facets and subsets of AI seem to be growing faster than viable solutions. Because the author's efforts are dedicated to the application of Machine Learning to supply chain & logistics, it is important to bring greater contextual meaning to four pivotal terms.

When AI experts speak of systems that learn from data to uncover patterns, offer predictions and make decisions without human intervention, they are referring to the capabilities of an "AI Agent." An offshoot of AI Agents, an "Expert System" works in a single domain and uses a combination of data, work rules and a programmed knowledge base to generate outputs. This nuanced, but important difference will resurface in the final Section of this paper.

Within the above framework, "Narrow AI" describes solutions that execute defined tasks and processes. Conversely, the newly minted realm of, "Artificial General Intelligence" (which doesn't exist yet, BTW), will create a world where a system can think and act in multiple environments, much like the human mind can multi-task or quickly toggle from topic to topic.

As the reader will have observed, these definitions portray a world of blurred lines, overlap and confusion. To be clear, the solutions described in this paper fall within the category of Narrow AI Agents and Expert Systems that someday may evolve into Artificial General Intelligence. For now, we'll stick to practical applications that take advantage of technologies and operational know-how that when done right, can have an order of magnitude impact on global trade.

Supply Chain at its Core: The Import Operating Model of Serna Outdoor Living

Supply chain networks are as abundant as the industries and organizations that engage in international trade. While every supply chain has unique characteristics, there are certain tasks, processes and financial goals that transcend industry, company, geography and culture. In the following Sections, reference is made to several Figures that depict the ongoing execution of fundamental supply chain & logistics functions during a one-year budget period, and how AI can augment and improve upon desired outcomes.

To bring the story to life, a fictitious U.S. seller of camping equipment provides the operating model. Headquartered in Dallas, TX, "Serna Outdoor Living" (aka "SOL") imports from eighty suppliers in ten Asian countries, selling to well-known retailers, as well as running its own e-commerce site. Serna sells to it retail customers through a national sales force and ships from three third party DCs. SOL carries 750 SKUs across its line of coolers, furniture, lighting, sleeping bags, cots and stoves, with a minimum of fifty new product introductions per year.

Serna uses a home-grown ERP that links essential functions including forecasting, materials planning, purchase order management, sales, distribution planning and accounting. Due to its evolving

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product selection, the company creates sales forecasts for both evergreen and new products. SOL's ERP does not currently receive real-time sales data directly from its retail customers' Point of Sales (POS) systems, nor does it feature a Warehouse Management System (WMS) or Transportation Management System (TMS).

Prior to describing SOL's operation, it must be noted that although many supply chain activities are sequential and others can be conducted simultaneously, a supply chain is best viewed as a system made up of players whose actions create feedback loops that span the entire enterprise. And whereas it's easy for humans to understand direct cause and effect dynamics between two entities, the multi-player feedback loops that truly drive results are hard to discern. It will be ML's ability to recognize and act upon feedback loops that boost its future value to SCM pros.

The reader's attention is called to Figure 1, the prose-based details of which are explained in a clockwise fashion. This process depicts Serna's historical use of its ERP, where import-related activities and processes are not currently augmented by Artificial Intelligence.

