The **MIT** Center for Transportation & Logistics

Annual Review
2015-2016

Massachusetts
Institute of
Technology

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2015-2016 Timeline

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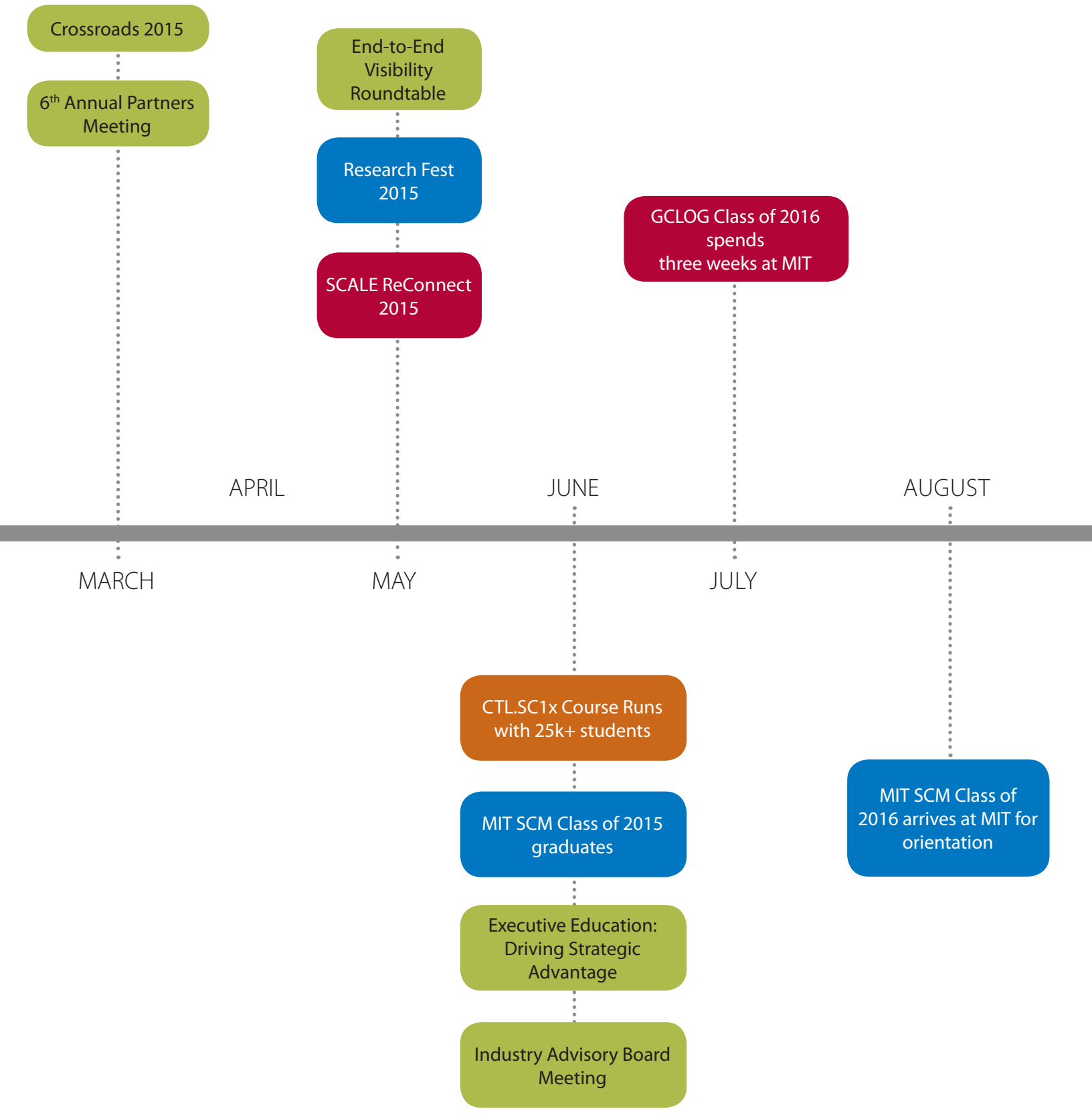


2015

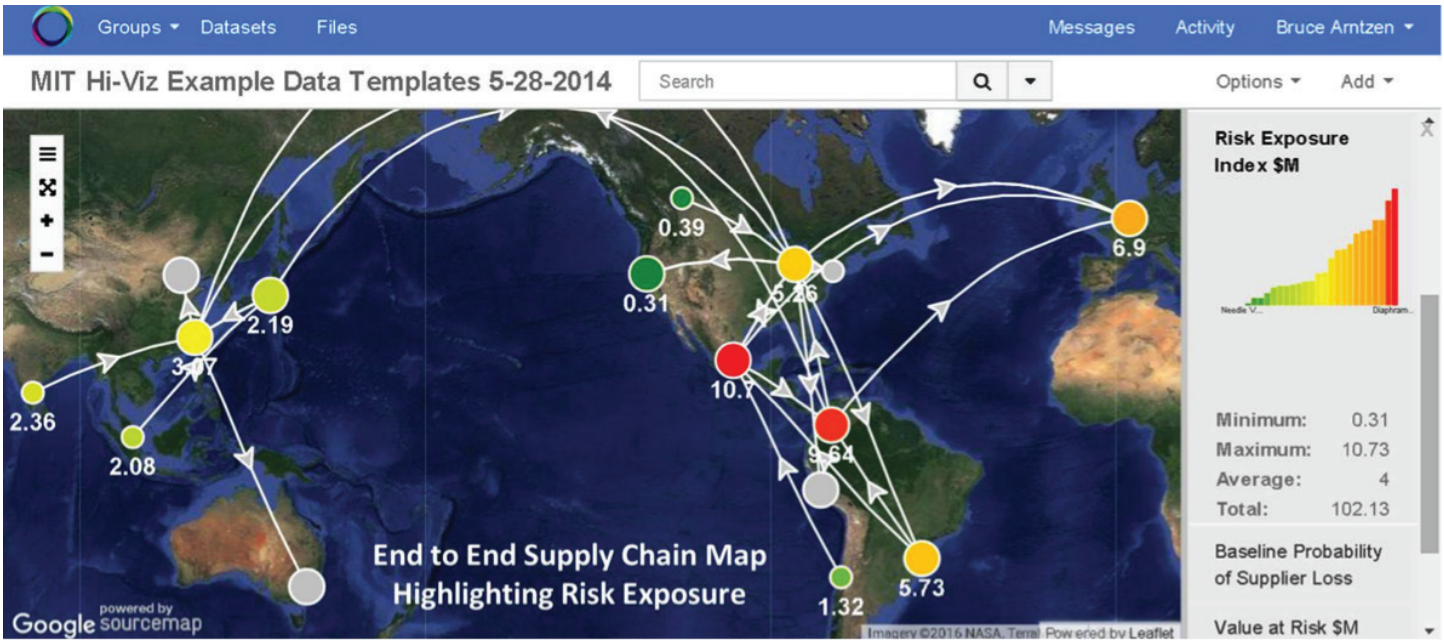

MIT SCM Alum Jeff Silver gifts MIT CTL with $2.5 million
SCALE Connect 2016 brings together over 100 SCALE students to MIT
Executive Education: Driving Strategic Advantage
Research Expo 2016
GCLOG Class of 2016 graduates
CTL.SC2x Course runs with 20k+ students
The Power of Resilience by Yossi Sheffi is released
The Race to Trace: Integrating Profits, Planet, and Precaution Roundtable
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MIT Announces MicroMasters in Supply Chain Management
Supply Chain Finance Workshop
Quantifying Resilience Roundtable
Innovation Summit at Flex
Luxembourg Centre for Logistics, the 5th member of the MIT Global SCALE Network, is announced
Ningbo Supply Chain Innovation Institute China, the 6th member of the MIT Global SCALE Network, is announced
CTL.SC1x re-runs with 30k+ students

2016

Research

Hi-Viz Supply Chain Project

Principal Researcher: Dr. Bruce Arntzen
Other Team Members: Siqi Gong, Jason Braud



Key Insights

1. Visual displays can dramatically speed up the decision-making process.
2. Inventing innovative displays is easy compared to the difficulty in getting the necessary data.
3. Corporate databases are missing key data elements needed to automate the visualization of supply chains.
4. Operations management must first convince Purchasing, then IT, and then Suppliers to collect the data needed for supply chain risk management.

The Hi-Viz Supply Chain Project seeks to automatically create Board-ready displays of a company's supply chain overlaid with key performance metrics. The displays include both:

1. A global map of the supply chain, and
2. A left-to-right material flow diagram.

Method:

Data is extracted from corporate databases (including bills of materials, inventories, and supplier names). Purchasing is then engaged to fill in missing info such as where-made locations of suppliers, recovery times, and sourcing splits. This information is used to draw both a map of the supply chain and a network flow diagram. Once these displays have been created, other performance information can be overlaid including inventory levels, risk levels, costs, etc.

Current Emphasis:

Our present goal is to combine these excellent visual displays of the supply chain with information on risk probabilities. Working with natural disaster modeling firms in the insurance industry and firms that calculate risk indices, we hope to enable companies to calculate the value at risk for nodes in their supply chain. Prior projects have focused on:

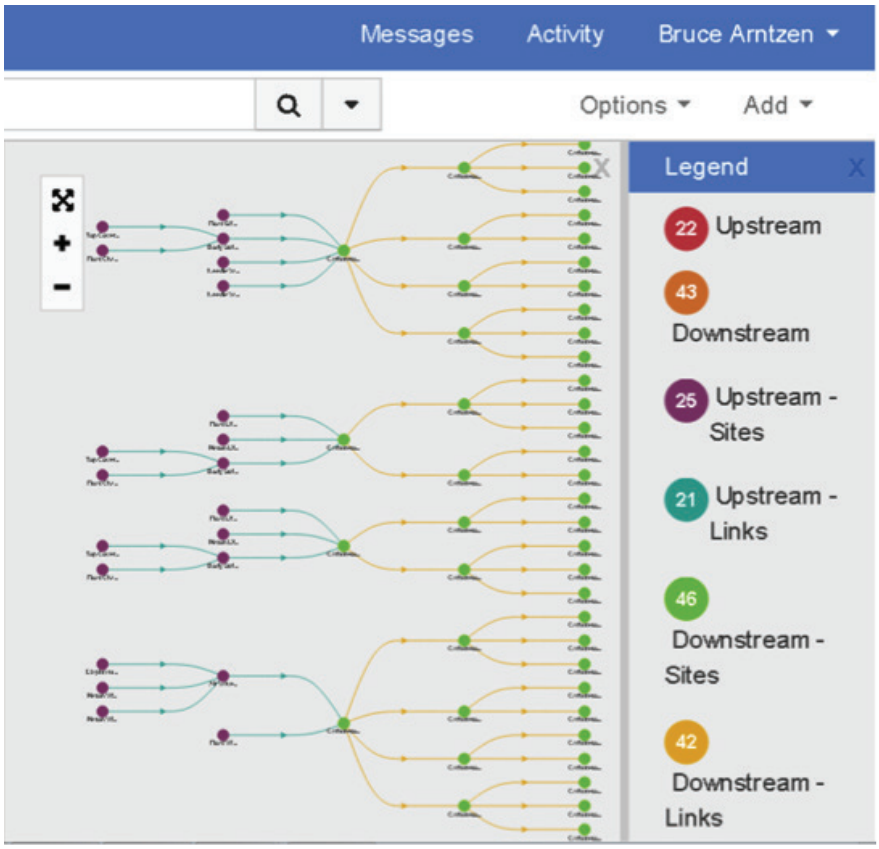
- Obtaining and displaying Geo-Emergency Alerts on the supply chain map and linking to impacted sites, lanes, and products using Financial Risk Ratings to estimate the likelihood of financial collapse of each supplier.
- Working through the Purchasing Function to gather risk indicators for Tier 2 suppliers.

