AI Supply Chain Management

Build a resilient, predictive, and efficient supply chain that increases visibility while reducing costs and risks

C3.ai

01

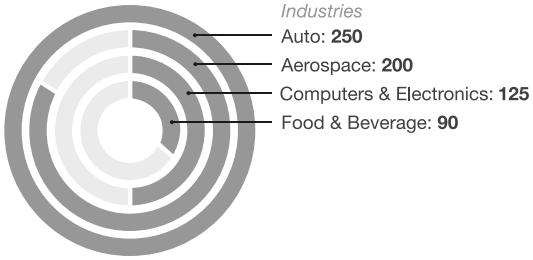
The Challenges of Managing a Complex Global Supply Chain

The recent pandemic has served as a reminder that today's global supply chains are extremely fragile. For years, supply chain professionals have been operating under pressure to support their organizations' growth objectives, including increased profitability, reduced cost, and improved customer satisfaction. These operational challenges have only grown in complexity as supply chain executives contend with issues including the need to build more sophisticated products that require specialized suppliers with highly skilled workers, rapid globalization with ever-expanding supplier networks, and exposure to raw material shortages and trade restrictions.

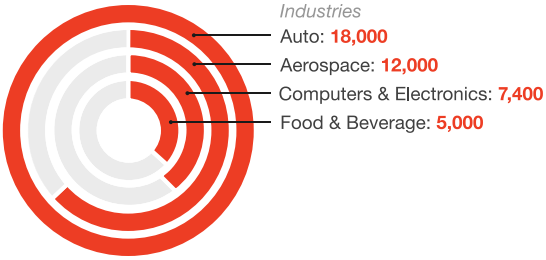
But these challenges pale in comparison to the shock caused by COVID-19 disruptions. Government mandated stay-at-home orders around the world caused a series of unintended and unplanned spikes in demand for products that normally had little variation in demand, and the inability of suppliers to foresee and respond effectively to these disruptions.

According to the McKinsey report on Risk, Resilience, and Rebalancing in Global Value Chains, manufacturers with complex global operations should expect supply chain disruptions from a number of causes that can last a month or longer and occur every 3.7 years.[1] These causes include financial crises, terrorism, extreme weather, and, yes, pandemics that result in severe financial consequences. Additionally, as supply chains have become more global and distributed, gaps in visibility have multiplied, leading to challenges in monitoring real-time inventory, obtaining delivery data, and generating actionable insights. An analysis of the global supply chains of four large industries in the manufacturing sector highlights the immense complexity and size of supplier networks:

Average Number of Tier 1 Suppliers



Non-Visible Tier 2 and Lower Suppliers



In a recent survey[2] by Capgemini Research Institute, 80% of supply chain executives from 1000 organizations said they were negatively impacted by the COVID-19 crisis. Though from diverse industries (such as consumer products, retail, discrete manufacturing, and life sciences) these organizations shared similar concerns:

74% struggled with shortage of critical parts and materials

74% also dealt with delayed shipments and longer lead times

69% had difficulties in adjusting production capacity in response to fluctuating demand