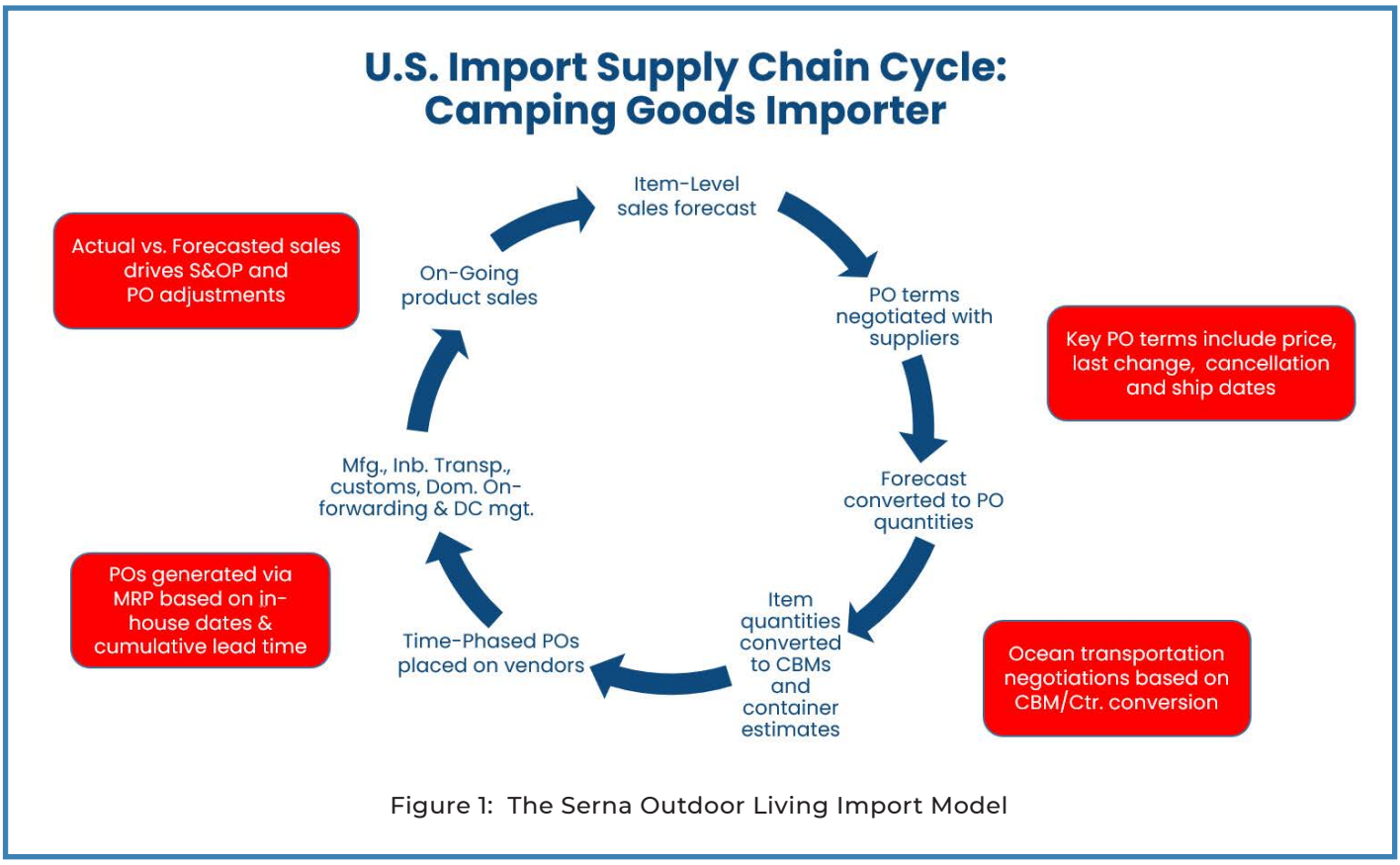

Figure 1: The Serna Outdoor Living Import Model

Item-Level sales forecast

Serna has access to its own e-commerce sales information, but it's a challenge to receive forecast data in a timely and consistent format from its retailers. The process is further complicated by the need to estimate sales for products the Company carries every year, as well as for new items. Because SOL's revenues are seasonal and camping seasons are longer in warm climates than in cold ones, the accuracy of region-specific forecasts has been problematic. Confounding matters is the fact that once a forecast is completed and products are selling, Serna's ERP can't automatically receive a retailer's real-time sales data.

Purchase order terms negotiated with suppliers

Serna Outdoor Living has worked with many of its vendors for years, but each buying season requires that PO terms be finalized based on the current year's projected volumes. Because most suppliers in Asia produce on a Build-to-Order basis, Serna's buyers can't order goods from a supplier's inventory and have them shipped the next day. As such, these inherently longer cumulative lead times require that terms like price, last PO change date, PO cancellation and last ship date are in-step with the conversion of the forecast to PO quantities.

The sales forecast is converted to vendor purchase orders

Once the forecast is done, Serna's ERP converts projected demand for each item into initial purchase orders (POs) that are then placed on eighty vendors in ten countries at different times during the year. Integral to the PO generation process, the SOL team manually calculates and uploads cumulative lead times into the ERP to assure that PO placement dates will align with the in-house dates imposed by its retail clients and three fulfillment centers.

Item quantities converted to cubic meters and ocean container estimates

Conducted outside of its ERP, SOL's logistics team works with colleagues in purchasing to calculate the quantities of each item needed for the upcoming year. With those quantities, logistics folks then convert carton weights and dimensions into cubic meters to determine the number of ocean containers that will be required to ship goods to the U.S. Bearing in mind that this task is updated throughout a budget year for all products and vendors, the logistics department must constantly adjust container needs to align with item quantities and customer in-house dates.

Time-phased purchase orders placed on overseas vendors

Fundamental to the business discipline Material Requirements Planning (MRP), POs must be placed on vendors throughout the year to meet the timing and quantity demands of the business. Based on MRP functions known as "Gross to Net Exploding" & "Lead Time Offsetting," and closely tied to the above-mentioned conversion of forecast quantities to POs, the timely placement of vendor POs that align with customer in-house dates is essential to SOL's Value Proposition. Although the ERP does generate POs on a time-phased basis, any change in product quantities must be manually adjusted. Finally, the creation of a PO is system-generated, but upon issuance by the ERP, each purchase order must be manually reviewed and approved by a purchasing manager.

Manufacturing, inbound transport, customs, domestic on-forwarding & DC management

Serna's supply chain is characterized by third party relationships with product suppliers, ocean carriers, freight forwarders, customs brokers, domestic transportation firms and warehouse operators. This 3rd party outsourcing model has the advantage of creating a variable cost

structure where SOL only pays for the products and services it needs. It also relieves the company of assets on its balance sheet that impact profitability and cash flow. However, from a planning and execution perspective, the Company is hobbled by the inability to connect with each player's system and gain visibility as to the whereabouts of its inbound inventory.

Ongoing product sales

The Holy Grail of SCM is the ability to automatically compare variances between forecasted and actual sales and make rapid up/down adjustments to the flow of inventory based on what the data shows. In a practice known as Sales & Operations Planning, SOL has a multi-functional team of sales, purchasing, logistics and accounting pros that meet monthly to act upon forecast variances. An effective exercise that has improved product availability and profitability, the SOL team still must deal with the lack of real time sales data from its retail customers and the gaps in supply chain visibility mentioned above. Of equal import, the Serna S&OP team must manually decide on any item-specific up/down PO adjustments and key those adjustments into its ERP.

How Machine Learning Works

The central feature of Machine Learning is that it allows computers to learn from data, formulate predictions based on that learning process and ultimately, make autonomous decisions. Unlike code-based programs that excel at automating defined work, ML strives to create "Thinking Machines" that not only execute algorithmic tasks, but demonstrate human characteristics that include understanding, deduction, inference and action. In the end, isn't that what supply chain management is all about?

To appreciate how ML can elevate supply chain performance to new levels, one must first visualize how it progresses from data analysis to thinking and on to decision making, all without human intervention. To that end, Figure 2 explains how ML works. Although this depiction ignores important technical must haves when building ML tools, it provides an understanding of the ever-improving nature of Machine Learning and sets the stage for an upcoming analysis of how Serna Outdoor Living can exploit its many benefits.

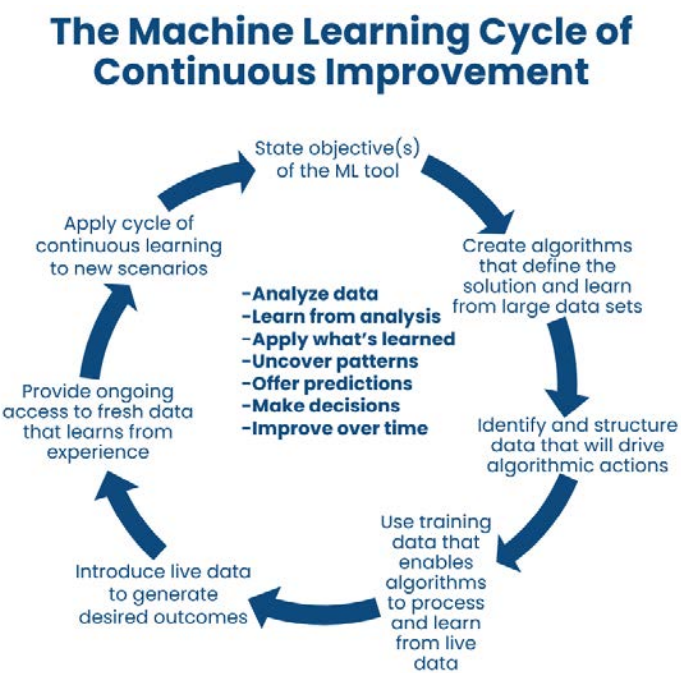

Figure 2: Machine Learning & Continuous Improvement

State the objective(s) of the Machine Learning tool

Like any computer-based solution, it will be impossible to create ML algorithms without first understanding what the objective(s) of the tool are. In the absence of clear goals, engineers will not be able to identify relevant data or design the algorithms that learn from data and drive outcomes. Given the potential of ML-centric solutions in global trade, this first step defines the goals of an application and as such, the scope of its technical requirements. First alluded to in the Introduction, it must be noted that today's ML-based supply chain solutions are designed to execute specific tasks in a field known as "Narrow AI." Someday, it is possible that ML for supply chain will expand to act in any type of situation in what has been labeled, "Artificial General Intelligence."

