Introduction


The thirty eight projects submitted by the SCM Class of 2023 at the Massachusetts Institute of Technology are presented here as executive summaries of the master’s research projects, framed for a business rather than an academic audience. These summaries are intended to give the reader a sense of the business problems being addressed, the methods used to analyze the problem, the relevant results and the insights gained.

The projects summarized cover a wide selection of interests, approaches, and industries, and address real-world business problems in areas including sustainability, urban logistics, digital transformation, supply chain strategy, machine learning, inventory management, and transportation.

Each of the projects is a joint effort between a sponsoring company, one or two students, and one or two faculty advisors. Companies who are partners of CTL’s Supply Chain Exchange and SCM are eligible to submit their ideas for research projects in June and July and then present these proposals to the students in August. In early September the students select which projects they will work on. From September until early May the teams conduct the research and write up the results. In late May all sponsors, faculty, and students participate in Research Expo where all the research projects are presented.

The SCM program is designed for early to mid-career professionals who want a more in-depth and focused education in supply chain management, transportation, and logistics. We welcome roughly 80 students each year from around the globe and across all industries. The research projects give students hands-on opportunities to put into practice the learnings they are receiving in their coursework.

We hope you enjoy learning about the types of projects our students completed this year. You may also view all of the full research papers on the CTL website: http://ctl.mit.edu/pubs. If you would like to learn more about the SCM Master’s Program or sponsor master’s student research, please contact us directly.

Happy reading!

Dr. Maria Jesus Saenz
Executive Director, MIT SCM Program
mjsaenz@mit.edu
Class of 2023 SCM Research Projects

**B2B Omnichannel Network Design and Inventory Positioning**
By Geoffrey Allen and Shoichi Ishida
Advisor: Dr. Eva Ponce
Topic Areas: **NTD - Network Design**

The foodservice distribution industry in the United States is projected to experience a 40% growth from 2022 to 2025. As the industry expands, an increasing number of companies are adopting an omnichannel supply chain strategy. In this context, our sponsor company, a large U.S. foodservice distribution company, aims to optimize the end-to-end supply chain network, including omnichannel options, in order to minimize the overall supply chain cost.

**Calculating Financial Business Risk to Identify Supply Chain Vulnerabilities**
By Romain Lucas and Pik Yien Lai
Advisor: Dr. Milena Janjevic and Dr. Jafar Namdar
Topic Areas: **RMG - Risk Management**

The COVID-19 pandemic has highlighted the vulnerabilities of supply chain systems, and companies must take Supply Chain Risk Management seriously to build resilience against future unknown disruptions. However, measuring risk and its impact is challenging due to data availability, interpretation of different types of risks, and complex product-supplier networks. Xylem, a global water technology company, posed a challenge to the capstone team to quantify the impact of risk using revenue as a measure.

**Case Fill Rate Prediction**
By Madeleine Lee, Kamran Iqbal Siddiqui
Advisor: Dr. Elenna Dugundji and Dr. Thomas Koch
Topic Areas: **MAL - Machine Learning**

Stockouts present significant challenges for Fast-Moving Consumer Goods (FMCG) companies, adversely affecting profitability and customer satisfaction. This Capstone report investigates key drivers causing Case Fill Rate (CFR) to fall below target levels and identifies the best model for predicting future CFR for the sponsor company. By utilizing hypothesis testing and feature permutation techniques, we conclude that forecasting error is the most critical driver influencing CFR.

**Cold Chain Management Optimization for COVID-19 Vaccine Distribution**
By Rohit Kapila, Nayantara Mehta
Advisor: Dr. Jarrod Goentzel
Topic Areas: **HEC - Healthcare**

In the wake of the COVID-19 pandemic, biotech companies faced an unprecedented challenge to develop vaccines within a very short time. The revolutionary nature of vaccines has expedited their development and deployment, but their association with ultra-cold storage and transportation poses challenges for equitable distribution. As the world approaches normalcy, there is a shift in demand from multi-dose vials to single-dose vials and pre-filled syringes.