Structure:

- *MIT*: Leads partner-funded research projects plus student master's thesis projects.
- *Sourcemap.com*: Develops and licenses the Hi-Viz Tool to participating companies.
- *Verisk Analytics:* Assists MIT with both country-specific risk indices and probability estimates of damage levels due to natural disasters.

Engagements:

- *Current:* Cintas is sponsoring an MIT SCM student thesis project to use Hi-Viz in order to map its end-to-end supply chain risks.
- *Prior Engagements:*
  - Church & Dwight (C&D): Modeled their supply chain for a recently acquired vitamin company.
  - BASF: Sponsored a student thesis project to collect supply chain risk data on Tier 2 suppliers.
  - Dell: Sponsored a student thesis project to assess and display their supply chain resiliency.
  - Procter & Gamble and C&D: Sponsored the development of the Hi-Viz tool during an initial three-year startup phase. Business units modeled included laundry, shaving, and personal health products.



Engage

Get involved and learn how you can model your supply chain risk. The Hi-Viz Supply Chain Project is looking for additional sponsors to both model supply chain risks in their company and to help support the continued development of the tools. This can be done by sponsoring an MIT Supply Chain Management Program student master's thesis to map out your supply chain risks.

For more information, please contact Dr. Bruce Arntzen at barntzen@mit.edu.

Responsible Supply Chain Lab

Principal Researcher: Dr. Alexis H. Bateman, Director
Other Team Members: Dr. Yossi Sheffi

Key Insights

1. Companies are increasingly seeking transparency in their supply chains to reduce risk and improve sustainability.
2. In many cases, sustainable business is moving from a "nice to have" to a license to operate.

The MIT Responsible Supply Chain Lab was founded in 2015 by Dr. Alexis Bateman to organize the multiple tracks of research in sustainable supply chains taking place at the MIT Center for Transportation & Logistics (MIT CTL). The lab builds on almost ten years of research on sustainable supply chains at the Center. Past initiatives include Leaders in Environmental Assessment and Performance (LEAP), an in-depth examination of environmental assessment methods, such as lifecycle assessment, with several progressive industry partners. Together with Professor Yossi Sheffi and MIT CTL Research affiliate Dr. Edgar Blanco, Dr. Bateman is collaborating on a book examining the challenges and opportunities in environmentally sustainable supply chains. Ongoing and new projects include a palm oil research initiative with Procter & Gamble, a risk assessment in the seafood industry, and a deep dive into the factors driving and facilitating supply chain transparency and traceability for sustainability.

Ongoing Research

Green SCM Book: A collaboration between Dr. Bateman, Professor Sheffi, and Dr. Blanco, this business-directed book presents a balanced view of integrating sustainable practices into the supply chain while maintaining efficiency and profitability. The book presents an examination of challenges, methods for assessment, best practices, and existing gaps. Looking across all industries, up and down the supply chain, over 150 companies and organizations have contributed through field visits, interviews, conferences and roundtables. Combining both academic and business perspectives, the book offers deep insight into the opportunities and challenges of reducing environmental impact while maintaining or improving profit in the supply chain, projected publication in 2016 or early 2017 through MIT Press.

Procter & Gamble Palm Oil Project: Procter & Gamble procures approximately 90% of its palm oil from Malaysia. To address ongoing social and environmental challenges in palm oil growth in Malaysia, this project with P&G addresses the challenge of procuring sustainably and ensuring social responsibility with various stakeholders, especially the independent smallholder farmers (ISHF) and small growers in its palm oil supply chain. The project is run primarily at the Malaysia Institute of Supply Chain Innovation (MISI) with research support from MIT CTL.

The objective of this study is enabling traceability and no-deforestation practices in the palm oil supply chain with ISHFs and small growers through the complex network of traders in Malaysia. In addition to examining transparency in the supply chain, a new framework for the ISHFs and small growers in the P&G palm oil supply chain is being researched and developed to facilitate and incentivize commitment to sustainability through Roundtable on Sustainable Palm Oil (RSPO) certification and beyond while improving their practice, productivity, and livelihood.

New and Future Research

Transparency Initiative: Significant environmental and social impacts often take place in the deepest tiers of the supply chain that grow, harvest, or mine raw materials. These are the tiers over which companies have the least control; in many cases, they do not know who these suppliers are because many commodities flow through a web of intermediaries and brokers. And even if the company knows the name of the distant supplier and their location, the company has no business relationship with the supplier and cannot influence its processes. Poor social practices in these supply chains, and extremes such as child and slave labor, are a continuing risk in deeply opaque chains, as well as future considerations that unsustainable agricultural and industrial

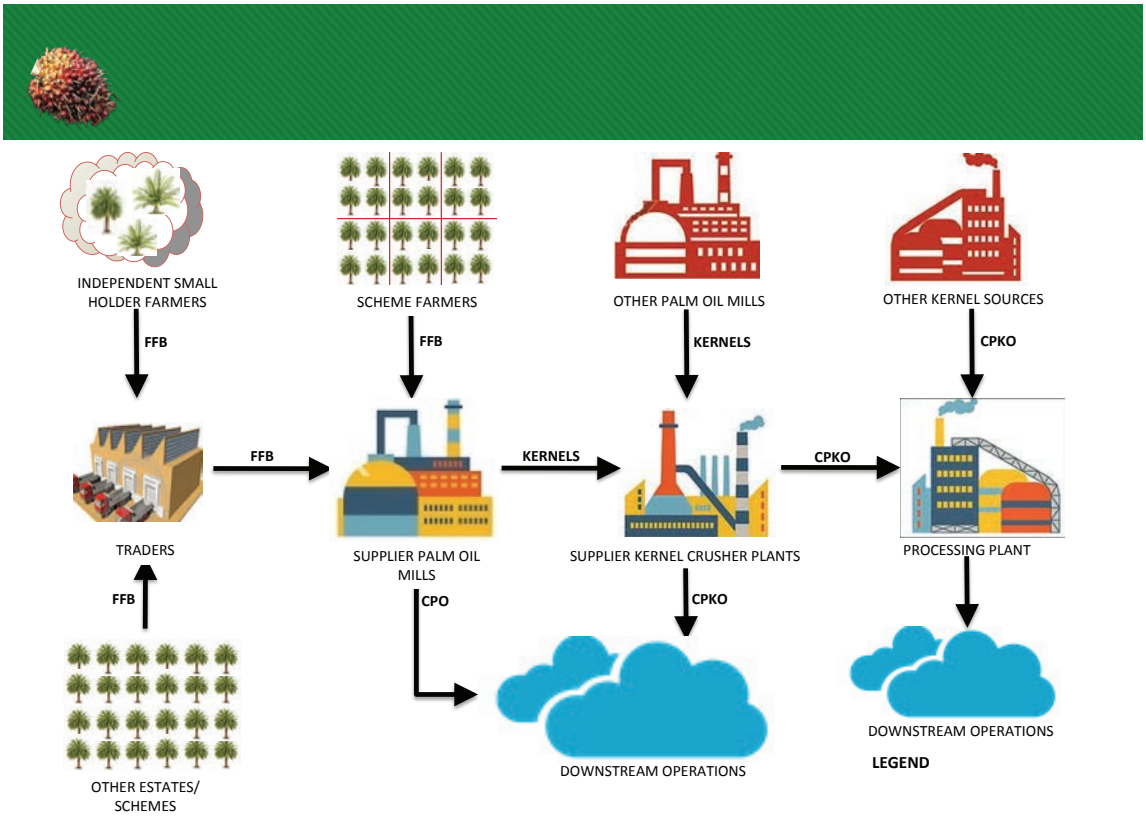
practices will lead to a collapse of ecological systems through water scarcity, contamination, species loss, erosion, drought, and damaging weather conditions.

To that end, the Responsible Supply Chain Lab is conducting a variety of research to shed light on these issues: an examination of the various organizations, standards, and labels enabling transparency in supply chains; an analysis of the drivers of supply chain transparency and how supply chain transparency can be evaluated quantitatively; and a broad review of commodities and their embedded traceability challenges.

In November of 2015, a roundtable was convened at MIT CTL that brought industry, NGOs, and technology providers together to discuss the issue of transparency and traceability for sustainability. The roundtable, *The Race to Trace: Integrating Profits, Planet and Precaution*, highlighted ongoing challenges for companies to get deep into their supply chains to verify practices. Building from this event and with much interest from various partner interactions, the lab is also looking to put together a consortium: Leadership on Ethical and Accountable supply chain Practices (LEAP 2). This consortium would serve as a platform for synthesis of prevailing trends in supply chain transparency and serve as a neutral ground for companies to come together to learn and share through cross-industry learnings to enable ethical and accountable practices through roundtables, workshops, and quarterly review reports.

Seafood Supply Chain Risk Assessment: The Responsible Supply Chain Lab and ThisFish, an initiative of Ecotrust Canada, are partnering to create a risk assessment framework, open database, and application that allows consumers, governments, seafood businesses, retailers, traceability service providers, and certifiers to assess the risk in supply chains with regard to the legality, responsible sourcing, and product claims of seafood. The initiative will be founded on open data and powered by a web and mobile application.

Currently, most seafood risk assessments are related to ecological risks and environmental sustainability. Moreover, traditional supply chain risk management assesses risks related to consistent, stable product supply and how the loss of such supply might disrupt production, distribution, or sales, causing financial losses to businesses. This proposed supply chain risk framework, database and, application focuses on risks related to responsible sourcing: that a product was legally harvested, legally processed, and legally labeled with accurate product claims.