Create algorithms that define the solution and learn from data

When it comes to AI, an algorithm is a set of instructions that tells the model how to process and learn from data. In the physical world, people learn from teachers and their own experiences. With AI, an algorithm not only defines what and how the model will learn, it learns from the data itself. For supply chain professionals to get the most out of AI, they must understand the essence of the mutually reinforcing relationship between data and algorithms.

Identify and structure data that will drive algorithmic actions

In the ML world, think of data as the raw material that algorithms use to produce the outcomes of pattern recognition, predictions and decisions. Supply chains generate endless amounts of data, so what the data contains, how it's structured, where it comes from and how relevant it is to the application at hand matters a lot. Once relevant and bias-free data sources are identified, solution architects can move on to structure training data in a way that allows the algorithm to learn and act.

Use training data that enables algorithms to process and learn from live data

Just like an athlete practices every day to improve specific aspects of her game, ML-based Artificial Intelligence models must train, as well. And just like an athlete has to do the right exercises and drills to improve, algorithms need the right training data to prepare for when the system is called upon to process real data. Given the abundance of supply chain information, systems designers must be circumspect in the data they choose to train algorithms and how that data is structured. If not, data is likely to be incomplete, biased or entirely inapplicable to the solution.

Introduce live data to generate desired outcomes

Regardless of how much an athlete trains and prepares, she still has to perform on Game Day. The same principle applies when training data is replaced by the real data flowing in from multiple supply chain sources. Assuming that training data is relevant, live data must have the same characteristics to optimize learning

and in turn, produce high quality pattern recognition, predictions and decision making.

Provide ongoing access to fresh data that learns from experience

As any supply chain professional knows, the older the data that is used for predictions and decision making, the less likely that data is a true reflection of present conditions. Whether it's Point of Sale (POS) data that fuels collaborative forecasting and S&OP, or the use of Predictive Analytics for accurate vessel ETAs, new data must constantly be fed into the model to maximize the probability of accurate predictions and correct decisions. The bane of supply chain managers since time immemorial, the lack of access to real-time data in an AI model will lead to inaccurate outputs.

Apply the cycle of continuous learning to new scenarios

As kids, we were taught that once we entered the workforce, we would "learn from experience" and that "experience is the best teacher". No truer words have been spoken and for AI, it must be stressed that not only should Artificial Intelligence learn from experience; the humans that design solutions should, too. With applications for trade still in its formative years, this mentality is what will assure that AI lives up to its potential.

AI and Supply "ChAIn" Applications for Import Business Models

It's ironic that in the word "Chain," the letters "A" & "I" appear consecutively. Maybe that's an indication that Artificial Intelligence and SCM really were made for one another. Ironies notwithstanding, it is through the first-time use of the term, "Supply ChAIn" that we proceed to Use Cases where AI is applied to both supply chain and logistics. The first example of AI for Supply Chain takes us back to SOL's import business and how it can enhance performance. The second demonstrates the use of a Narrow AI Agent in SOL's import transload process.

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Prior to undertaking the enterprise-wide application of AI to its business model, Serna Outdoor Living needs to address existing tactical and technical challenges. If they don't, SOL will end up juxtaposing Artificial Intelligence over flawed processes and gap-ridden technology. Whether it's the inability to ingest live sales data from retail clients or purchasing managers having to manually adjust and approve POs prior to issuance, SOL should endeavor to fix these issues.

Of critical importance, the SOL team has to be leery of mistaking automation for AI. The Company's ERP already has code-based features that include the (initial) automation of Gross to Net Exploding and Lead Time Offsetting. However, it must be reiterated that these functions only do what the code tells it to do; AI uses a combination of hardware, algorithms and code to think on its own. As such, the SOL team needs to constantly remind itself that if a computer doesn't uncover patterns, offer predictions and/or make decisions independently, it is not AI.

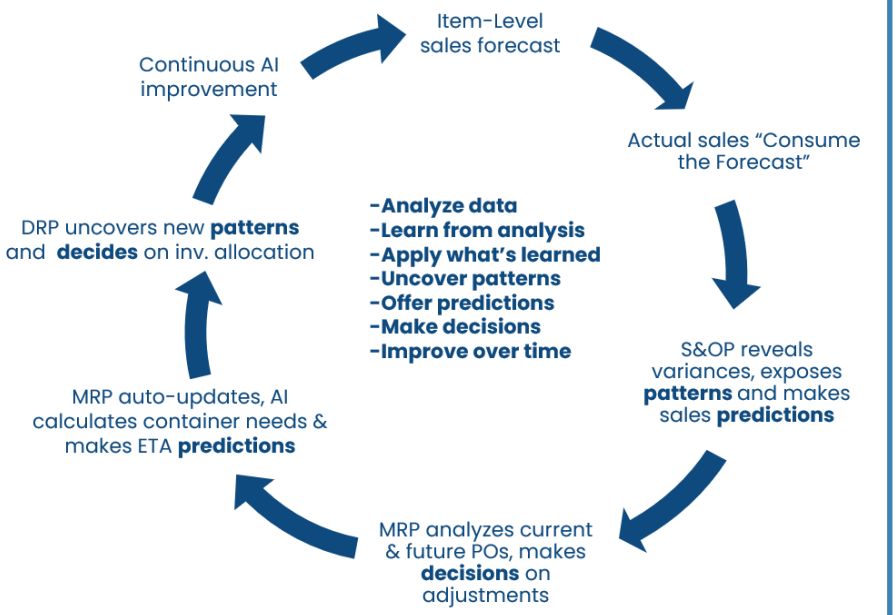

Figure 3: The transition from Supply Chain to Supply ChAIn

As SOL goes through this transformational process, it also must be realistic about what the learning capabilities of an AI platform really are. Let us not forget that humans make in-the-moment decisions (in part) based on experience and to do that, people must remember what those past experiences were. Implicit in that cognitive process is reliance on memory and folks' ability to draw on the past to guide current decisions. Whether an algorithm can be designed to really draw on memory is a limitation that any importer must acknowledge.