70% required more than three months to restore operations

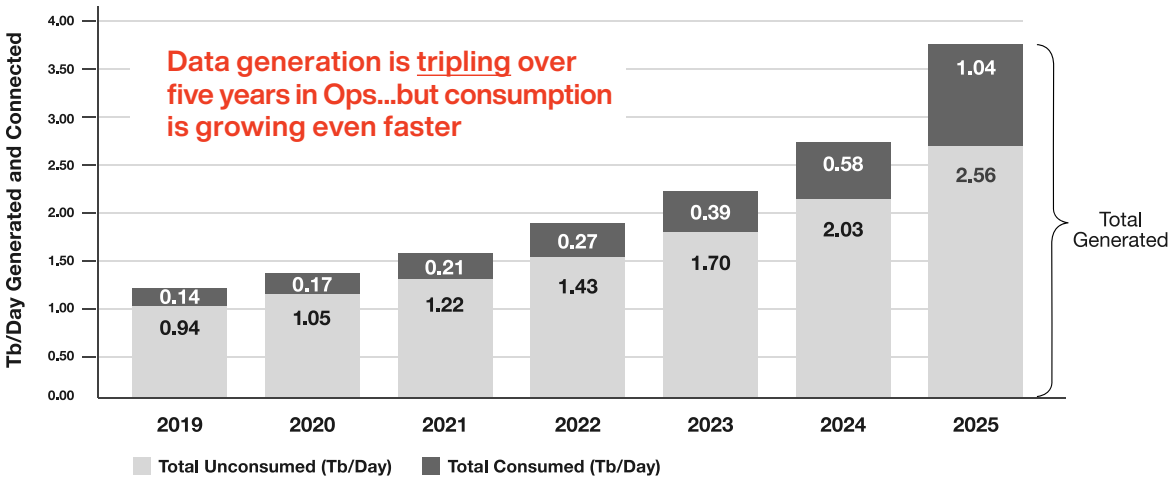
Supply chain challenges are not limited by the complexity of the products produced, access to technically savvy suppliers, or trade-related issues. More commonly, these challenges also include proliferation of data across unintegrated systems, lack of global real-time visibility, demand uncertainties, supplier network risks, and the lack of comprehensive part-level visibility.

Deriving Value from Vast Operational Data

Large industrial manufacturers rely on IT and OT infrastructure, systems, and applications to manage their operations and supply chains. Data gathered from the manufacturing environment can identify critical parameters and generate key insights to help drive value for the organization, such as better visibility into the entire supply chain, inventory optimization leading to cost reduction, improved asset availability via predictive analytics, and determining supplier risk using internal and external big data analytics.

However, much of these data is often locked up in isolated legacy systems and not readily available for value creation by planners and operators. According to IDC[3], the data generated from industrial operations triples every five years, and while data consumption continues to grow over time, a significant portion (over 70%) remains unexamined, limiting the potential value to be gained from these data.

Data Generation and Consumption in Industrial Operations (Tb/Day in a Typical $250M Operation)[3]



02

The Supply Chain Reimagined

The crisis caused by the pandemic has created near-consensus among supply chain executives about the urgent need to address gaps in their supply chains. An overwhelming 93% reported that they plan to take steps to make their supply chains more resilient, including building redundancy across suppliers, reducing the number of unique parts, and regionalizing or nearshoring their supply chains.[4]

As organizations begin to evaluate and build a more intelligent supply chain, they should consider the following attributes for AI-enabled, intelligent, and resilient operations:

The next generation of supply chains must be able to consolidate all sources of data in weeks, not months or years.

Any solution should be designed both for resiliency and agility.

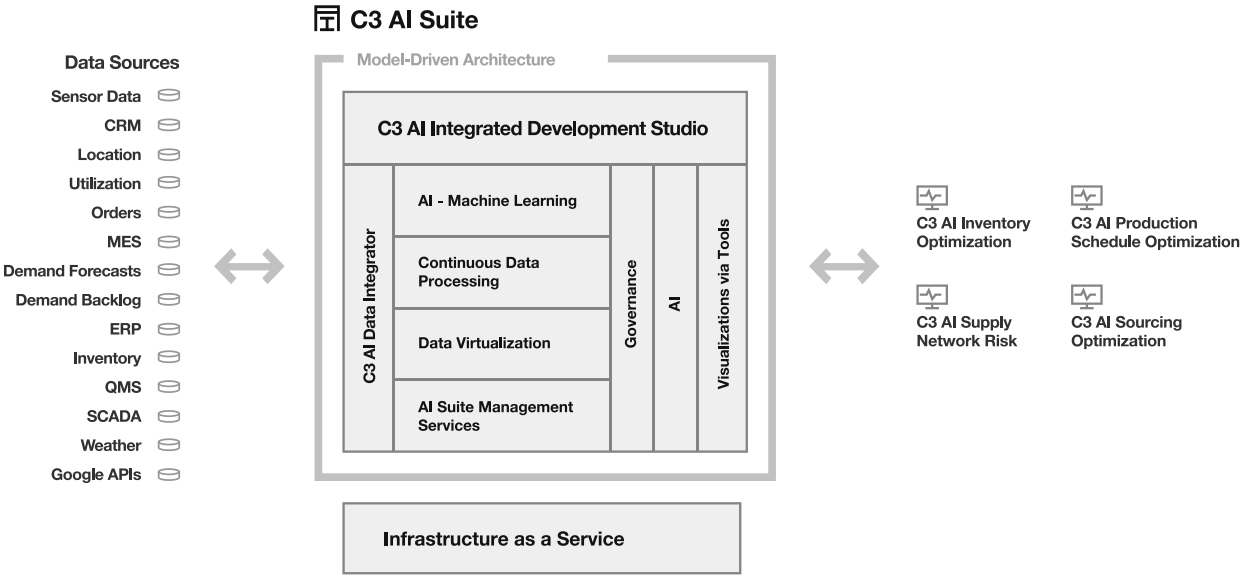
An AI-enabled supply chain should be predictive, not just reactive, and be able to identify risks and recommend the best course of action in real time.