Engage

This Responsible Supply Chain Lab is looking for more industry partners. Interest in supporting the seafood risk assessment project or participating in the LEAP 2 consortium are welcome!

Please contact Dr. Alexis H. Bateman at hickmana@mit.edu, by phone at +1 617-715-5182, or via the lab website: **http://responsible.mit.edu**

Retail Backroom Storage Optimization

Principal Researcher: Dr. Chris Caplice
Other Team Members: Dr. André Carrel, Lita Das

Key Insights

1. Retail backroom management impacts, and is impacted by, supply chain activities, packaging, and store operations.
2. Omni-channel retailing is placing new and challenging demands on backrooms.
3. Store profitability can be improved by simultaneously designing storage space, package sizing, order frequency, and other factors.

In dense urban settings, food retail stores are often operating in highly constrained spaces. Typically, at the point when the store was opened, part of the available space was allocated to the front of the store, where customer sales occur, and part of it to the backroom, where inventory is stored. However, as demand grows and changes over time, store managers may find themselves struggling to find space for storing the necessary levels of inventory to meet customer demand. In this project, which is a partnership between the MIT CTL and a large food retail chain, MIT researchers are leveraging large-scale datasets containing several years of historical sales and ordering records to develop a set of advanced backroom decision support tools to help the retailer optimize both the use of its available backroom space and the product flow from its distribution centers to the stores to maximize profitability.

Big Data as a Key Ingredient

We start with a given store with a fixed amount of space available in the backroom and an assortment of products that are offered to customers. Many of these products utilize a number of different ingredients from the backroom, and the ingredients have to be stored in different temperature zones. In the initial design phase of the store, planners had to use forecasts to decide on where to place the dividing wall between the front and the backroom and further divide the backroom into frozen, refrigerated and ambient temperature zones. Along with orderable pack sizes, product perishability, and the maximum daily customer demand that the retailer wants to satisfy, the space allocated to the storage of various products in the backroom is an important driver of how frequently a store requires deliveries.

When rethinking the store delivery policies and the backroom storage of an operating store, there is a key difference to the design phase: typically, there are vast amounts of historical sales and ordering data available, which allow the company to drill down and understand the store's sales patterns at a very detailed level. These data, which make it possible to forecast future demand very realistically, can be leveraged as input into optimization models that help determine how product should be delivered to a store. Given that inventory levels and ordering policies for a given product are closely linked, it comes as no surprise that the amount of space allocated to a given product in the backroom is actually not the critical decision. Rather, that space is driven by a number of levers that can be changed: delivery frequency, minimum order quantities, the pack sizes in

which products are delivered, the pack sizes in which products are stored in the backroom, and the desired level of service all ultimately determine how much space is taken up by a given product.

This optimization model is exactly what the MIT team is developing. The team is following a modular approach: in a first cut, the behavior of individual items within temperature zones was understood with the help of historical data. Then, the dependencies between meals and beverages that are prepared inside the store and products ordered by the store were incorporated. This allowed the researchers to determine the amount of space used in an unconstrained situation. Next, the optimization model was formulated for a constrained retail space environment. This will be aid in determinining the optimal space allocation to the backroom given a total retail store space. The work is being done in close contact with several teams at the partner's corporate headquarters in order to ensure that the decision support tool is designed in such a way that it readily ties in with their existing systems and can be used immediately by operations teams.

It is expected that several of the levers which can be used to improve the delivery of product to a single store and storage in the backroom will have effects beyond the single store that is the subject of the optimization. An example is pack size: changing a product's pack size is costly and affects all stores served by the respective supplier. Therefore, in a next step, the MIT team will consider approaches to generalizing the findings from single stores to the regional network level.

Findings and Insights

The overall finding from this still on-going research is that what happens in the backroom rarely stays in the backroom! How inventory is stored, ordered, prepared, packaged, etc. all have deep and potentially long-ranging impacts on the store as well as the entire network of stores. The interactions between these factors are complex and typically opaque.

Take, for example, the package size. As anyone in retail can attest, stores will always want the smallest possible order size at the highest delivery frequency ("eaches" delivered daily!) while the supply chain function responsible for replenishment will prefer the largest order size possible (full truckloads delivered annually!). Actually, there are three relevant package sizes to consider for backroom optimization: the size of the case that is ordered, the size of an intra-pack within the case that can be stored, and the size of the end sales item. These influence different aspects of the backroom and store operations. As the case size gets larger, the amount of cycle stock increases while delivery frequency decreases. Also, if the intra-pack size is simply the full case, this also consumes a significant amount of backroom real estate. Reducing the intra-pack size can help minimize the storage footprint for the backroom without significantly impacting the supply chain costs. This research has uncovered the quantitative relationship between these three "pack-sizes" and is helping to monetize this impact in terms of store costs and profitability.

In addition to this, the team is investigating the changing role of backrooms in retail operations. Store pick-up, local delivery, and other new distribution options are forcing stores to view their backrooms differently. Omni-channel strategies are placing new requirements on the backroom. Over the last 30 years, the backroom as a percentage of total store area has been shrinking. Now, with the increase in operations to be conducted out of the backroom, it might need to be expanded.

Engage

We are just beginning our investigation into the changing face of the retail backroom. If you are a retailer – or a manufacturer or distributor – then what happens in your backroom, or that of your customer, impacts your operations.

If you are interested in learning more or joining the project, please reach out to Dr. Chris Caplice at caplice@mit.edu.

FreightLab

Principal Researcher: Dr. Chris Caplice
Other Team Members: Dr. Francisco Jauffred

Key Insights

1. Measuring and managing trade-offs is critical to transportation planning and design. These trade-offs include risk sharing between shipper and carrier (e.g., fuel costs), costs versus level of service, robustness versus flexibility, etc.
2. Transportation networks are dynamic and are highly uncertain in most aspects to include demand levels, transit time, supply, costs, etc. These uncertainties need to be measured and managed. This can be handled through over capacity (robustness), back up planning (flexibility), or a combination of both. Most firms do **not** consider uncertainty when making their transportation design decisions.

Freight transportation is a critical link in virtually all supply chains since product has to move from the original source to final point of consumption. Transportation is one of the only functions that spans the entire supply chain, from raw material suppliers to final customers (and back, for reverse supply chains). Transportation operations are also typically inter-firm as they usually involve three or more separate entities (shipper, receiver, carrier, 3PL, port operator, etc.). For these and other reasons, transportation is one of the more complex functions for a firm to manage.

The MIT FreightLab is dedicated to exploring and improving all aspects of freight transportation. We achieve this through a number of different mechanisms:

- **Events:** FreightLab holds both focused roundtables and larger symposia on different aspects of freight transportation. Past roundtable topics have included transit variability, ocean transportation management, robust planning, e-procurement, fuel cost risk sharing, etc.
- **Teaching:** FreightLab designed and delivers MIT's only freight transportation focused graduate level course (ESD.266 Freight Transportation Systems and Analysis). The course attracts students from the schools of engineering, management, and architecture and planning.
- **Student Thesis Projects:** In order to engage students even deeper into freight transportation, FreightLab sponsors and advises a number of graduate level theses each year that address real freight transportation problems with corporate sponsors. Past thesis sponsors have included Amazon, C.H. Robinson, Coyote Logistics, Anheuser-Busch InBev, Walmart, Chiquita, Ford, and many others.
- **Focused Research Projects:** In addition to a one-year thesis project, FreightLab engages with firms for more in-depth and focused research projects. These typically involve several researchers and last one or more years. Current and past research projects include: Optimal Freight Portfolio Management (Walmart), The Living Plan: Robust Transportation Planning (United States Transportation Command), Planning for Future Freight Flows (United States Department of Transportation), Ocean Transportation Reliability (Ford Motor Company), Distribution Strategies (Subway Restaurants), and Global Visibility (BASF).

FreightLab is dedicated to finding better ways to plan, procure, manage, and assess freight transportation across all modes and regions.

Engage

We are always looking for firms to engage with us on their own pressing freight transportation challenges. If you are interested in becoming involved in any aspect of FreightLab's activities, please contact Dr. Chris Caplice at caplice@mit.edu for more details.

Global Health Supply Chains

Principal Researchers: Dr. Jarrod Goentzel and Erin Hasselberg
Sponsors: Centers for Disease Control, Paul G. Allen Family Foundation, U.S. Agency for International Development, MIT Supply Chain Exchange Partners

Key Insights

1. Effective private sector supply chain capacity is essential in providing vital healthcare products for millions of people globally, yet most studies in resource-constrained countries focus only on public health systems.
2. Numerous global healthcare companies, e.g. pharmaceutical and medical equipment manufacturers, are pursuing initiatives with the dual purpose of increasing access to healthcare technologies while also growing market share in emerging economies.
3. The market context of business models, infrastructure, and human resources vary greatly by country, which makes it difficult to define commercial and public health supply chain strategies, especially in lower and middle income countries.

An MIT student conducts a semi-structured interview with a retail pharmacist in a well-stocked urban location.

"Much of the [world's] burden of disease can be prevented or cured with known, affordable technologies. The problem is getting drugs, vaccines, information and other forms of prevention, care or treatment—on time, reliably, in sufficient quantity and at reasonable cost—to those who need them."
- World Health Organization (WHO) [1]

Properly diagnosing and treating the globe's most prolific infectious and non-communicable diseases such as malaria, HIV, tuberculosis, and cancer, all require that the right tests and treatments are available at health facilities. Supply chains are fundamental to making vital health products more affordable, available, and accessible for communities around the world. Pharmaceutical companies, health care distributors, even regulatory bodies, such as the US Food & Drug Administration[2], are prioritizing secure health care supply chains, end to end.

The MIT Humanitarian Response Lab (HRL) develops new science and creates collaborative space for public, private, and non-profit actors to improve these vital supply chains. HRL research on global health supply chains focuses on driving efficiency and effectiveness and managing risks in resource-constrained settings.

HRL researchers balance theoretical and applied work through active engagement with the private sector, government agencies, humanitarian, international development, and community organizations on several continents.

International donors and private foundations have invested billions of dollars in support for both the procurement of necessary health commodities and systems to deliver those commodities in-country. The majority of the investment and research has been into public sector systems, which is needed. However, in order to properly address the growing burden of disease, the commercial sector must also be leveraged, and strengthened through research and training, in order to improve health outcomes as well as economic growth.