Guided by the above, the reader is directed to Figure 3 and the subsequent explanations of where and how AI Agents can transform SOL's import supply chain model. With the goal of creating a Supply ChAIn, it is recommended that what is presented here be treated as a futuristic portrayal of how AI can improve operational and financial performance.

Item-level sales forecast

Whether AI is being used or not, tactical supply chain management starts with an item-level sales forecast. Because a forecast serves as the genesis for nearly all downstream actions, the data must not only be timely, relevant and complete, it must also be labeled so the AI recognizes what it's analyzing and knows what to do with it. Ideally for SOL, forecasts from the recent past will be used as training and test data to avoid structural differences when real sales information is introduced to the system.

Actual sales "Consume the Forecast"

The technique of using real time sales data to consume a forecast is a well-known SCM practice and should serve as a vital component of an enterprise-wide AI project. As weekly time buckets pass, actual sales from each period are used to "consume" (replace) the forecast figures and expose up/down variances. Whereas SOL has partially automated this process for its e-commerce business, to take full advantage of its capabilities Serna still needs real-time sales data from its retail partners. Full automation of consuming the forecast is what will enable AI-based functions further downstream.

S&OP reveals item-level sales variances, identifies patterns and makes predictions of future sales outcomes

S&OP techniques that are AI-enabled exploit the ability to isolate variances between forecasted and actual sales to expose patterns across items in each product category. Unlike SOL's traditional ERP that left the identification of item-level sales patterns to humans, Machine Learning enables the system to not only ID patterns but make predictions of future sales outcomes based on what is learned from them. This process marks the first

appearance of an AI Agent designed to uncover variances in product sales and make pattern-based predictions about future outcomes.

MRP analyzes current & future POs and makes decisions on up/down adjustments

The outputs from consuming the forecast and subsequent S&OP activities flow into Material Requirements Planning where an AI Agent makes decisions about current, as well as future PO adjustments. Specifically, as updated AI-born forecasts cascade into Serna's MRP module, new quantities and the timing of PO releases are adjusted based on Gross to Net Exploding and Lead Time Offsetting calculations. These Agent-generated decisions will not only reflect shifts in PO quantities and timing; they will also update key PO terms like last change date, last cancellation and last ship date, all while auto-notifying SOL's vendors of these changes.

MRP auto-updates, AI calculates container count and makes ETA predictions for inbound containers

On top of AI-generated updates to PO quantities and release dates, the added beauty of AI is that it will require no human intervention to convert purchase order quantities into cubic meters and calculate the size, quantities and timing of ocean containers that vendors will need to ship goods once produced. Additionally, when goods are on the water, a fully integrated AI tool will allow SOL to make ETA predictions on inbound containers.

DRP uncovers newly emerging patterns and decides how to allocate inventory

Much like MRP, Distribution Requirements Planning (DRP) takes a time-phased approach to determining the timing and quantities of finished goods that SOL will need to meet the demands of its retail customers and its own e-commerce business. Ideal for scenarios where an importer is beholden to its customers' in-house date requirements, the application of AI to DRP opens a whole new world for dynamic inventory allocation. How Serna Outdoor Living can use an AI Agent to make DRP-based inventory allocation decisions is illustrated in an upcoming transload Use Case.

Continuous AI improvement

A major benefit of ML is that when properly designed, it learns from experience and applies learnings to new data. Starting with the Serna Outdoor Living sales forecasts that must be used for data training & testing, and moving through SOL's entire Supply ChAIn Cycle, what the system learns at each step of the process must be baked into new iterations of pattern identification, predictions and decision making. In what clearly becomes a virtuous cycle, forecast variations will decrease, PO changes will be less frequent, container predictions will be more accurate, inventory fill rates will improve and lost sales will be reduced.

An AI Agent for Import Transload Operations

As a subset of supply chain management, the field of logistics is rich with opportunities for the application of Narrow AI Agents to mission critical scenarios. As an example of how Serna Outdoor Living can improve specific elements of its current import environment, our attention now turns to a well-known model used by many importers, “Transload” (aka “Transloading”).

Although an exercise in maritime logistics, Transload is as much a drill in inventory allocation as anything else. In use for upwards of forty years, importers utilize transload to “postpone” the allocation of on-the-water inventory until a vessel arrives at its port of discharge. As is the case with Serna Outdoor Living, transloading is ideal for importers that source multiple products from overseas vendors in volumes that allow for Full Container Load (FCL) shipments.

A transload program hinges on the devanning of containers at a facility near a U.S. port of discharge, where the contents of those containers are transferred to outbound trailers based on “Split Instructions” provided by the importer. These instructions are the product of sales data that reveal the consumption of existing inventory in the network, with product sent to the sites that have the greatest need. As the mechanics of this model demonstrate, the goal of transloading is to match available inventory with product demand at the last possible moment.

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The advantages of transloading are most evident in import models where there is a continuous flow of multi-product FCL shipments from several overseas vendors. Within this ongoing flow of containers, an importer allocates goods from different suppliers and product categories into outbound trailers that are in turn shipped to their destination with just the right product mix. In terms of destination, transload affords an importer the added flexibility of sending goods to an internal DC or fulfillment center, directly to a customer’s facility or even to a retail store.

With a lineup of five product families and 750 SKUs that are sourced in FCL quantities from eighty vendors in ten countries, Serna Outdoor Living has successfully used transload in ports that include Long Beach, CA and Savannah, GA. Although SOL transmits Split Instructions to its transload operators electronically, all the processes and decisions related to inventory disbursement are manual, with the final call on item-level allocations made by humans.

By referencing Figure 4 and its prose-based explanation, the following depicts how a transload-centric AI Agent can uncover patterns, generate item-level sales predictions and make decisions on how to best allocate inventory. As part of an integrated approach to deploying AI across its entire supply chain, this transload model takes advantage of upstream outcomes generated by the SOL platform to augment its own performance.