Consolidate Your Data – In Weeks Not Months

Any solution that attempts to tackle challenges facing global supply chains with AI and machine learning must begin with the ability to integrate, ingest, and federate large volumes of industrial-scale data from non-homogenous data sources. These data sources include ERP, MRP, SCADA, and CRM, as well as sensor data from IoT networks, and extraprise data including weather, terrain, satellite imagery, market data, etc. However, organizations do not have years to build this capability and are now seeing solutions that can accomplish this task in a matter of weeks instead of months, quarters, let alone years.

The data aggregated and processed in these systems consists of every type of structured and unstructured data, including images, telemetry, graph, voice, and videos available to the enterprise.

Example of a Supply Chain Architecture with Integrated Applications



Building a Supply Chain That Is Both Agile and Resilient

The term “agile supply chain” refers to the use of responsiveness, competency, flexibility, and speed to manage how well a supply chain entity operates on a daily basis.[5] An agile supply chain uses real-time data to proactively validate demand forecast, which helps with overall efficiency, productivity, and customer satisfaction.

An agile supply chain can quickly respond to shifts in supply and demand, scale production up or down, monitor supplier availability anywhere in the world, track logistical and transportation constraints, and reconfigure plants operations to support new business models. For example, in response to increased risk of disruption in a particular region, supply chain executives can run simulations that prioritize diversifying the supplier base and manufacturing footprint, as well as reconfiguring production lines and transportation options to reduce risk.

Agility leads to flexibility, which is a fundamental component of the resilient supply chain. During the pandemic, consumer demand for many products fell sharply while demand for others rose dramatically. Organizations that have successfully implemented a visible, flexible, and AI-enabled supply chain have the ability to use it as a source of competitive advantage, and they are willing to invest in future-proofing their operations to address upcoming disruptions.

A Predictive AI-Enabled Supply Chain

Over the years, manufacturers have developed and relied on ERP systems and their MRP modules for production planning and inventory management. However, these software solutions are rules-based and not designed to predict inventory levels or measure risk across the supplier network with a high degree of accuracy.

With AI-enabled supply chains, analysts and planners can either select or build predictive solutions with C3 AI Suite to forecast inventory levels and anticipate supplier risk with a high degree of accuracy. When building a solution, the C3 AI Suite software uses a model-driven architecture that reduces the amount of code developers need to write to enable services or create underlying components. C3 AI uses thousands of pre-built conceptual models that can be easily modified or extended to enable computing resources and services (database, stream processing, storage, etc) and business objects (customer, order, contract, etc) as well as others that an application requires to operate.