**Cost and Carbon Implications of a Patient-Centric Supply Chain**
By Shobhit Yadav and Kyle O’Brien
Advisors: Dr. Jarrod Goentzel
Topic Areas: **SUS - Sustainability**

Trends toward patient-centric deliveries in the pharmaceutical industry pose a challenge for integration of sustainable supply chain design. This patient-centricity entails more distributed demand, smaller shipments, and more frequent deliveries. Our research utilizes scenario planning for quantification of CO2e and taxation within a pharmaceutical distribution network located in Brazil, where tax policy has a major impact on supply chain costs.
**Demand Forecasting of Consumer Goods for the Indian Subcontinent**
By Kristen Foster and Lanyan Feng
Advisors: Dr. Ilya Jackson
Topic Areas: **DMP - Demand Planning**

Our sponsor company, a leading fast-moving consumer goods corporation in the Indian Subcontinent (ISC), faces ongoing challenges in forecasting the volatile demand in this region. Currently, company’s demand planning relies heavily on human judgment, resulting in persistent inaccuracies and biases. This capstone develops a standardized and quantitative demand forecast methodology through three explorations.

**Detect, Communicate, Collaborate: An agile digital network to manage disruptions**
By Prateek Tewari and Simon Wei
Advisors: Dr. Maria Jesus Saenz and Dr. Jafar Namdar
Topic Areas: **RMG - Risk Management**

This project sought to address critical gaps in the extended supply chain network of the sponsor company by evaluating the efficacy of establishing a communication protocol with upstream suppliers to detect and mitigate supply chain disruptions. Leveraging an agent-based simulation model, the study examined what supply chain elements should be activated, and what internal and external stakeholders should be tracked to facilitate effective communication during disruption. The simulation results demonstrate the model's robustness in various scenarios, achieving a significant reduction in the detection lead time of disruptions ranging from 12% to 53%.

**Developing a Dynamic S&OP Process for Third-Party Logistics**
By Richard Elmquist and Luis Davila
Advisor: Dr. Ilya Jackson and Dr. Jafar Namdar
Topic Areas: **WRH - Warehouse**

This paper explores the complexities of temperature-sensitive food supply chains and the role of third-party logistics (3PL) providers in managing them. Specifically, we partner with the world's second-largest cold chain 3PL provider to establish a dynamic Sales and Operations Planning (S&OP) process for their warehousing services. In this project, we propose a novel inventory forecasting framework that could complement the S&OP process proposed aimed at aligning supply and demand, optimizing inventory levels, and preserving the quality of temperature-sensitive food.

**Development and Evaluation of Market-Based Routing Guide Strategy**
By Jorge Oliver and Aaron Zheng
Advisor: Dr. Chris Caplice
Topic Areas: **TRS - Transportation**

The truckload market in the United States is large, fragmented, and highly competitive. Shippers utilize routing guides to manage and tender shipments to carriers. This research examines how the macro market characteristics and micro shipper characteristics affect routing guide performance.

**Digital Twins: Warehouses of the Future**
By Moutaz Ali and Yumeng Chen
Advisor: Dr. Maria Jesus Saenz and Dr. Thomas Koch
Topic Areas: **DTF - Digital Transformation**

As warehouse operations grow in complexity, many organizations turn to digital twins to increase their performance capabilities. Digital twins are virtual replicas of physical entities and their interactions with one another. The technologies in a digital twin capture real-time data to support improvements and decision making.
Do companies’ actions reflect the urgency of their net zero goals?
By Samara Vilar da Costa and Julia Fernandez Del Valle
Advisor: Dr. David Correll
Topic Areas: SUS - Sustainability

As concerns around climate change increase, companies have been more eager to adopt environmental sustainability goals. The focus of this research is to provide insights into how a company's position in the overall supply chain impacts their decisions to set environmental sustainability goals and initiatives. In this report, we take both a quantitative and qualitative approach to highlight the sources of pressure that influence companies' setting of net zero goals and how they differ depending on the company and industry type.