Emerging Market Research

The MIT Humanitarian Response Lab has conducted thesis projects with companies to better understand the business context and supply chain in countries such as Zambia, Zimbabwe, and Uganda. These exploratory studies have revealed several insights:

- The nature of the in-country supply chain is not well understood. Business processes (e.g., inventory management, procurement) and financial structures (e.g., P&L, cash flow) vary greatly across distributors and retailers within and across the countries studied. Further, processes and financial management are rarely formalized, as the knowledge base for many proprietors is limited.
- Insurance schemes are not common and public clinics often have unreliable stocks. As a result, the patient often pays full price for medical products at retail pharmacies. Retailers play a more critical role in sales growth than in markets with more formalized health schemes.
- The retail sector is very fragmented and small retailers lack the resources and knowledge to engage directly with large manufacturers. The Zimbabwe study identified distributors who are establishing chains of retail outlets, providing more direct connection between a global manufacturer and the retail base.
- The fragmented retail sector in Africa may benefit from better-aligned pharmaceutical and consumer supply chain strategies, which is challenging due to different commercial strategies and regulation.
- The Zambia study showed that some medical distributors are not effective in penetrating peri-urban, rural, and/or base of the pyramid communities in Africa; meanwhile, some entrepreneurs are creating new ways to reach these market segments.
- The Uganda study identified many retailers with good cash positions and poor profitability. Training may help retailers identify when to carry more inventory and extend customer payment terms in order to drive sales and increase profitability.
- The Uganda study also determined that financing is often available for business operations through large banks and through community-based or micro-financing organizations, yet these options are underutilized. Meanwhile, credit for consumers is not available.

In spite of these challenges, our research has shown that strategies designed and implemented with business partners can increase access to affordable, good quality medicine and grow sales. In Zimbabwe, the team designed a strategy during the first project and studied its implementation in the second project. The pharmaceutical company established pilot agreements with distributors to provide two off-patent products to retailers at a lower price. Through field visits and mystery shoppers, we verified that retailers passed on the savings to consumers rather than capture the markup. This resulted in much higher sales volumes and a price for one product that was equivalent to generic products.

Strategy Development

The MIT Humanitarian Response Lab has developed practical expertise in conducting collaborative field research and has cultivated relationships with various actors in the Africa supply chain. This research provides the foundation for a more comprehensive description of the Africa business context. We can also convene experts to use this knowledge to design better supply chain strategies for these markets. Finally, the Lab can leverage a combination of public and private funding to conduct further study and generate lessons learned that cut across sectors.

[1] World Health Organization. "Everybody's business--strengthening health systems to improve health outcomes: WHO's framework for action." (2007).

[2] Title II of the Drug Quality and Security Act of 2013. Pub. L. no. 113-54. 127 Stat. 599-640. 27 Nov 2013.

Relevant Publications

- Goentzel, J. "Supply Chain Innovation Critical in Ebola Response," Supply Chain Management Review, January/ February 2015.
- Dokmo, C. and Patel, N. "Financing Medicine's Last Mile in Uganda: Exploring Linkages between Patient Access to Medicine and Supply Chain Access to Finance," Master of Science Thesis, MIT, May 2015.
- Ghersa, Ricardo and Chelsey Graham. "Increasing Access to Medicines in Southern Africa." Master of Science Thesis, MIT, May 2014.
- Bhatia, Anand and Brittany G. Johnson. "Increasing Access to Medicines in the Private Sector in Zambia and Zimbabwe." Master of Engineering Thesis, MIT, May 2013.
- Allain, L., Goentzel, J., Bates, J. and Durgavich, J. Reengineering Public Health Supply Chains for Improved Performance: Guide for Applying Supply Chain Segmentation Framework. Arlington, Va.: USAID | DELIVER PROJECT, Task Order 1, 2010.

Engage

Our next steps are to study and characterize the supply chain in several country contexts: product lines, actors (e.g., manufacturing sources, distributors, wholesalers, retail pharmacies, financial institutions, regulatory bodies), management practices and processes, financial structures. We also intend to develop tailored supply chain strategies based on requirements for segment in a country.

We are interested in engaging with other stakeholders in the international business and health communities for feedback. Examples include financial institutions, logistics companies, and international development organizations.

If you are interested in learning more about these projects, please contact Dr. Jarrod Goentzel at goentzel@mit.edu.

Emergency Response Supply Chains

Principal Researcher: Dr. Jarrod Goentzel
Other Team Members: Mark Brennan, Emily Gooding, MIT; Adam Norige, MIT Lincoln Laboratory; Jason Acimovic, Penn State; Aruna Apte, Naval Postgraduate School; Erica Gralla, George Washington University; Marianne Jahre, BI Norwegian Business School; Marie-Eve Rancourt, University of Quebec at Montreal

Key Insights

1. Humanitarian crises resulting from natural disasters, disease outbreak, and armed conflict continue to rise.
2. Government and non-government organizations increasingly rely on private sector supply chains, directly or indirectly, to meet vital needs.
3. Rigorous analytical tools are underutilized in assessing and planning emergency response supply chains.

Humanitarian crises continue to rise. Between 1994 and 2013, the Centre for Research on the Epidemiology of Disasters recorded 6,873 natural disasters worldwide, which claimed 1.35 million lives. In addition, 218 million people were affected by natural disasters on average each year. Major natural disasters continue to strike: 2010 Haiti earthquake (222,570 killed), 2011 Japan tsunami (15,840 killed), 2013 Philippines typhoon (7,354 killed), 2015 Nepal earthquake (8,881 killed). The recent Ebola outbreak killed 11,315 and threatened millions worldwide, demonstrating global vulnerability to disease outbreak. Even more people are affected by complex emergencies resulting from armed conflict, with the war in Syria alone producing over 4.4 million refugees.

The population affected by emergencies continues to rise due to the following trends: 1.) the number of extreme-weather events, such as floods, storms, and droughts is increasing; 2.) population and economic activity are concentrated in vulnerable locations such as coastlines, rivers, and earthquake faults; 3.) world population growth occurs in the urban areas of the less developed regions, where systems are weakest and disease spreads fastest; and 4.) armed conflict displaces an increasing number of people. In spite of these trends, there is ample supply of shelter, food, water, and medical products for affected populations, and individuals and politicians are increasingly inclined to offer the response resources required. Effective response hinges on a supply chain designed to move critical supplies to areas of need.

Supply Chain Science and Practice

The science to manage material flows among actors (e.g., manufacturing, transportation, warehouse, delivery) emerged in the past sixty years; by the 1990s, logistics costs as a percent of GDP had dropped dramatically with better product availability. However, attempts simply to apply the same supply chain strategies and systems to the emergency context have failed, and response efforts are often inefficient and ineffective. Supply chain science must be further developed to incorporate the unique context of emergencies: limited data; security risks; damaged infrastructure; population migration; volatile economies; poor governance.

MIT faculty, staff, and students have developed a practical research approach with numerous government, non-government, and private sector organizations, domestically and internationally, to address the challenge. It is a cycle of observation, development, and application:

- Empirical research to develop theories on decision-making during crises and to characterize how supply chains adapt in resource-constrained contexts.
- Scientific development of tools and integration of technology to optimize product flows based on empirical insights.
- Practical application by upgrading skills via education and training, and shifting policies in various organizations and communities.

Coordinated Public-Private Capacity

Emergencies create needs among citizens and disruptions for businesses. Increasingly, government agencies are leveraging private sector capacity during emergencies to increase efficiency and effectiveness for response efforts and more rapidly restore local economies. For companies, active participation in emergency response provides enhanced public image and accelerates business continuity efforts. The key is developing new designs and policies for public-private emergency response supply chains that benefit both citizens and companies.

The MIT Humanitarian Response Lab has developed an analytical tool to measure the combined emergency response capacity for life-saving commodities across public and private actors. This Commodity Response Capacity (CRC) tool is a key component for assessing and planning public and private operational preparedness for emergency response. It is also the foundation for our efforts to develop a Response Capacity Index. This tool is now being utilized by lead agencies for coordinating emergency response domestically (U.S.) and globally.

Engage

We offer active opportunities for corporate participation in efforts led by the US Federal Emergency Management Association (FEMA) and the United Nations Office for the Coordination of Humanitarian Affairs (OCHA):

- Domestic: FEMA, the lead federal agency for emergency response in the United States, is currently using our CRC tool to plan strategic stockpiles. FEMA invites MIT to engage companies in assessing the combined public-private capacity for post-emergency supply of key commodities (e.g. water, food, fuel).
- International: OCHA, the lead United Nations agency for coordinating international emergency response, incorporated our CRC tool into Emergency Response Preparedness (ERP) Framework. Private sector contributors are invited to share capacity commitments as part of global preparedness activities.

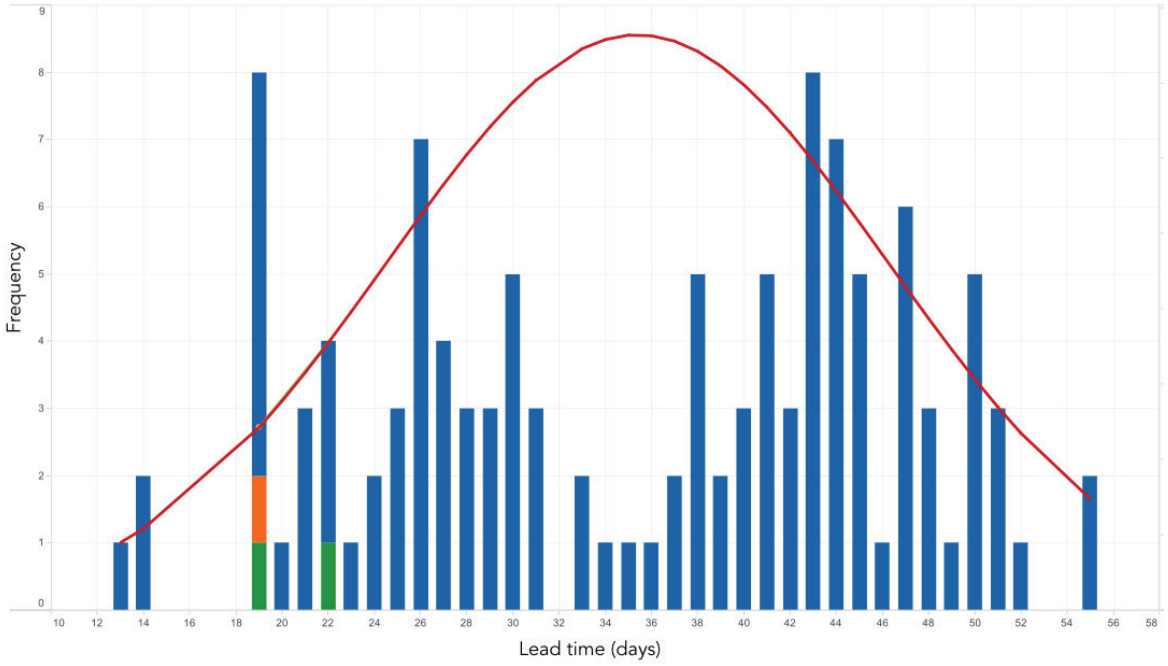
If you would like to learn more about these projects or our related work on emergency response and international development, please contact Dr. Jarrod Goentzel (goentzel@mit.edu).