For an inventory management application, a leading global discrete manufacturer selected C3 AI for a 12-week trial of C3 AI Inventory Optimization to dynamically optimize inventory levels for each part. Using the model-driven approach, the C3 AI team was able to rapidly load data, identify data issues, and resolve those issues through quick iterations. During this process, three years of historical data on production orders, bills of materials, reorder parameters, and movements of parts were captured in 42 files from 11 different legacy source systems. The C3 AI team then developed an algorithm that dynamically optimized reorder parameter levels (e.g., safety stock, safety time) and at the same time, avoided stock-out of parts. Through this trial, C3 AI was able to identify 25-35% savings in inventory holding costs which represented savings of $100-$200 million annually when scaled across the customer's locations. Using predictive models that learn and adjust continuously by monitoring real-time manufacturing, inventory, and supplier data from internal and external sources increases the probability of accurate, predictive results.

Armed with this insight, manufacturers can reduce holding costs for safety stock, plan for supplier delays, and prepare for disruptions on the production-line, resulting in enhanced organizational efficiency, improved customer satisfaction, and increased operating performance.

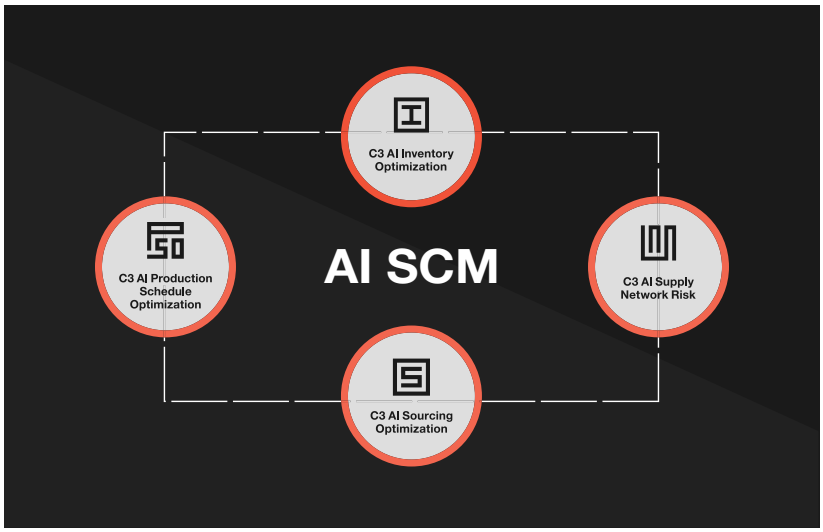
03

How to Optimize and Build the AI Supply Chain Management

As the results of the Capgemini survey highlighted, the pandemic has forced manufacturing organizations to question long-established supply chain practices. Traditional systems such as ERP and MRP, legacy data infrastructure, and Excel-based data analysis and reports dominate the supply management workflows today. However, these systems and processes have significant gaps.

As we discussed in the previous chapter, the new resilient supply chain paradigm requires speed and agility. It also needs to be driven by data from relevant internal and external data sources and utilize the latest machine learning technologies to accurately predict and recommended optimal operational settings. This is the definition of AI SCM.

To build this type of supply chain management capability, organizations need a roadmap from an experienced and technically savvy provider with years of AI and ML development experience and key partnerships with leading cloud solution providers (Microsoft, Amazon, Google). For an end-to-end solution, the core offering in the product roadmap must include the following applications:



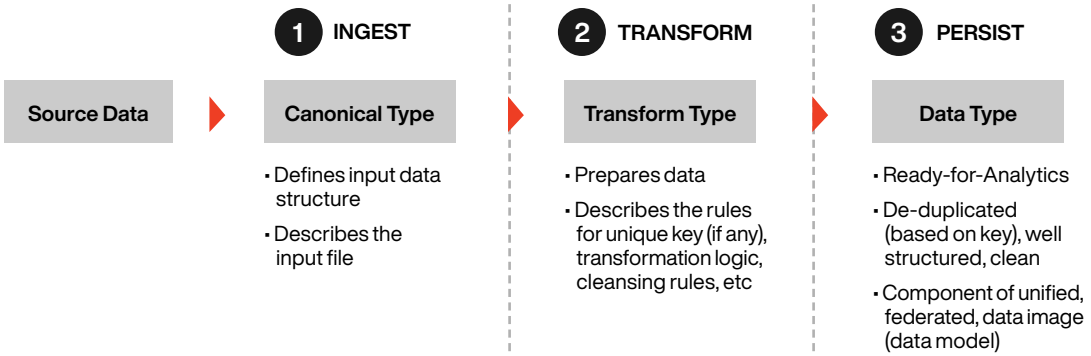
In Chapter 4, we'll describe the high-level capabilities of each of these core applications belonging to the C3 AI Supply Chain Suite, that are designed to allow large enterprises digitally transform their manufacturing operations using AI SCM. With this approach, organizations are now empowered and enabled to address the gaps that have long been associated with legacy data infrastructures and supply chain management systems.