Empty Miles Reduction in the Downstream Network for a Consumer Goods Manufacturer
By Sneha Neversu and Anumanth Sarma Murugesan
Advisor: Dr. Inma Borrella and Dr. Miguel Rodriguez Garcia
Topic Areas: NTD - Network Design

Logistics and transportation companies face a significant challenge with empty miles, which results in costs without generating revenue. To tackle this issue, we explored two potential strategies: one involves generating revenue by collaborating with external companies, while the other involves adopting backhauling strategies to identify potential loads within the network. To generate revenue, we considered utilizing the company’s private fleet as a third-party logistics (3PL) fleet for other organizations and analyzed the associated costs.

End-of-Life Inventory Optimization during Runout Events for a Manufacturing Automotive Company
By: Francisco Calero and Andrea Esposito
Advisor: Dr. Matthias Winkenbach and Dr. Juan Carlos Pina Pardo
Topic Areas: IVM - Inventory Management

Effective and efficient inventory management is today more crucial than ever. Three factors drive its importance: (i) the ever-increasing complexity of bills of materials, causing firms to dedicate a large part of their spending to their supply base; (ii) unprecedented uncertainty, making inventory indispensable for business survival; and (iii) an emerging inflationary economy, which multiplies the cost of holding inventory. One of the most critical inventory management processes is the runout phase, which refers to stock depletion as products approach their end of life.

Forecast Drayage Demand
By Pu Gao and Stephen Mei
Advisor: Dr. Chris Caplice
Topic Areas: TRS - Transportation

Drayage, which involves transporting goods from ports to drop facilities, has become increasingly difficult to predict due to the volatility of macroeconomic conditions. As a result, our sponsor company, a third-party logistics (3PL), sought to identify the key macroeconomic indicators that affect drayage volume and whether these indicators vary by port. To do this, the study utilized SARIMAX, a time-series forecasting method that can incorporate external variables and capture trends, seasonality, and cycles in the data.

Impact analysis of packaging box composition on supply chain emissions
By Nauryzkhan Dildabekov and Ritesh Rai
Advisors: Dr. Josué C. Velázquez-Martínez and Dr. Sreedevi Rajagopalan
Topic Areas: SUS - Sustainability

This capstone project studies the methods to effectively calculate scope 3 emissions for the packaging boxes of Dell Technologies. The study emphasizes that all sustainability elements are interconnected, and trade-offs need to be considered to optimize overall sustainability in packaging. The model answers questions such as the relationship between material composition, and greenhouse gas emissions, how it can help teams make better decisions, and how greenhouse gas emissions can be controlled by changing packaging variables such as recycled content.
**Incorporating Equity into Vaccine Access**
By Mehdi Tagorti and Matthias Schumm
Advisors: Dr. Jarrod Goentzel and Mr. Tim Russell
Topic Areas: **HUM - Humanitarian**

COVID-19 vaccine access inequity was a major challenge during the pandemic. This inequity was present between countries and regions and within cities. We developed a novel approach to measure and improve vaccine access equity to address this issue.

**Leveraging Simulation-Based Optimization to Generate Optimal Transportation Plans in the Real World**
By Adriele Pradi and Andrew Duncan Mohn
Advisor: Dr. Ilya Jackson
Topic Areas: **TRS - Transportation**

This capstone project evaluates the application of stochastic optimization techniques in middle-mile transportation planning, incorporating historical variance in transportation time and yard dwell time. Wayfair's current middle-mile planning process uses advanced forecasting and optimization techniques, but it struggles to account for the randomness and variation of the real world. To address this, the capstone project evaluates whether incorporating sources of variance into the optimization process can outperform traditional models in generating resilient transportation plans. After analyzing 70,000 trips from January 2022 to January 2023, three significant lanes were selected to evaluate changes in the distributions based on day of the week, season, and carrier.

**Network Design in MRO Inventory for Oil & Gas Company**
By Mauricio Taborga and Tulio Castillo
Advisor: Mr. Jim Rice
Topic Areas: **NTD - Network Design**

To mitigate operational disruptions, oil and gas companies maintain high levels of Maintenance, Repair, and Operations (MRO) inventory. However, our sponsor company was found to have twice the nonmoving inventory value compared to its competitors, prompting an interest to reduce inventory holding costs — the cost associated with the storage of inventory, such as cost of capital, annual warehouse fees, annual taxes, and annual warehouse costs. This study aims to reduce such costs by segmenting 19,153 MRO SKUs based on their demand characteristics and building a Mixed Linear Integer Programming (MILP) model to redesign the network of warehouses and plants.