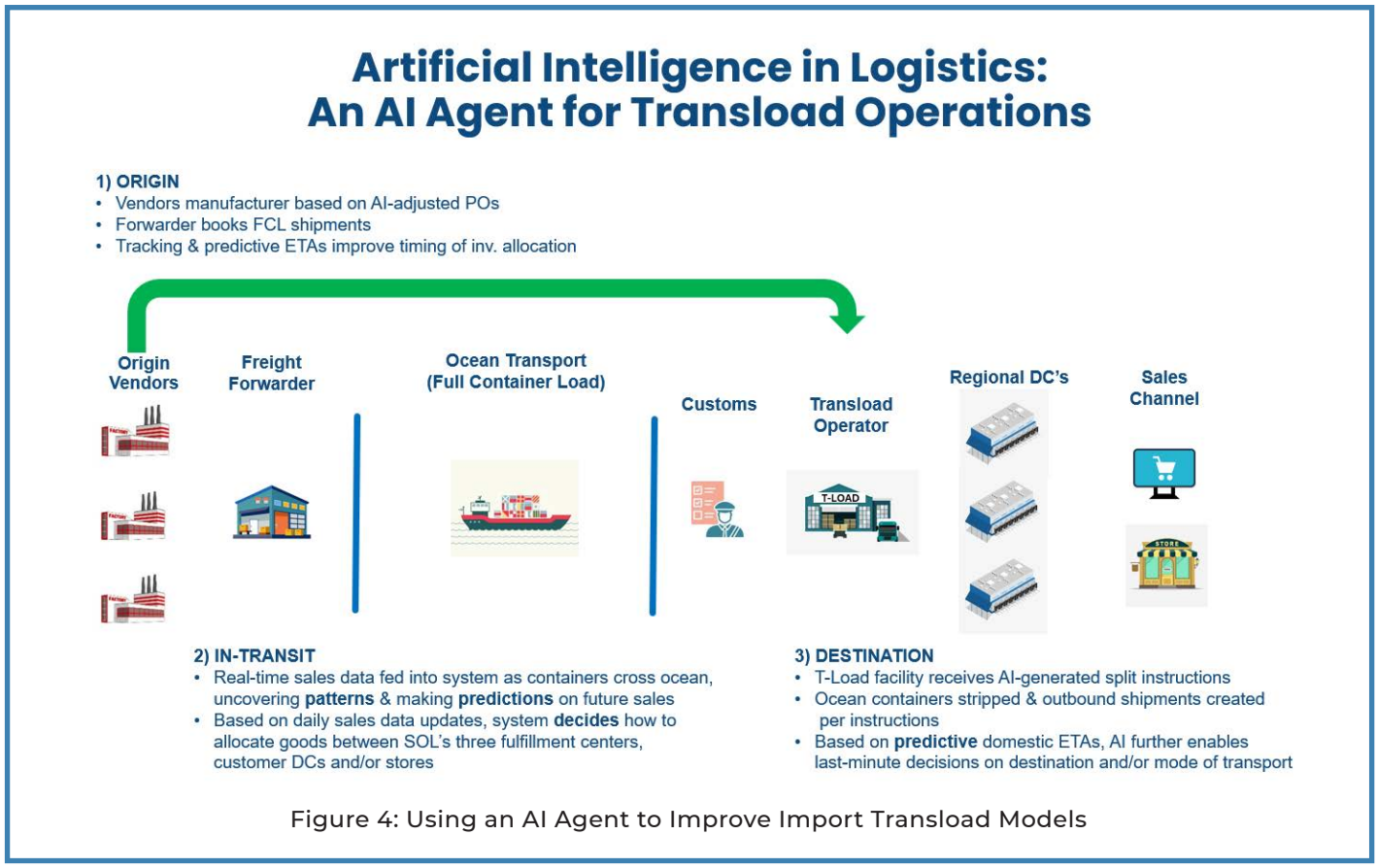

Figure 4: Using an AI Agent to Improve Import Transload Models

ORIGIN

Although it is a Narrow AI Agent designed for use in a transload environment, this element of SOL's overall platform will ideally be empowered by the upstream AI work already executed by the system. Described in previous Sections, this upstream work includes MRP re-alignment, the adjustment of purchase order quantities derived from consuming the forecast, and customer in-house dates.

As a downstream beneficiary of the above patterns, predictions and decisions, origin freight forwarders coordinate with vendor factories to book FCL shipments in a timely and efficient manner. As goods are shipped, AI kicks in to make predictions on the ETA of containers, thus allowing the Transload AI Agent to correctly postpone decisions on item-level inventory allocations until just before the container is drayed to the transload facility.

IN-TRANSIT

As containers make their way across the ocean, real time sales data from its own e-commerce platform, as well as from retail customer feeds, allow Serna Outdoor Living to see exactly what products are selling where, and in what quantities. With insights from AI-enhanced ETAs, the Serna system continues to align real-time sales figures with the contents of specific containers to decide what inventory goes where. The ultimate enabler of product mix and OTIF logistics, these decisions are made by the AI Agent without human intervention.

DESTINATION

When containers arrive at the transload facility, the 3PL operator will have already received AI-generated split instructions from SOL's system. As the process continues and the platform compares product fulfillment needs with in-house dates and lead times, the SOL platform can also make decisions on where to ship goods, and what mode of transport to use. For example, a hot item originally bound for a Dallas DC via rail can be switched to a hot shot truck shipment, with a few pieces sent overhead via air freight to meet immediate demand.

Supply ChAIn Management: Reality Checks & Downsides

Let us begin to wrap things up with a reality check on the current state of AI for supply chain. Despite the claims of a Hype Cycle on blast, there isn't an AI-powered platform in the SCM market today that can do all the things described in the preceding Sections. That does not mean, however, that the technology isn't there to enable Supply ChAIn or that Narrow AI Agents for logistics aren't available in the market right now (March 2025).

To the contrary, this author's enthusiasm for Supply ChAIn is based (in part) on the existence of said technologies. For example, there is an AI Agent that allows drayage companies to compare ocean terminal appointments to the availability of their trucks and chassis, decide what appointments to take and then, determine what equipment to assign to a container. The Agent also makes decisions on what driver to assign to a load based on his location and remaining hours of service during a shift.