FEATURE	TRADITIONAL APPROACH	AI SCM
Data Sourcing	**Inconsistent** data in silos	**Unified** data from all sources
	Weak demand signals	**Specific** demand signals
	Limited supplier data	**Supplier** and transportation data
Insight Generation	**Mostly** manual updates	**Real-time** updates
	Traditional rules-based approach	**AI-based** models with continuous self-learning
	Static forecasting	**Scenario** analysis and simulations

Create a Supply Chain Digital Twin

A supply chain digital twin is a virtual replica and a parallel version of an organization's physical supply chain and its supplier network containing hundreds or thousands of assets and tens or hundreds of inventory warehouses and logistics centers. By deploying a supply chain digital twin, an organization gains unprecedented visibility, and therefore predictability and control, into its distributed and interconnected production networks.

The sources of supply chain data in large manufacturing organizations are often legacy enterprise systems such as ERP, MRP, Analytics and CRM systems. Other relevant systems include demand forecasting, planning calendars, and sensor data, as well as external sources such as weather, GIS, market data, social media, pricing, and any other relevant data. To start, data must be ingested, deduped, cleansed, transformed, normalized, and finally prepared for analytics.



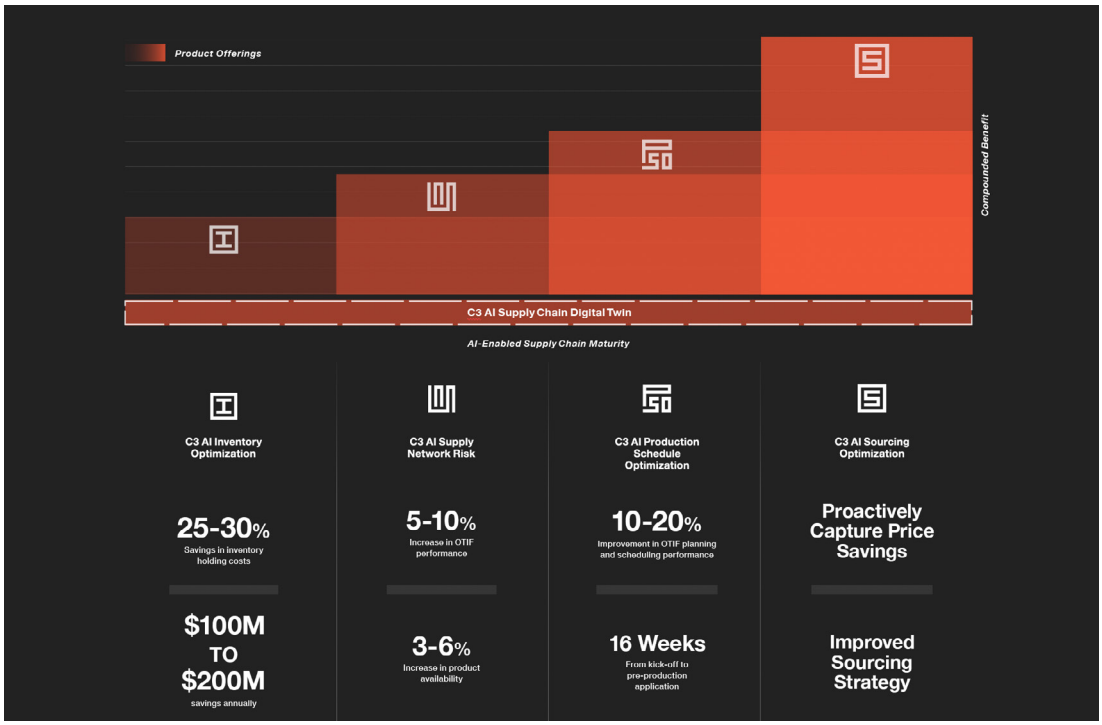
The federated data model is created by storing and mapping multiple autonomous databases into a single virtualized database. In this model, the autonomous databases that host the source data are interconnected over a computer network and are often geographically distributed and decentralized. The work of applying machine learning models starts once the data have been unified. By connecting the data image to an organization's IT and OT environments, including the internal and external datafeeds, it is now possible to dynamically update the overall view of the supply chain as internal parameters and environmental conditions fluctuate or as significant changes to input data are recorded (e.g., if a major supplier begins operations from a new country).