Supply Chain Visibility

Principal Researchers: Dr. Jarrod Goentzel and Dr. Fredrik Eng Larsson
Other Team Members: Anna Stanchik, Michael Badtmann (visiting student)

Key Insights

1. Both shippers and carriers find it difficult to quantify the value created from investment in technology that increases supply chain visibility.
2. The sales pitch for investment in a supply chain visibility solution (SCVS) often features the potential to take dynamic action; our case studies indicate it is easier to quantify value from structural improvements over time.
3. Advanced analytics and diagnostics that leverage extensive datasets from tracked shipments are rarely employed to identify structural improvements.



Shippers and carriers are both exploring solutions to increase supply chain visibility. A supply chain visibility solution (SCVS) is typically set-up to monitor, measure, and manage transport and inventory movements across the supply chain. An SCVS aims to improve collaboration with suppliers as well as customers, and create value for a company through operational improvements and cost reductions.

This research focuses on understanding how the implementation of an SCVS affects supply chain decision-making and exploring how these decisions create value in a supply chain. The research takes a multi-pronged approach:

1. survey of shippers and carriers followed by a roundtable discussion;
2. case studies of supply chain control tower initiatives;
3. financial analysis for visibility value creation; and
4. prototype analytics and diagnostics tools for decision support.

Empirical evidence

Our empirical research found that SCVS have a direct positive effect on efficiency and effectiveness of data management process via multiple enabling factors, such as automation, standardization, and better raw data. Key operational processes were affected by the SCVS, often indirectly, via better data quality. The detailed case studies used a "with and without" approach to determine the incremental change in business processes resulting from the SCVS. This research identified shipment and inventory management, procurement and partner collaboration, and risk management processes as the ones that most affected by an SCVS. However, the strength of impact on these processes, and therefore on company performance, typically varies by company characteristics and stage of implementation.

We have also developed a preliminary framework for companies considering an SCVS to evaluate the financial benefits. During the various stages of research, companies repeatedly mentioned the difficulties of building a business case for SCVS implementation.

Our framework provides a basis to quantify the financial impact of an SCVS using relevant, incremental cash flows, which builds on our "with and without" case studies. The next step is validating the framework with specific use cases developed with industry partners.

Next Phase

We are also launching our final phase exploring the potential for analytics and diagnostics. Initial plans aim to focus in the following areas:

- *Lead time assessment.* For analytical reasons, inventory and production models often assume lead times are normally distributed, while in practice, they often are not. With visibility data, the "true" distribution at different points in time can be assessed and used for decision-making.
- *Lead time predictive analytics.* Visibility data can further be used to analyze which factors determine the lead time variability and how the variability is correlated among trade lanes, shippers, and time, which is crucial for optimal routing and sophisticated ETA prediction.
- *Marginal value analysis of real-time information.* Visibility data has a higher value when uncertainty is higher; as a given shipment is approaching port, visibility data has a lower marginal value. Understanding how the marginal value of information decreases is important for setting up the right information collection strategy.
- *Root cause analysis*, to better understand potential supply chain problems.

Based on the these analyses, we plan to explore optimization and structural improvements in the following areas:

- *Inventory control and expediting rules.* Based on the "true" lead time distributions and real-time predictive analytics, more tailored inventory control policies can be implemented, leading to lower total inventory and expediting costs.
- *Operational routing and carrier selection.* Lead-time variability drives the risk of incurring the potentially high costs associated with expediting and/or backordering and extra inventory. However, for a given shipment there may be several routing alternatives and carriers, each with its own (often correlated) risk. A portfolio-type model based on information from the diagnostics can optimize the routing/carrier selection to minimize risk and/or costs on a day-to-day-basis.
- *Information collection strategy.* Collecting, handling, analyzing high-frequency real-time visibility data is costly and time-consuming. At the same time, the analytics tells us how the marginal value of these data is decreasing as a shipment progresses. A formal evaluation can help decide how much visibility information to be collected, and when, from each shipment.

Key Operational Processes	Effect of SCVS on Company Performance		
	Shipper 1	Shipper 2	Shipper 3
Shipment and Inventory Management			
Shipment planning and inventory policy	H	H	H
Tracking & Tracing Cargo	H	M	H
Cargo ownership transfer	H	-	-
Procurement and Partner Collaboration			
Partner collaboration	M	H	M
Performance evaluation of carrier / supplier	H	H	H
Carrier / supplier nomination & contract negotiations	H	H	L
Risk Management			
Event monitoring & exception management	L	H	H
Response and contingency planning	L	H	M
Documentation & Compliance	L	L	M

Engage

The next phase of this research focuses on further developing the financial analysis framework and prototyping analytics and diagnostics tools for decision support. We seek engagement with companies interested in:

- Prototyping analytics and diagnostics approaches based on available supply chain visibility data for specific trade lanes and/or business processes.
- Collaboratively determining the incremental value of a supply chain visibility solution based on changes in operational processes.

If you are interested in learning more, please contact Dr. Jarrod Goentzel at goentzel@mit.edu.

Supply Chain Strategy Lab

Principal Researcher: Dr. Roberto Perez-Franco, Director

Key Insights

1. Rethinking a supply chain strategy is a complex task. We have developed and tested a comprehensive, structured approach to help you accomplish it.
2. The Supply Chain Strategy Lab continues the work on supply chain strategy that started in 2006 under the Supply Chain 2020 Project.
3. We have developed methods to articulate, evaluate, and reformulate the supply chain strategy of an organization.
4. We have also developed a visioning method to address the long-term challenge of preparing for an uncertain future.

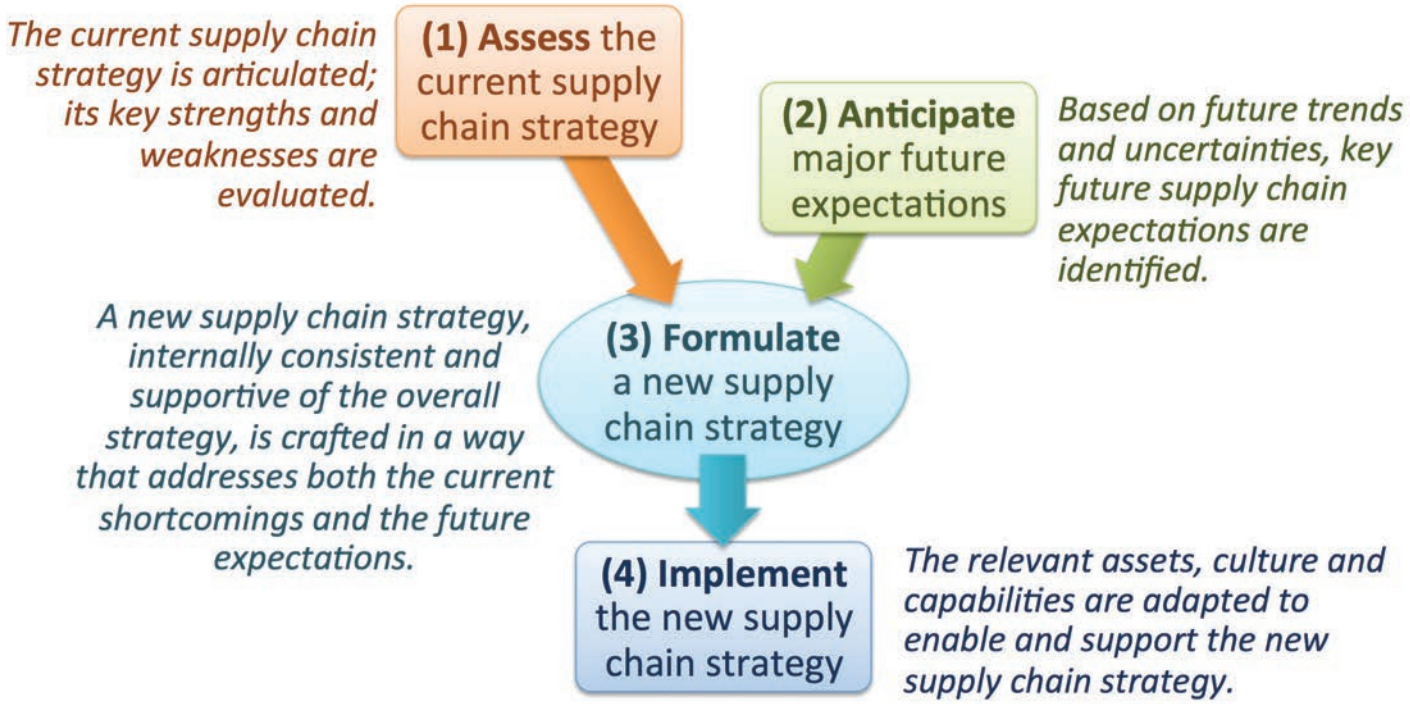
Business strategies change. Products progress along their life cycle, and new products are launched. Disruptive technologies appear. Regulations and consumer preferences evolve. All these changes require us to stop and reconsider our current supply chain strategy, to ensure it remains sound, and adapt it if needed. Rethinking a supply chain strategy, however, is not a trivial problem. Supply chains are complex entities, and rethinking their strategy reflects this complexity. The absence of an established answer in the supply chain management literature on how to rethink a supply chain strategy further compounds what is already a daunting problem. That is why MIT's Center for Transportation & Logistics (MIT CTL) has been working on the problem of supply chain strategy, as part of a the Supply Chain Strategy Lab (SCSL).

The SCSL is a continuation of the efforts on the supply chain strategy of the Supply Chain 2020 Project (SC2020), regarding the development, documentation, and dissemination of a toolkit of methods to rethink a supply chain strategy. The ideas generated in SC2020 and continued in SCSL have been thoroughly tested in multiple projects with world-class organizations, including several Fortune 100 companies. Significant progress has been made towards documenting its results in the form of an actionable guidebook that can be applied by practitioners. A first draft of this guidebook should be completed this later this year.