The main impediment to the rollout of fully integrated Supply ChAIn platforms is the same problem that's plagued companies since EDI was introduced to global trade in the nineteen eighties. Illustrated in Figure 5 under what is called a "Zen of When Diagram", it is the

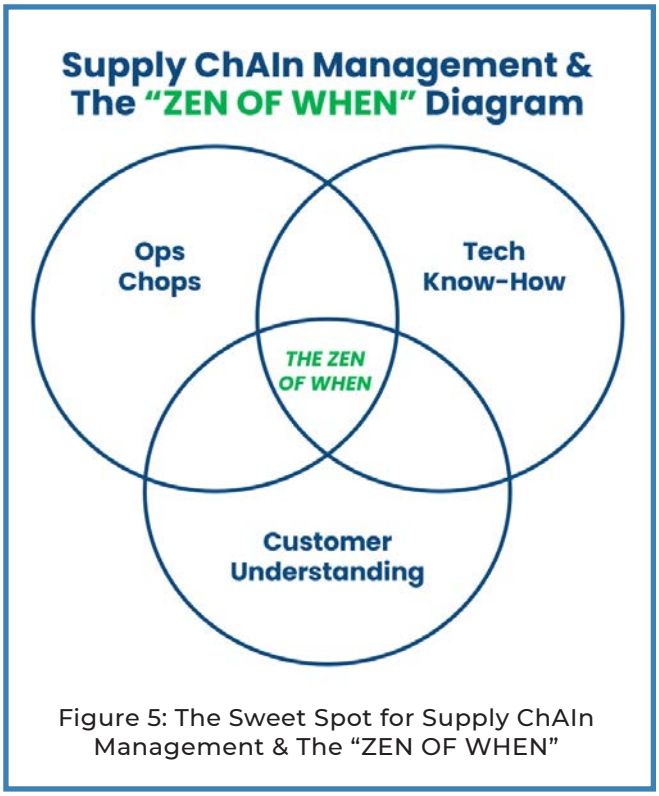

Figure 5: The Sweet Spot for Supply ChAIn Management & The "ZEN OF WHEN"

imbalance between Ops Chops, technical prowess and customer understanding that is putting the brakes on enterprise-wide AI rollouts.

The left circle depicts the supply chain & logistics operational folks that have tons of knowhow ("Ops Chops"), but limited exposure to technology. The right-hand side are the people who are tech experts, but that lack the operational experience needed to convert abstract Wish Lists into real solutions. As shown in the lower circle, the unfortunate reality is that in many cases, neither technical nor ops experts know what customers need now or what they'll require in the future.

Of course, the sweet spot for breakout Supply ChAIn solutions lies at the intersection of the Venn Diagram called the “Zen of When.” As the name indicates, the posit of the diagram is that the best AI solutions will emerge only WHEN companies create environments where equal measures of all three inputs are present. From an AI perspective, the tech circle can be especially troublesome.

Creating software-based solutions for global supply chain & logistics was hard long before AI crashed the party. There are many reasons for this, but for the sake of brevity let’s say that writing programs for global trade is hard because out in the physical world, supply chain is hard. In short, there are too many players involved in a single international transaction (all of whom do their own thing technologically), for it not to be difficult.

On top of well entrenched challenges, when one looks at the skills required to create AI solutions, the pool of capable people shrinks dramatically. Just for ML, where pattern recognition, predictions and decision making are ever present, people need expertise in areas like Boolean algebra, linear regression, probability, statistics and differential calculus. Add the competition for talent that Supply ChAIn firms face from the likes of Google, AWS and Microsoft and the international trade community will continue to experience constraints in this circle.

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The issues related to the Zen of When Diagram can be solved with long-term commitments to training, education and shared learning within development teams. A more ominous concern lies in the very real downsides born of accelerated growth in the AI space. As is the case with any breakthrough of this magnitude, these issues are of a human and technological nature.

The conflict between productivity-enhancing technology and workers emerged at the dawn of the Industrial Revolution and not much has changed since then. Whether one speaks of artisans in England vandalizing textile factories in the early 1800s or U.S. dock workers railing against port automation in 2024, the theme is the same and AI will be no exception to this People vs. Technology struggle.

What distinguishes AI from the software revolution that eliminated so many labor-intensive tasks is that the former ventures into areas of human thinking that include logic, understanding, inference, deduction and ultimately, decision making. If Machine Learning tools develop at the current pace, there is a real possibility that thinking machines will someday be capable of demonstrating other human characteristics like perception, empathy and judgement.

Although the future isn't clear, one certainty is that AI will replace some jobs in global trade while creating others. A classic example of what the Austrian economist Joseph Schumpeter labeled, "Creative Destruction," Supply ChAIn will foster vast opportunities for developers and engineers, while people working in time consuming analysis & ops roles will find it hard to compete with the computing power of AI.

Tangential to the unfathomable computing power of AI platforms is the environmental fallout from the millions of chips, computers and servers needed to run Supply ChAIn solutions. The incredible amounts of electricity consumed by data centers was a concern before AI and the augmentation of AI-induced computing power will require a legion of energy-sucking hardware, generators and cooling systems to run these networks.

With competing technologies like EVs and crypto-mining vying for similar amounts of juice, we can only hope that competition spawns new businesses dedicated to protecting Mother Earth from the undesirable biproducts of the AI Revolution. Perhaps some of the folks displaced by AI in previous roles can find new homes in jobs that foster conscientious growth in this field. That would please the memory of Dr. Schumpeter a great deal.

The Future of Supply ChAIn Management & The "Spock Effect"

This author believes that the potential for AI in global supply chain management, logistics & trade compliance is as vast as trade itself. By no means the ephemeral nothing burger that "Blockchain for Supply Chain" turned out to be, the array of AI capabilities that align with the tenets of international business are just too numerous to ignore.

In what could become another People vs. Technology irony, the author also believes that the success of Supply ChAIn will depend more on the human side of the equation than on technology. In no way a contradiction of The Zen of When Diagram, it is certain that fields like Computer Vision, Robotics and ML will blossom from their technological roots. Let us cue up the commentary on the human side of AI deployment by going through some predictions for AI tech.

First, Narrow AI will continue to proliferate. Global trade is too tricky for one company to create an out of the box, end-to-end solution that uncovers patterns, make predictions and decides the fate of a supply chain on a daily basis. It might happen, but it will take time. Instead, it is a fair bet that a series of Narrow AI applications will come together to serve as the glue that unites the Supply ChAIn mosaic. Once that breakout company binds enough tiles in the mosaic, true SCM integration will be the next step and competition will soon follow.

> "In the end, the amazing success or spectacular failure of Supply ChAIn hinges on one word: Trust."