In addition to gaining access to a globally unified view of their supply chain, organizations can conduct 'what-if' scenarios with the option to measure and analyze the impact of different demand and supply variables, replay demand forecasts, and test contingency plans. In summary, supply chain digital twin benefits include:

- End-to-end visibility and longitudinal tracking
- Improved decision making by conducting simulations
- Enhanced supply chain design
- Cost savings with early issue detection
- Improved productivity

Infographic

Shift from Crisis Management to Resiliency



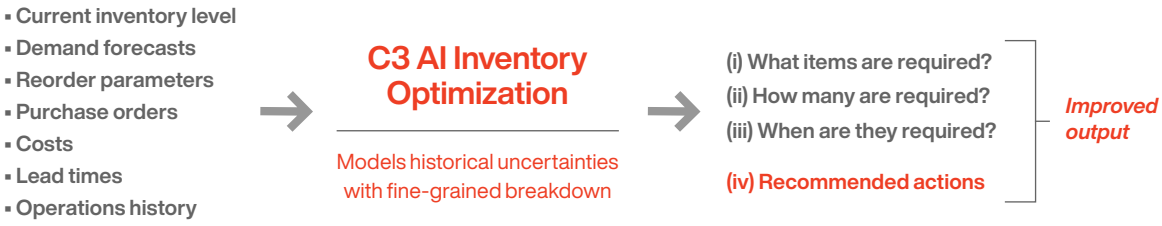
Ingest Data and Make Recommendations in Real-Time

In a traditional operation, supply chain planners and managers are typically forced to work with inconsistent and outdated data. This results in manual processes to adjust inventory levels, evaluate risks, and mitigate plans to production schedules.

AI-enabled supply chain solutions offer a quantifiable shift from traditional manual operations to the creation of data-driven, automated, and predictive real-time recommendations. AI-enabled supply chains can receive demand signals as they arrive, updating demand forecasts and supply risks dynamically. This provides companies with greater agility, while ensuring that the supply chain is recognizing and resolving risks as they occur.

AI-enabled supply chain management applications model uncertainties to allow supply chain professionals to optimize re-order parameters by part and by location and to gain visibility throughout their supply chain operations. For example, supply chain professionals can now identify vulnerable sources of raw materials or weakness in hubs and aggregation points. Planners and operations managers gain insight into potential delays and recommendations that result in improved OTIF performance leading to increased customer satisfaction. The C3 AI Inventory Optimization is an example of an AI-based application that combines supply chain digital twin functionality with AI and machine learning models that improve visibility, reduce inventory holding costs and increase productivity of inventory analysts through automated recommendations. This application is designed to model and learn from uncertainties and provide recommendations that are used as inputs into existing MRP modules.

AI-Based Approach



Apply AI to Your Highest-Value Use Cases

Demand forecasting, planning and production scheduling teams can benefit significantly from the use of enterprise AI. These teams typically rely upon manual tools and processes that operate on outdated data and historical trends to make planning decisions. This often results in suboptimal outcomes. For example, launching a new product where there is no historical sales data can result in a large deviation in actual demand from forecasted demand.