Our approach to supply chain strategy invites practitioners to decompose the problem into a set of four interrelated challenges. The first challenge is to assess the current supply chain strategy and identify its strengths and weaknesses. The second challenge is to anticipate the future supply chain needs that the organization may encounter. The third challenge to craft a new supply chain strategy that can satisfy the anticipated future needs, while retaining or improving all the good features of the current supply chain strategy, and fixing as many of its weaknesses as possible. The fourth and final challenge is to translate the new supply chain strategy into action. Our toolkit includes methods to accomplish each one of these four challenges in a structured manner.

Supply Chain Strategy Lab

- How can supply chains prepare for future challenges?
- Rethinking a supply chain strategy for today and tomorrow



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Our method for strategy evaluation can help you better understand the internal consistency of your supply chain strategy, as well as its 'alignment' with your business strategy. Our method for scenario planning can help you anticipate the impact that many future threats and challenges may have on your supply chain. Our method for strategy formulation can help your team assemble a new supply chain strategy that retains the good, fixes the bad, and readies you for the future.

Please reach out to Dr. Roberto Perez-Franco at roberto@mit.edu if you are interested in learning more.

Supply Chain Team Dynamics

Principal Researcher: Dr. Roberto Perez-Franco, Director

Key Insights

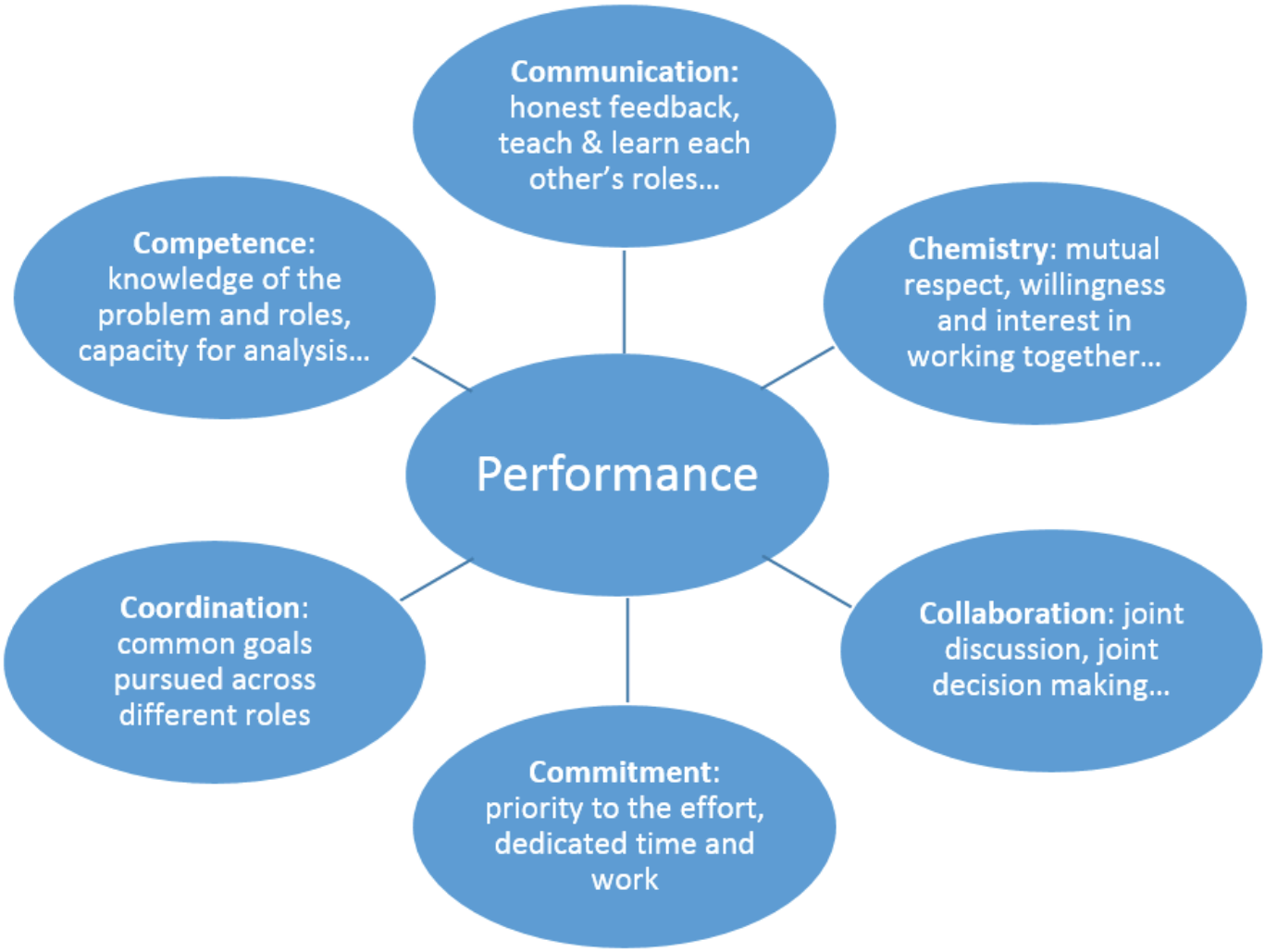
1. Good team chemistry does not guarantee success. However, it does seem to lead to failure, if not in the short term, then for sure in the long run.
2. Effective teams tend to communicate in several ways, including real-time meetings with voice and video.
3. Effective teams do more preparation work before meetings, and are better at giving feedback and learning from their mistakes.
4. Effective teams are composed of members who are committed, and whose commitment translates into work and time invested.

Supply chains operate across multiple functions, which often have competing—even conflicting—objectives among themselves. So, not surprisingly, the success of the overall supply chain depends on the ability of these functions to come together and collaborate as a team towards achieving the overall goals of the organization. Effective teams are fundamental to supply chain success.

But what do we know about effective supply chain teams? Surprisingly little, it turns out. There is almost no literature on the subject of supply chain teams. And—although some useful insights may be derived from what we know already about teams on the one hand and supply chains on the other—it is possible that there is something particular to effective supply chain teams.

To understand what makes supply chain team effective, researchers at MIT CTL have been taking a closer look at the best, and the worst, student teams competing in a supply chain simulation over the past four years. The students conduct this simulation as part of their graduate training in supply chain management. They describe their team's dynamics through interviews, questionnaires, and surveys.

Although the research is still in its early stages, and the data collected so far has not been thoroughly analyzed yet, a comparison of the team's dynamics to their performance yields some interesting insights, listed in the box above. These and other early learnings make us think this is an area that is ready for in-depth formal research. If you are interested in supporting this research, please contact us.



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You can support this research by providing us access to your supply chain team for observation or by sponsoring a master's thesis project based on your organization.

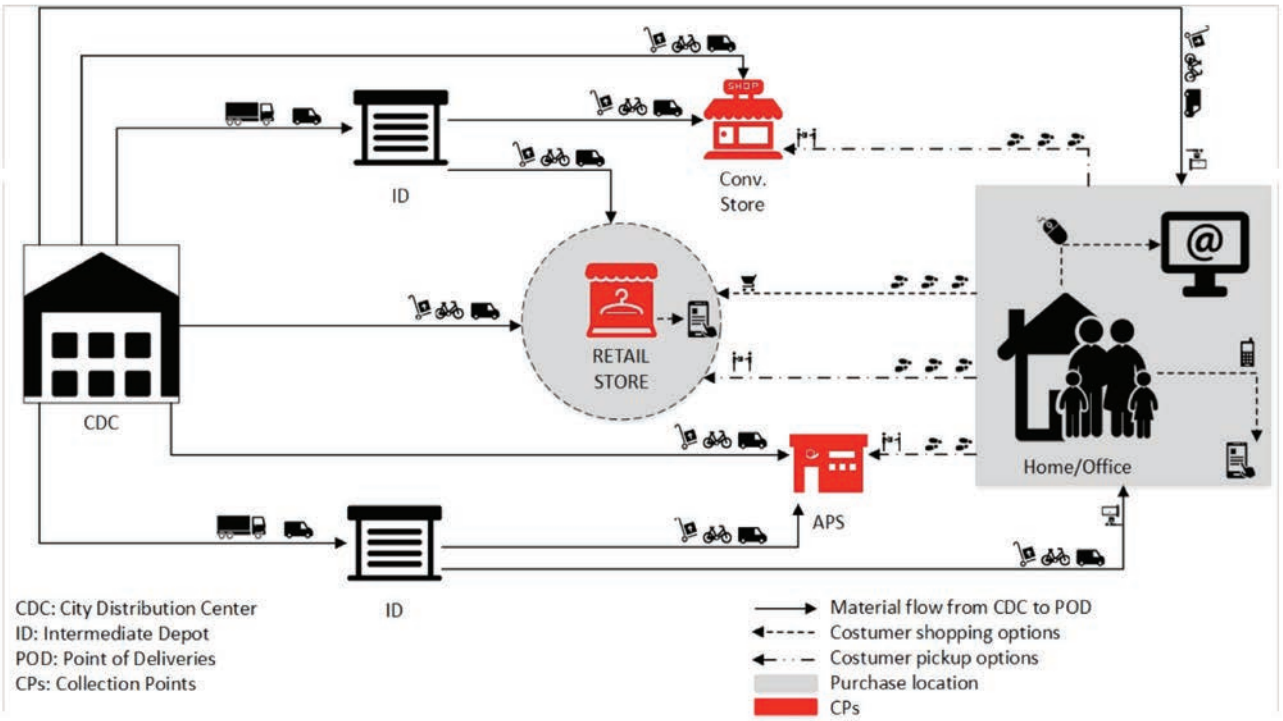
Please reach out to Dr. Roberto Perez-Franco at roberto@mit.edu for more information.

Omni-Channel Distribution Strategies

Principal Researchers: Dr. Eva Ponce and Dr. Matthias Winkenbach

Key Insights

1. Retailers and manufacturers are increasingly pursuing omni-channel distribution strategies in urban areas since the growth of e-commerce and the use of mobile devices for consumer purchase.
2. This requires new methods to design last-mile distribution networks that will include new distribution channels and multi-modality.
3. Our model supports companies to design their omni-channel distribution strategies and improve their last-mile distribution efficiency.



Omni-channel retailing brings a number of challenges, including the need for more coordination between trading partners and more complex urban logistics networks that support multiple distribution channels and delivery models, as well as increasingly high consumer expectations regarding the convenience and reliability of delivery services.