Integral to the above prediction on Narrow AI is that any importer deploying a Supply ChAIn solution must do so using a combination of its own data, and that of its business partners. Although there are firms that sell training and test data to replicate a user's model, there is just no substitute for the real thing. This point was illustrated in the example of Serna Outdoor Living and just like SOL, if a real company cannot access multiple data sources, things won't go well.

Briefly mentioned in the Introduction, we'll round out the tech discussion with some thoughts on Expert Systems (ES). As defined, a subtle difference between an AI Agent and an Expert System is that the latter uses a combination of data, work rules and programmed knowledge to generate outputs. It is this emphasis on work rules and in particular, programmed knowledge, that sets an ES apart from an AI Agent.

Given that humans create value in the workplace by applying knowhow to a particular scenario, the role that ES can play in global trade cannot be underestimated. The trick for ES will be how human expertise gets programmed into a solution. Because ES relies on pre-programmed human knowledge, it may also reduce reliance on the memory of experience to make decisions. Clearly an area with lots of upside, the balancing of a purely technological approach to AI with a humanistic slant takes us to the final topic of this white paper.

In the end, the amazing success or spectacular failure of Supply ChAIn hinges on one word: Trust. And that is because for all its complexity, global trade comes down to people believing one another. Whether it's a buyer in Boston trusting an offshore supplier to ship OTIF or a fashion influencer that trusts a designer in Milan to remain true to her vision, the absence of trust in global trade always leads to systemic breakdowns.

The same trust-based principles apply to Supply ChAIn, with the whole story coming down to one question: Will people trust solutions built on Artificial Intelligence to make decisions without human intervention? The answer to that question takes us into unchartered waters that before responding, requires a deeper look at the recesses of human cognition and emotions.

We already know that ML is supposed to enable decision making. However, it must be reiterated that a thinking machine can only make decisions within the context of the data made available to it. It has no awareness outside of its data universe and as such, is incapable of contemplating externalities like company strategy, corporate culture or competitor activities.

We also know that AI-based decision-making is sanitized, without any consideration for human motivations that include gut feelings, political posturing, deference to colleagues or a manager's willingness to go against her better judgement and "take one for the team." Similar to the hyper-objective, zero emotions behavior of Mr. Spock from the original Star Trek series, facts-based logic is AI's greatest strength but it can also be its biggest weakness.

So, this paper concludes with a question and a recommendation. In a world that is already rife with uncertainty, what right-minded supply chain executive will feed data into a computer, hit "Enter," pop a brew and hope for the best? The answer is, only those that are willing to bet their careers on machine-made decisions that may end up being way more artificial than intelligent.

Just like human-to-human interactions, AI needs to build trust over time with small (but correct) decisions that establish credibility. And much like a new employee that climbs the ladder through performance, Supply ChAIn solutions must earn their stripes, too. The good news is that trade pros can exercise control over the elegance of their algorithms and the relevance of the data they feed the system. May the Zen of When Diagram guide them in that endeavor.

Returning to the case of Serna Outdoor Living one last time, just because an AI tool can make decisions does not mean it should be allowed to do so. A recommendation designed for real world use, SOL should start by fixing underlying issues like access to real-time data from retailers. From there, a Supply ChAIn journey can kick-off with a Narrow AI App to uncover sales **patterns** and makes **predictions** that offer ***proposals*** to supply chain managers. In other words, the system does a lot of the heavy analytical lifting but leaves decisions to the humans.

> "In a world that is already rife with uncertainty, what right minded supply chain executive will feed data into a computer, hit 'Enter', pop a brew and hope for the best?"

Companies can take a similar approach on the distribution side of their import supply chains. As shown in SOL's transload model, a Narrow AI Agent can be deployed to uncover sales **patterns**. Instead of making autonomous decisions, the Agent makes ***suggestions*** on how best to allocate items. As time goes by and the system improves through algorithmic tweaks and learning from mistakes, companies still have the option to allow an Agent to make decisions.

Supply chain executives can also use AI to run simulations that aid in decision making. Be they in sales forecasting, materials planning or inventory management, AI-fueled simulations will broaden a manager's perspective and lead to better outcomes. When fully optimized, these simulations can also analyze the impact of different scenarios on item-level profitability and the results found in a firm's income statement, balance sheet and cash flow statement.

By exploiting two of the three things that AI does best (uncovering patterns and offering predictions), executives can leave final approvals to humans that will flavor their decisions with external awareness, input from other parties and professional judgement. While not fully adherent to the three-part definition of ML for Supply ChAIn touted in this paper, it's an approach that beats getting fired for betting too heavily on AI.

Although he never worked in supply chain, real "Trekkies" know that the often-conflicted Mr. Spock was at his cognitive best when blending Vulcan logic with human feelings. In what might one day become known as the "Spock Effect," trade practitioners are well advised to create the same hybrid approach to their global Supply ChAIn efforts. Within this hybrid approach, it is likely that Expert Systems will reduce an AI Agent's reliance on memory to make decisions.

As a closeout comment, if you don't buy into the Mr. Spock analogy for Supply ChAIn, you should apply what President Ronald Reagan preached when negotiating with the Soviet Union in the nineteen eighties: Trust but verify.

The Scariest Acronym in the Supply Chain World: Keys to Mastering "OTIF"

In addition to placing orders on overseas vendors that synch up with a product sales forecast, importers must align inbound shipments with the in-house dates mandated by customers and internal company stakeholders. Whether shipping to a company facility or direct to a customer, the goal for U.S. importers is to always ship goods "OTIF" (On Time, In Full).

The key to mastering the OTIF metric is found within two tenets of Material Requirements Planning: Gross to Net Exploding and Lead Time Offsetting. Inexorably linked to the quantities and timing of products manufactured by offshore suppliers, the absence of these techniques in an import supply chain is a recipe for chargebacks, inventory imbalances and lost sales.

When a company creates a sales forecast, it is estimating the gross quantities needed for each of the fifty-two time buckets in a year. It is called a "gross requirement" because the forecast does not consider on-hand inventory, goods in transit, POs that were already issued or planned PO releases. MRP software creates a "net requirement" by subtracting this pipeline inventory from the original gross number to provide a netted out forecast for all items in each time bucket.

Working backwards from in-house date requirements, Lead Time Offsetting establishes the date on which a PO must be placed on a vendor to receive goods right when they're needed. To do this, the MRP software must know the "Cumulative Lead Time" (CLT) for every imported product. Defined as the time that transpires from the moment a product need is recognized until that need is fulfilled, execution against accurate CLTs will make or break OTIF performance.