An AI-enabled demand planning application is able to unify internal and external data to generate precise, fine-grained, and dynamic demand forecasts. AI algorithms model each location, customer, and product SKU using their unique characteristics and dynamically update forecasts with changing market conditions and customer preferences. With an AI-enabled application, demand planners can more accurately forecast demand, lower inventory costs, improve order fill rates, and drive operational efficiencies.

Similarly, production planning and scheduling can benefit significantly from AI-enabled applications. In this case, these applications consider capacity, fleet condition, emerging market irregularities, and supplier uncertainties to translate the forecasting and planning outputs into more accurate manufacturing and distribution schedules.

By using a full featured AI-enabled application, planners can capture all forecasting, planning and scheduling constraints that change over time, including parts and equipment availability, asset performance, cost and staff readiness to include in the process.

04

C3 AI Supply Chain Suite Applications

C3 AI Inventory Optimization

C3 AI Inventory Optimization applies advanced AI, machine learning, and optimization techniques to help manufacturers reduce inventory levels at any stage of production (e.g., raw material, work in progress, finished goods) while maintaining confidence that they will not run out of parts, materials and components during the production process.

22%
Inventory savings for SKUs in scope

6 Months
From kick-off to production-ready

10K SKUs
Representing $200M in inventory made visible

Reference: C3 AI Inventory Optimization, Fortune 500 Electronics Manufacturer case study

C3 AI Inventory Optimization benefits include:

- **Reduction in inventory holding costs** and improved cash flow without compromising part availability
- **Reduction in total landed costs** that includes standard and expedited shipping costs
- **Improved visibility** of critical uncertainties such as seasonality in demand, uncertainty in arrivals, quality issues from suppliers, and production-line disruptions
- **Improved ability** to manage and negotiate with suppliers
- **Improved organizational efficiency** through a common view across various teams such as materials management, supplier management, logistics team, etc.
- **Increased productivity** of inventory analysts through automated recommendations based on new data and live integration with operational systems

C3 AI Supply Network Risk

C3 AI Supply Network Risk provides supply chain and order management professionals with unprecedented visibility into the status and delivery risks of customer orders and a set of actionable recommendations to ensure on time and in full (OTIF) delivery of customer shipments.

35%
Reduction in delayed sales orders

4 Weeks
For initial production deployment

50M
Rows of data unified across four disparate systems

Reference: C3 AI Supply Network Risk, Global HealthTech Company

Employing advanced machine learning algorithms and models, C3 AI Supply Network Risk predicts order lead times and identifies delivery risks. For orders at risk of delay, C3 AI Supply Network Risk rapidly identifies remediation options including shipment from a different facility, moving inventory between facilities, reprioritized sales order lines, accelerating delivery from supplier, and modifying sales order for users to action.

C3 AI Supplier Network Risk benefits include:

- **Improved customer satisfaction** by ensuring OTIF delivery by identifying customer orders at risk and executing remediation options
- **Improved production reliability and quality** through advance notification and preparation of backup supply options specific to individual product lines and geographic supply and delivery chains
- **Increased flexibility of the supply chain** through predictive identification of specific portions of the supply chain with extra capacity or available redundancy

C3 AI Production Schedule Optimization

C3 AI Production Schedule Optimization (C3 AI PSO) is an enterprise AI application that generates dynamic manufacturing and distribution plans and schedules using a holistic view of customer demand, supply chain, manufacturing, and distribution operations.

AI-enabled optimal manufacturing and distribution schedules can unlock **$10M-$100M in value.**

Reference: C3 AI Internal Research, 2021

C3 AI PSO reduces transition, inventory, transportation, staffing, and other costs by deploying optimally allocated tasks to resources at the right time, in the right order, and at the right capacity. By reducing the gap between planning and scheduling, manufacturers ensure that customers get their orders on time and in full (OTIF).

C3 AI Sourcing Optimization

C3 AI offers C3 AI Sourcing Optimization, a new supply chain application to optimize supplier and sourcing operations. C3 AI Sourcing Optimization applies AI and machine learning techniques to help enterprises reduce costs, minimize risks and increase efficiency.