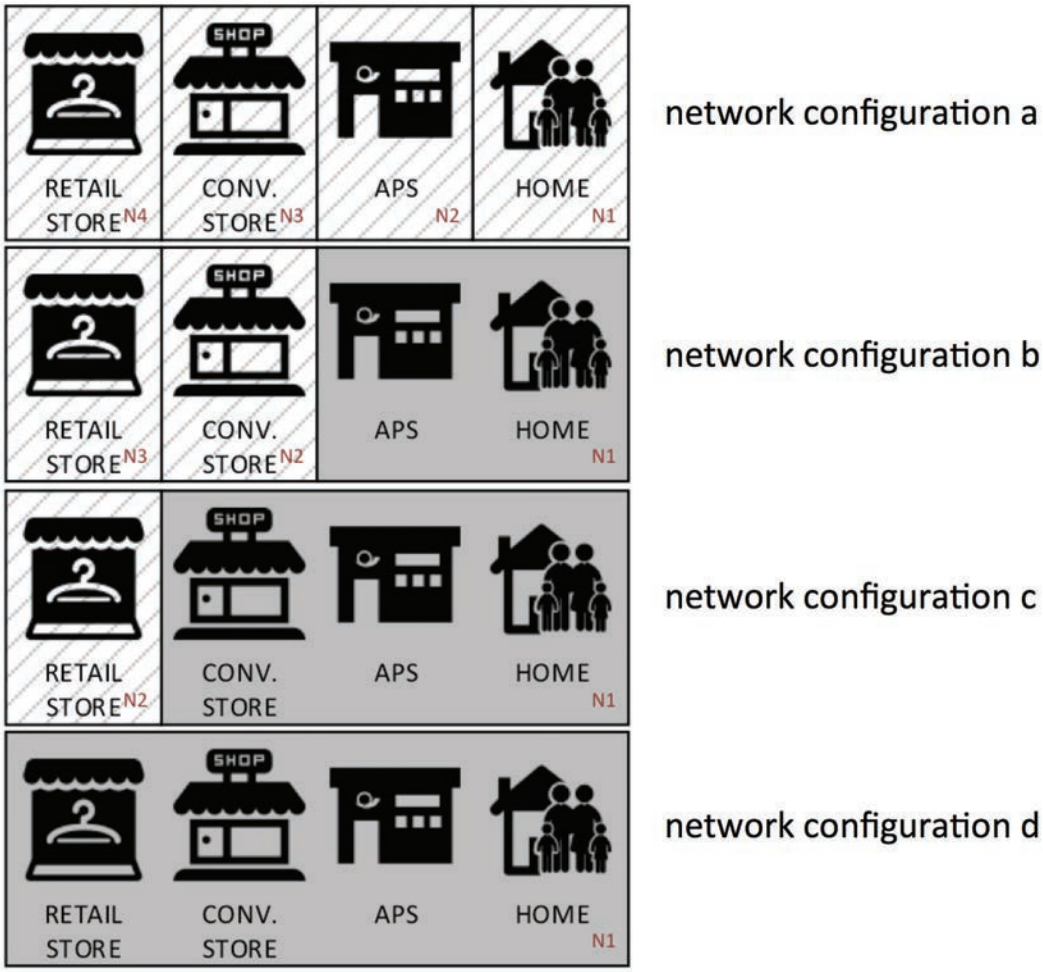
We propose a model that helps retailers to design urban last-mile distribution networks that support omni-channel strategies. While most of the existing research in this area has focused on the sales side of the omni-channel movement, our work focuses on appropriately designing the physical network of urban goods transportation that would form the backbone of any such strategy. In an example of a real-world case study based on a major fast-fashion retailer, we show how such a model can be applied and which important lessons for retailers can be drawn from it.

Omni-channel Distribution Strategy

In response to the growth of e-commerce and changing consumer buying behavior, more and more retailers are developing multi-channel sales and distribution strategies. As an essential part of the omni-channel retail experience, online buyers are given many different options for receiving and returning the products they buy.

The figures above and on the next page represent the last-mile delivery flows in an omni-channel distribution strategy.

We conclude that a fully integrated omni-channel network configuration reduces the cost of network operation by some 50%.



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Please contact Dr. Eva Ponce (eponce@mit.edu) for more information or visit http://ctl.mit.edu/ponce.

We are looking for companies to engage with us on:

- Research projects to design future last-mile networks including omni-channel dimensions.
- Industry and/or government experiments to evaluate online sales and their impact on urban freight policies.

Supply Chain Innovation

Principal Researcher: Mr. James B. Rice, Jr.

Key Insights

1. Supply chain (aka process) innovation is distinct from product innovation, and achieving it requires a different approach.
2. Sustaining supply chain innovations are often created through continuous improvement, business process re-engineering, and kaizen initiatives that make incremental improvements in cost, quality, and cycle time.
3. Disruptive supply chain innovations occur when the dominant supply chain design or design element is changed and brought to scale within a particular industry. These are rare.
4. At the heart of every successful SCI is the careful and clever reapplication of known solutions that are productive and scalable.

Overview

Supply chain innovation (SCI) captures the interest of many practitioners, but many find it elusive and even difficult to understand and pursue. This project has produced a number of publications that address some of the challenges that exist for practitioners interested in creating supply chain innovation in their businesses.

What is Supply Chain Innovation?

Through the research to date, we have come to define SCI as the combining and application of a mix of inventions, existing processes, and technologies in a new way that achieves a desirable change in cost, quality, financial flows, and/or service. Practitioners should note that this definition includes all SCIs regardless of the time required to achieve them, the impact (i.e. sustainable or disruptive), or originality (i.e. whether the SCI has been adopted by other industries or companies).

In pursuing SCI, firms should recognize that supply chain innovation (or process innovation) is distinct from product innovation. Technical invention does not necessarily constitute innovation.

Supply chain innovation:

- Entails a change in method and/or process, often, but not always, enabled by technology.
- Often involves recombining and substituting existing processes and methods.
- Results in a positive change in performance, but rarely is it rapidly "disruptive."
- Can accrue through deliberate small improvements and developments that together make more significant impact.

Lingering questions about SCI remain:

- How can the firm pursue SCI?
- How should the firm organize and staff to pursue SCI?
- What are the necessary skills to develop SCIs and implement SCIs in the firm?
- Is there a distinct calculus required for making SCI investments?
- How should firms consider and utilize emerging technologies?
- How should firms work with upstream and downstream partners to create SCIs in the extended supply chain?

Publications Produced

- "Deconstruct to Reconstruct: Using the Past to Create the Future" - *Supply Chain Management Review*, September/October 2015.
- "Perseverance Pays in the Innovation Game" - *Supply Chain Management Review*, May/June 2014.
- "Inapt Innovations Do More Harm Than Good" - *Supply Chain Management Review*, January/February 2014.
- "Innovative or Inconclusive? Evaluating New Supply Chain Ideas," MIT CTL White Paper, Spring 2013.
- "SC Innovation: A Conceptual Framework," MIT CTL White Paper, February 7, 2012.

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If you have interest in working to address these issues or have related questions, please contact Mr. James B. Rice, Jr. directly at jrice@mit.edu or by phone at +1.617.258.8584.

Quantifying Supply Chain Resilience

Principal Researcher: Mr. James B. Rice, Jr.

Key Insights

1. The concept of Supply Chain Resilience has become fairly well understood. Methods to create and build resilient supply chains are also known and understood.
2. The investment decision to build supply chain resilience is not well defined, and the problem exists for several reasons.
3. New and refined data sources are bringing opportunities to improve and inform supply chain resilience investment decisions.
4. A recently-developed Balanced Scorecard of Resiliency provides an initial overview and multi-faceted assessment of a supply chain's resilience.

Overview

For decades, researchers have studied how to make supply chains more capable of dealing with uncertainty, leading to new understandings of how to build flexibility, agility, and other capabilities into the supply chain. The study of how supply chains should prepare for and respond to low-probability, high-consequence disruptions became a new focus soon after the 9/11 terrorist attacks. Subsequent large-scale disruptions provided repeated examples illustrating the importance of supply chain resilience—the ability to bounce back from disruptions—and the consequences of a lack of supply chain resilience. In response, researchers have successfully outlined options for firms to create supply chain resilience. As a result, the concept of supply chain resilience has become fairly well understood, and methods to create and build resilient supply chains are also known and understood.

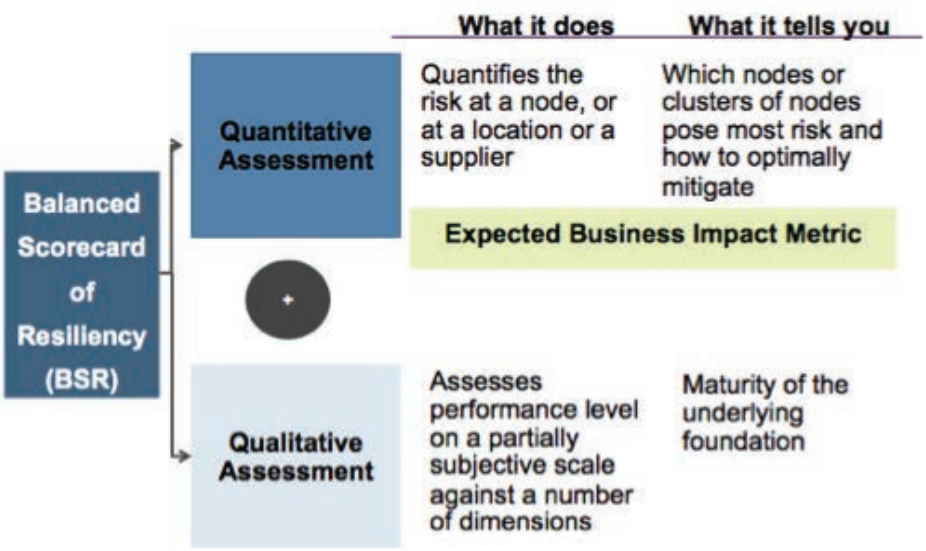
Investing in Supply Chain Resilience

The investment decision to build supply chain resilience, however, is not well defined. Practitioners lack the ability to adequately measure and assess the resilience of the supply chain. There is a lack of pertinent data and information about the costs to create resilience, the effectiveness of various resilience initiatives, the cost of recovery, and the value at risk (although there has been some progress in identifying the value at risk through research efforts such as the Hi-Viz research project conducted by Dr. Bruce Arntzen, MIT CTL, see page 9).

New and refined data sources, and analytical methods, are bringing opportunities to improve and inform supply chain resilience investment decisions. Recent work through an SCM thesis (MIT SCM Master Thesis, *A Supply Network Resiliency Assessment Framework*, by Jasper Siu and Santosh Stephen, 2015) created a Balanced Scorecard of Resiliency (BSR) that provides an initial assessment of a supply chain's resilience. The BSR has both a qualitative and quantitative side, each with several components. Together, the qualitative and quantitative assessments can provide the practitioner with a high-level assessment of the resilience of their supply chain. Additional work is required to enhance the functionality and to calibrate the BSR.