Cumulative lead time is the number of days that go by from the date a PO is placed on a factory until the goods are received at destination. That means the total time consumed in issuing POs, manufacturing time, shipping transit time, customs clearance and domestic onforwarding. So, if an inhouse date at a customer site is the 1st of July and the CLT is one hundred and eighty days, the POs that cover that commitment must be issued by January 1st.

As noted in the body of this paper, lots will happen between the time a forecast is generated and actual sales take place. By consuming the forecast, demand planning professionals can identify item-level variances between forecasted and actual sales, an exercise that should trigger up/down adjustments to vendor purchase orders that will land in future time buckets.

Whereas today's Enterprise Resource Planning software packages automate the above processes, it is not a stretch to visualize a world where AI complements automation by uncovering sales patterns, offering predictions about future sales and deciding how to proceed with purchase order quantities and timing. If that ever happens, it will be a huge leap forward for the people in charge of the OTIF metric.

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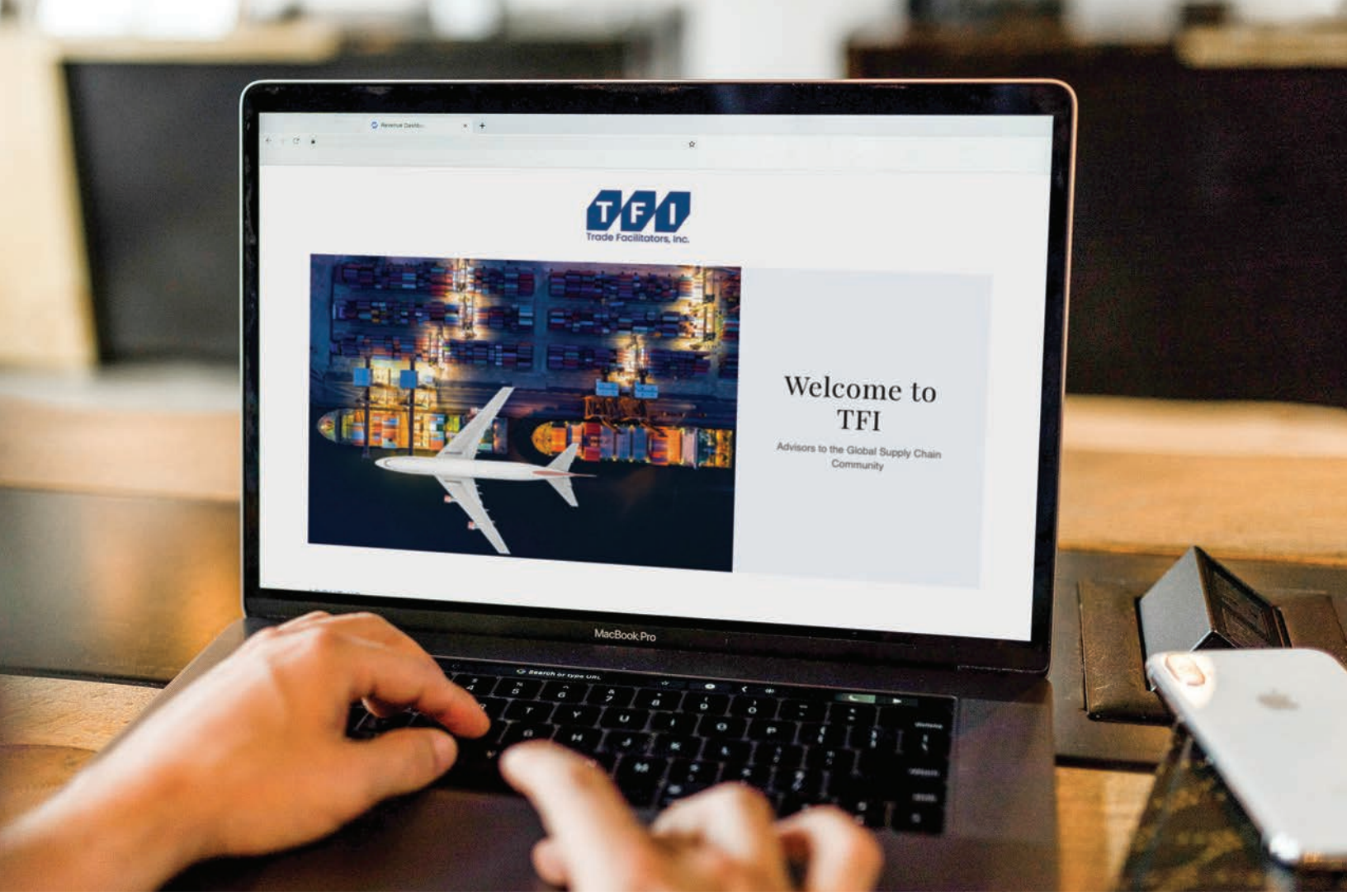

About the Author

Dan Gardner is president of Trade Facilitators, Inc., a Los Angeles based supply chain, logistics and trade compliance consulting firm and is co-founder of the tech-enabled U.S. freight forwarder & customs broker, Trade XCelerators. Prior to founding TFI and TXC, Dan worked in the 3rd Party Logistics industry where he held senior roles that include President of Ocean World Lines, President of Latin America for Exel Global Logistics and SVP USA with DHL Global Forwarding.

As President of Trade Facilitators, Inc., Dan consults with Beneficial Cargo Owners, 3PLs and technology firms on matters related to global supply chain management, international logistics, U.S. trade compliance and technology deployment. Headquartered in Miami, FL, Trade XCelerators harnesses a proprietary combination of transportation and trade compliance technology to streamline shipping and customs clearance procedures for U.S. importers.

Over the course of his career, Dan has been directly involved in twelve acquisitions, the largest of which was the $7b sales of Exel Global Logistics to Deutsche Post. Mr. Gardner was part of the management team that sold ATC Logistics & Electronics to Genco (later acquired by FedEx) and also served as Chairman of the Advisory Board for STG Logistics.

In addition to his professional experience, Mr. Gardner is an author of five books on global trade and is a multi-award-winning professor of supply chain management. A native of Lynn, MA, Dan holds an MBA from the University of Miami and is a licensed U.S. Customs Broker. During his career, Dan has travelled multiple times to over sixty-five countries, having lived in Colombia and Mexico for a total of five years. He can be reached at dgardner@tradefacil.com.