Optimize sourcing strategies and reduce procurement costs with **C3 AI Sourcing Optimization.**

C3 AI Sourcing Optimization identifies the lowest prices paid for parts to allow sourcing of new orders or adjustment of existing orders at the best possible price. Additionally, it identifies and analyzes price anomalies, compares performance, tracks and analyzes purchase orders across parts/vendors/facility, identifies availability of inventory, and provides a single, unified view into global sourcing operations.

05

How It Works

Case Study: Global Discrete Manufacturer

Company

A leading North American discrete manufacturer operates hundreds of factories globally and makes highly complex industrial equipment. It generates approximately $30 billion in annual revenue, has 60,000 employees and has been in operations for nearly 180 years.

Challenges

The company's products are configured with hundreds of individual options leading to products with thousands of permutations. The customized nature of each product drives significant complexity in managing inventory levels during the manufacturing process. Since the final configuration of a product is often not known until the order is submitted for production, factories often hold excess inventory to fulfill their orders on time.

Like other manufacturers in the industry, the company had deployed Material Requirements Planning (MRP) software to support production planning and inventory management. Prior to engaging with C3 AI, the company had also experimented with various inventory optimization software. However, the existing software solutions were unable to dynamically optimize inventory levels of individual parts at scale while also managing uncertainty and learning continually from new data.

Solution

To reduce inventory cost and improve analyst performance, the customer selected the C3 AI Inventory Optimization application for one product line at one factory. C3 AI developed an algorithm that dynamically optimized reorder parameters (i.e., safety stock, safety time) and avoided stock-out of parts with a specific confidence level. This was accomplished by collecting, loading and processing data from production orders, product configurations, BOMs, parts movement events, historical settings of reorder parameters, lead time and shipping costs from suppliers.

Implemented C3 AI Inventory Optimization in 12 Weeks

3 Years
of historical data on production orders, BOMs, reorder parameters, and movement events of parts within factory

42
individual files across 11 legacy source systems

9M rows of data

C3 AI Inventory Optimization application applied a machine learning and stochastic optimization algorithm to learn from variability in demand, supplier delivery times, quality issues, and production disruptions to dynamically and continuously optimize reorder parameters and minimize inventory holding and shipping costs for each part.

The Results

The savings from reduced inventory holding costs far exceeded the customer's expectations. Through the trial, C3 AI was able to identify 25-35% savings in inventory holding costs, and when scaled across the customer's locations, represented a savings of $100 - $200 million annually.

25-35%
Savings in inventory holding costs

$100-$200M
Annualized savings

06

Ready to Get Started?

Learn how to build foundational capabilities, accelerate deployment, and achieve supply chain resiliency with C3 AI Applications.

Contact Sales

Learn More

Download Case Study

1. *McKinsey & Company, "Risk, Resilience, and Rebalancing in Global Value Chains," Susan Lund, James Manyika, Johathan Woetzel, Edward Barriball, Mekala Krishnan, Knut Alicke, Michael Brishan, Katy George, Sven Smit, Daniel Swan, Kyle Hutzler, August 06, 2020.*
2. *Capgemini Research Institute, "Fast Forward, Rethinking Supply Chain Resilience for a Post-Pandemic World," Roshan Gya, Cyndi Lago, Michael Becker, Jorg Junghanns, Jean-Pierre Petit, Laurent Perea, Ralph Schneider-Maul, Sven C Dahlmeier, Vikas Kumar, Adrian Penka, Jerome Buvat, Subrahmanyam KVJ, Roopa Nambiar, Ramya Krishna Puttur.*
3. *IDC, "The Digital Journey to Manufacturing's Industry 4.0," Doc # US47678821, May 2021.*
4. *McKinsey & Company, "Reimagining Industrial Supply Chains," Thomas Baumgartner, Yogesh Malik, Asutosh Padhi, August 11, 2020.*
5. *GlobalTranz Resources, "Agile Supply Chain: Why Agility is Trumping Lean in the Supply Chain," February 18, 2016.*

C3.ai 1300 Seaport Boulevard, Suite 500 • Redwood City, CA 94063 • www.C3.ai