**Network Optimization for Middle Mile Delivery for an Oilfield Service Company**
By Brian Hinkamp and Marwan Ismael
Advisor: Dr. Elenna Dugundji
Topic Areas: **NTD - Network Design**

The global transportation sector holds the top position as the primary source of greenhouse gas emissions, with road transportation, especially heavy-duty vehicles, being the primary source. Greenhouse gases significantly impact global warming by trapping heat in the Earth’s atmosphere, causing rising temperatures. This phenomenon, the greenhouse effect, results in various climate change repercussions.

**Optimization of Cost and Carbon Emissions in a Multi-Echelon Distribution Network**
By Amina Benhassine and Boping Shan
Advisor: Dr. Matthias Winkenbach and Dr. Juan Carlos Pina Pardo
Topic Areas: **TRS - Transportation**

Over the past decade, the oilfield services industry has experienced two major trends: the drive to reduce costs and the push for sustainability. In this context, our sponsor company seeks to optimize the distribution of materials and supplies in their global network, while considering both distribution costs and greenhouse gas (GHG) emissions.
Predicting Food Bank Demand: A Socioeconomic Analysis and Forecasting Model Investigation

By Kaitlyn Rakestraw
Advisor: Dr. Inma Borrela

Topic Areas: **DMP - Demand Planning**

Food insecurity is a problem that affects people in every county within the United States. To combat this issue, many organizations across the country provide charitable food assistance to their communities. The demand for these services is variable, and many of these organizations do not have a consistent method of predicting future demand.

Procurement Control Tower: Proof of Concept through Machine Learning and Natural Language Processing

By Bishwajit Kumar and Pablo Andres Barros Gomez
Advisors: Dr. Elenna Dugundji and Dr. Thomas Koch

Topic Areas: **PRC - Procurement**

An organization’s procurement process is pivotal for its success in a competitive market. The increased uncertainty and complexity of post-pandemic supply chains have made procurement a more valuable focus point among organizations and a differentiating factor to achieve a competitive advantage. The sponsor company of this study believes that the key to being competitive in today’s VUCA (volatile, uncertain, complex, and ambiguous) market relies on getting faster insights into the problem areas, having enhanced decision-making capabilities, and optimal exception management.

Profit-Driven Network Redesign Through Value-Creation Services

By Morgan DeHaan and Yujia Ke
Advisor: Dr. Milena Janjevic

Topic Areas: **NTD - Network Design**

Design of supply chain networks is a key strategic decision in supply chain management. Our capstone sponsor Armada is a supply chain service provider to restaurant chains across the United States. The company is envisioning a redesign of their current service network based on two components: (1) the addition of new distribution centers (referred to as iDCs), located closer to high volume service areas, (2) the deployment of value-creating services from the iDCs.

Quantifying packaging material complexity to improve portfolio management

By Marcela Navarro Lara and Joseph Anthony Lynch
Advisors: Dr. Chris Mejia

Topic Areas: **SCS - Supply Chain Strategy**

Product portfolio complexity poses a significant challenge for many consumer packaged goods (CPG) manufacturers, resulting in higher costs, risks, and production time. This work aims to assist the sponsor company in managing and measuring its complexity and determining the financial impact of delisting complex SKUs. We used a four-phase methodology involving data collection and mapping, analytics, complexity analysis, and financial analysis to achieve this.

Rationalizing Inventory: A Multi-Echelon Strategy for Safety Stock Justification

By Rohan Alexander and Yuta Chen
Advisors: Dr. Ilya Jackson

Topic Areas: **IVM - Inventory Management**

This work presents a multi-echelon inventory optimization model for a manufacturing company to evaluate optimal inventory levels for a selection of products and their sub-components. The guaranteed service model is employed to identify potential improvements in inventory allocation while maintaining service levels. The model’s results are compared with the company’s current inventory policies to provide insights into the effectiveness of the proposed approach.
Reimagining Procurement: Differentiated vs Standardized Services
By Mel Meleney and Hassaan Jaffar
Advisor: Dr. Chris Caplice
Topic Areas: **PRC - Procurement**

Our sponsor company is a leading player in the healthcare market. Its procurement organization is split into three divisions: corporate, business unit, and global services. The procurement strategy is set by corporate procurement, and then business unit and global services perform the procurement execution, and measure their procurement through metrics in experience, efficiency, and effectiveness.

Resilience in Upstream Supply Network
By Gianmarco Merino and Mostafa Khedr Elzanfaly
Advisor: Mr. Jim Rice and Dr. Jafar Namdar
Topic Areas: **RMG - Risk Management**

After the Covid-19 pandemic, organizations re-evaluated their supply chain strategies and began a race to build resilience in their networks. However, quantifying the level of resilience of any supply chain is a complex task, given the uncertainties associated with disruptions and the dynamics of global markets. This paper proposes a novel framework for quantifying supply chain resilience, with a focus on the upstream side of the network. Using Social Network Analysis (SNA) indicators and Business Impact concepts, we developed a methodology that captures the impact and robustness within the different tiers of suppliers.

Risk Mitigation to Increase Time to Survive
By Gabriel Szuma and Szuya Huang
Advisor: Mr. Tim Russell
Topic Areas: **RMG - Risk Management**

In our increasingly interconnected global economy, businesses confront heightened risks of supply chain disruptions. This capstone project, sponsored by Tempur Sealy International Inc., a leading manufacturer in the mattress industry, focuses on evaluating and enhancing supply chain resilience to mitigate these disruptions. The project introduces a unique methodology that combines Time to Survive (TTS) analysis and procurement optimization. This dual approach quantifies the cost of resilience measures, providing a tangible value to efforts often viewed as abstract or precautionary.

Solutions for Preventing Trailer Theft
By Lydia Lim and Harry Hawkes
Advisor: Dr. David Correll
Topic Areas: **TRS - Transportation**

Motor carriers with tight margins and cost constraints are under increasing pressure to improve utilization of their labor and assets. Many carriers face theft of their trailers that are exchanged between shippers, carriers, and contractors. Our project aims to answer the following question: How can trucking companies incorporate anti-theft measures to improve asset retention and therefore utilization of their trailer pools?

Surviving Disruption: Designing a Resilient 3PL Network
By Charles Snow and Yusuke Tanaka
Advisor: Mr. Tim Russell
Topic Areas: **NTD - Network Design**

Our project sponsor, a major third-party logistics provider in Japan, experienced a severe disruption that destroyed one of their primary distribution centers for a specific industry. This disruption led to increased lead times, degraded service levels, higher logistics costs, and the loss of a client. Consequently, our research focused on supply chain disruptions and resiliency. We aimed to answer three research questions: (1) what was the loss caused by the disruption? (2) how should the network be rebuilt to recover from the disruption? (3) how can resiliency be added to mitigate the risk of future disruptions?
**Sustainable Network Design of Perishable Foods**
By Maria Tartaglia and Miki Wang
Advisor: Dr. Josué C. Velázquez-Martínez and Dr. Fabio Amaral de Castro
Topic Areas: **NTD - Network Design**

Our project analyzes the trade-offs between costs, service level, inventory strategy, and CO₂ emissions in a global food and beverage retailer's current network design. We analyze the network design of a perishable product and evaluate which levers or variables can change (transportation mode, suppliers’ locations, inventory) in their existing network, as well as what variables are constraints and cannot be changed (truck sizes, product specifications, DC locations). We explore how full truckload vs. less-than-truckload transportation impacts their network and consider new supplier locations.

**Tackling Food Waste: A System Dynamics Approach to Analyzing Food Waste in Wholesale Markets and Developing Targeted Interventions for Sustainable Operations**
By Furqan Khalil Syed
Advisor: Dr. Chris Mejia and Dr. Saartjie Grobbelaar
Topic Area: **ROP - Retail Operations**

This study addresses the global issue of food waste in wholesale markets, where 1.3 billion tons of food are wasted annually (in the whole value chain) while millions face food insecurity. Our contribution is a preliminary framework to tackle food waste challenges and promote a more sustainable and efficient food supply chain, emphasizing the importance of implementing targeted strategies and recommendations for lasting impact. Partnering with the World Union of Wholesale Markets (WUWM), our goal was to understand food supply chains in wholesale markets and identify opportunities to mitigate food waste. This study uses system dynamics (SD) modeling techniques, including causal loop diagrams and stock and flow diagrams, to analyze supply chain-related food losses and propose potential intervention strategies.

**The Green Route: An Analysis of Mode Change as a Strategy for Carbon Emission Reduction**
By Elizabeth Bruttomesso and Shruti Pant
Advisor: Dr. Elenna Dugundji and Dr. Thomas Koch
Topic Areas: **SUS - Sustainability**

Having recognized the growing need for decarbonizing the maritime transport industry, the sponsor company is assessing the economic feasibility of implementing Green Intermodal Corridors. For a route to be considered a viable option as a Green Corridor, it must have the potential for significant decarbonization while also being economically implementable. This paper covers the feasibility assessment for three corridors, exploring the different scenarios possible in each of these routes and how they compare with the base case of current operations in terms of costs of operation and carbon emission reduction. The report discusses the scenario simulations over the alternate routes that deploy an electric barge and a hybrid barge in combination with an electric truck (Route 1), an electric truck (Route 2), and an electric train in combination with an electric truck (Route 3), in place of the regular diesel trucks for the delivery of cargo from the port to the warehouse.

**Time Series Forecasting and Dynamic Pricing for Cloud Usage**
By Donald Ekanem
Advisor: Dr. Ilya Jackson
Topic Areas: **DMP - Demand Planning**

This capstone explores different classical time series forecasting models to forecast cloud usage for an Infrastructure as a Service (IaaS) provider. The objective is to provide forecast information to help with capacity planning and propose a pricing model to optimize the capacity and manage revenue. The Mean Absolute Percentage Error (MAPE) performance criteria was compared for all candidate forecasting models to select the most suitable one. Analysis of the data showed a high linear trend in most of the zones, as well as a weekly seasonality. An elastic pricing model was proposed to influence customer demand behaviors to smoothen out capacity during the week.
Transforming Micro-Retailing in Emerging Markets
By Hannah Sonnenberg and Emma Eustis
Advisors: Dr. Josué C. Velázquez-Martínez and Dr. Sreedevi Rajagopalan
Topic Area: SCS - Supply Chain Strategy

Nanostores, small family-owned businesses, are a critical component of the Mexican economy, providing employment and acting as major customers for consumer-packaged goods companies. Our capstone paper presents a study of innovative business models aiming to help nanostores survive and grow, at a time when the Mexican economy is projected to expand. The study includes field research from over 4,000 nanostore owners and consumers in Mexico and explores innovative business models worldwide to identify potential solutions.

Transforming Warehouses Towards a Sustainable Future
By Kirill Lobanov and Osama Alhasan
Advisor: Dr. Eva Ponce and Dr. Miguel Rodriguez Garcia
Topic Area: WRH - Warehouse

Climate change is a global problem, and CO2 emissions are the primary cause of rising temperatures. Many companies, including our capstone sponsor Maersk, have committed to reaching net zero emissions by setting decarbonization targets. In this project, our goal was to identify specific actions that could be taken at the warehouse level to reduce greenhouse gas emissions and help companies achieve their decarbonization goals.

Unraveling the Relation between Trucking Modes: A Correlation Analysis between Less Than Truckload Metrics and Truckload Market Tension
By Nicolo Tosi and Sean Moran
Advisor: Dr. David Correll
Topic Area: TRS - Transportation

In 2021, The United States trucking industry generated over $400 billion in revenues. As the economy cycles through waves of contractions and expansions, the transportation industry moves through cycles of slack and tension. This research quantifies the relationship between TL market tension metrics and key LTL metrics on a national and corridor level.

What makes the Beauty more beautiful?
By Joon Choe and Kefan Chen
Advisor: Dr. Milena Janjevic
Topic Area: NTD - Network Design

The team is trying to figure out the strategic initiatives and directions for strengthening supply chain of botanical ingredients that are used for beauty products.