Quantifying Resilience

This research initiative will address some of the shortcomings and challenges that hamper the assessment of supply chain resilience and make effective investment decision-making more difficult. The research team seeks to develop methods to quantify the various key components of the investment decision—the cost and time to recover, the cost to mitigate, the effectiveness of mitigation options, the value at risk, and the value (revenue or contribution) at risk, to cite a few. Additionally, the team will develop various business cases utilized by different practitioners to offer a broad set of options for the practitioner to capably make supply chain investment decisions.



Ref. from the MIT Master Thesis, *A Supply Network Resiliency Assessment Framework* by Jasper Siu and Santosh Stephen, 2015.

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If you have interest in working to address these issues of have any related questions, please contact Mr. James B. Rice, Jr. directly at jrice@mit.edu or by phone at +1.617.258.8584.

Advanced Product Promotion Planning from the Supply Chain Perspective

Principal Researcher: Mr. James B. Rice, Jr.
Other Team Members: Dr. Francisco Jauffred, Dr. Daniel Steeneck, Dr. Fredrick Eng Larsson

Key Insights

1. Accurate promotion forecasting by considering: 1.) Day of week 2.) Promotional price drop, and 3.) Prominent display of the promoted product .
2. KPIs for supply chain efficacy during promotions:
   - Forecast accuracy
   - Store level stock out incidences
   - Post-promotional period store level inventory
3. Phantom stock outs are at least twice as frequent as observable stock outs.

Just about anyone who has been shopping has seen a product promotion. These retailer product promotions are especially common in the consumer product goods (CPG) industry. Of course, the objective of product promotions is to increase product sales. The increase in product sales during a promotion over the normal sales volume is called *sales lift*.

However, from a supply chain perspective, sales lift is problematic and essentially a disruption to the supply chain. In this project, we investigate how a CPG manufacturer should execute specific product promotions in order to (1) maximize product lift, and (2) minimize the supply chain costs.

Broadly, this is a multi-year project and involves answering the following five (5) major questions:

1. How can product demand for a promotion be forecasted more accurately?
2. How should the success of a promotion be measured?
3. What are the root causes of low on-shelf availability during promotions?
4. How can a new supply chain strategy improve promotion execution performance?
5. Are there incentives the manufacturer can provide to the retailer to improve the outcome of a promotion?

The first question regarding how to better forecast product demand is central to the overall problem. The demand forecast specifies the sales potential for the product and will be the yardstick against which we can measure the success of a promotion. Our study to forecast sales lift on a particular product has been successful, and we are currently working to generalize the forecasting technique to be used on a wide variety of products.

Measuring promotion success (Question 2) has been addressed by a recent SCM master's thesis. The thesis defined the required KPIs for measuring the success of a promotion as the number of stock outs during a promotion and end-of-promotion days of supply. After analyzing over 8,000 promotion events, it was concluded that the cost of stock outs and insufficient post-promotional inventory levels dwarfed the cost excess, post-promotional inventory.

Our current focus is on improving supply chain execution of promotions to minimize stock outs. In fact, a major finding is the existences of both observed and unobserved stocks outs. Unobserved stock outs occur when the inventory record indicates product on hand, but really, there is no product on the shelf. This phenomena is termed a *phantom stock out,* and it is estimated they occur roughly 4% of the time (observed stock out rates are about 1–2%). Using on-shelf availability audit data, historical point-of-sale data, historical inventory records, and similar information from product with highly correlated sales, we are developing sophisticated analytics to identify phantom stock out states. This method will be important in several key activities: 1.) helping retailers and manufactures quickly and accurately identify and fix phantom inventory states and 2.) estimating true product demands by avoiding consideration of low or zero sales days that are really due to product stock outs and not consumer demand.

With a solid foundation of accurate forecasting and the ability to measure promotions, we can optimize the supply chain to improve the execution of promotions through appropriate promotional order quantities, inventory allocations, and inventory replenishment policies. This is the goal of the last two phases of the project: to improve promotion execution we must 1.) leverage a new supply chain strategy (Question 4) and 2.) collaborate with the retailer (Question 5).

Engage

Is on-shelf availability is an issue for your company during promotion events (or in general)? How do you define what a "perfect promotion" looks like from an execution standpoint? Do you feel that promotions are more trouble than they are worth? Is your forecast accuracy low for promotion events? Have you had to restructure your supply chain to handle product promotions more effectively?

We are eager to hear from you about these, or any other issues related to product promotions!

Please contact Mr. James B Rice, Jr. at jrice@mit.edu for more information.

Productivity in Small- & Medium-Sized Enterprises

Principal Researcher: Dr. Josué Velázquez-Martínez
Academic Partners: Jan Fransoo (TU/e, Netherlands), Jose Larco Martinelli (UTEC, Peru), Karla Valenzuela (ITESM), Camilo Soto (LOGyCA, Colombia)

Key Insights

1. Small- and Medium-Sized Enterprises (SMEs) account for 60 to 70% of jobs (and new jobs) in most OECD countries. However, less than one-half of start-ups survive for more than five years, and only a fraction develops into a high-growth firm.
2. The main challenge of SMEs is low productivity, particularly in regions like Latin America, due to the lack of managerial quality and technologies.
3. Low productivity in SMEs can be improved by studying the outcomes in terms of efficiency, and then by building behavioral operations models to provide guidance in the business decisions.

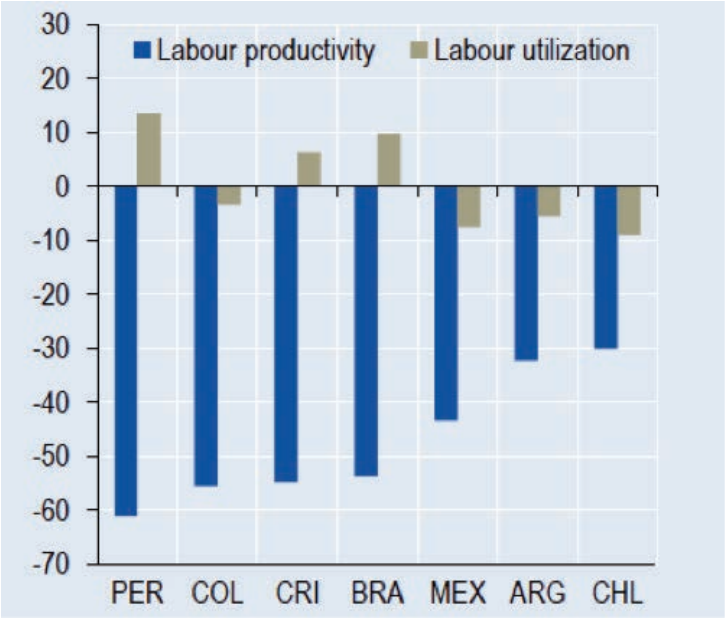


Figure 1. Percentage difference in levels with the OECD average (Source: OECD National Accounts Database)

SMEs account for an important share of jobs and economic activity in the world. However, we observe a generalized problem of low productivity in these types of companies, particularly in countries from Latin America (see Figure 1). At the earlier stages, management capabilities and strategic operations management are crucial to the survival of SMEs. However, SMEs in Latin America complain of not finding the right high-quality skills for the jobs.

To increase productivity, we first need to understand the outcome of SMEs and the process of how they make decisions. Some of the questions we intend to answer: What are the causes of the inefficiencies? How do companies use a 'Choice Model'? Who makes the decisions? Is there any difference in terms of age, education, etc.? What are the activities that add value? How many of these activities are conducted during day-to-day activities?

Increasing Efficiency in SMEs in Latin America

A study directed by Dr. Josué Velázquez-Martínez is launching with the objective to understand the main causes of the inefficiencies in SMEs by conducting a macro analysis, and then by building a framework using behavioral operations techniques to understand how SMEs make operational/logistics decisions (micro study). See Figure 2.

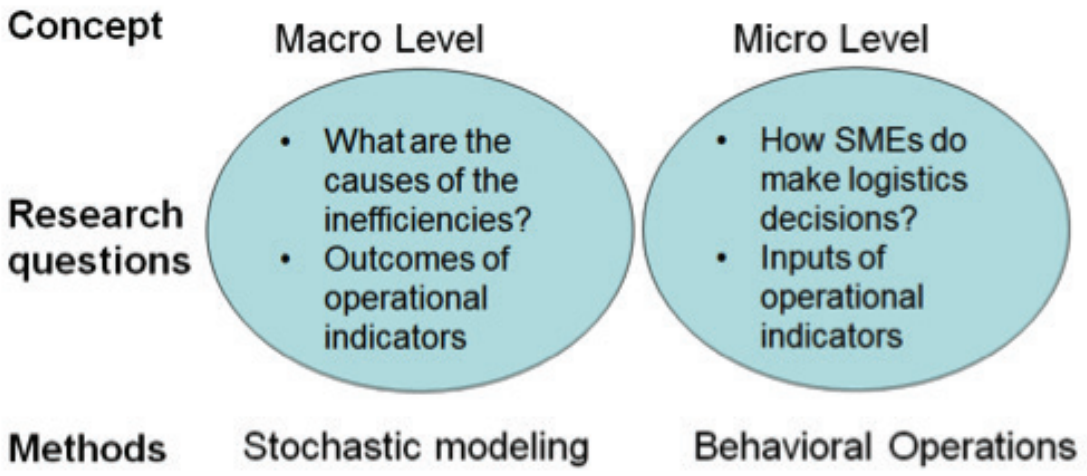


Figure 2. Conceptual model for the study on productivity for SMEs

Engage

Please contact Dr. Josué Velázquez-Martínez (josuevm@mit.edu) for more information. We are looking for companies to engage with us on:

1. Providing data from industry and/or government to build robust models to understand the causes of inefficiencies in SMEs.
2. Funding to continue research development of models to increase productivity in SMEs in the US and Latin America.

Sustainable Logistics

Principal Researcher: Dr. Josué Velázquez-Martínez
Academic Partners: Jan Fransoo (TU/e, Netherlands), Hugo Elizalde (ITESM, Mexico), Viviana Rangel (LOGyCA, Colombia), Yann Bouchery (EMN, France)

Key Insights

1. Studies show that road transportation is the fastest growing major source of CO_2 emissions in the US.
2. These emissions can be affected by many logistics decisions such as the assignment of trucks to delivery areas, fleet acquisition, replenishment strategies, and building delivery routes.
3. In the future, more companies will look for alternatives to reduce CO_2 emissions by making smarter logistics decisions.

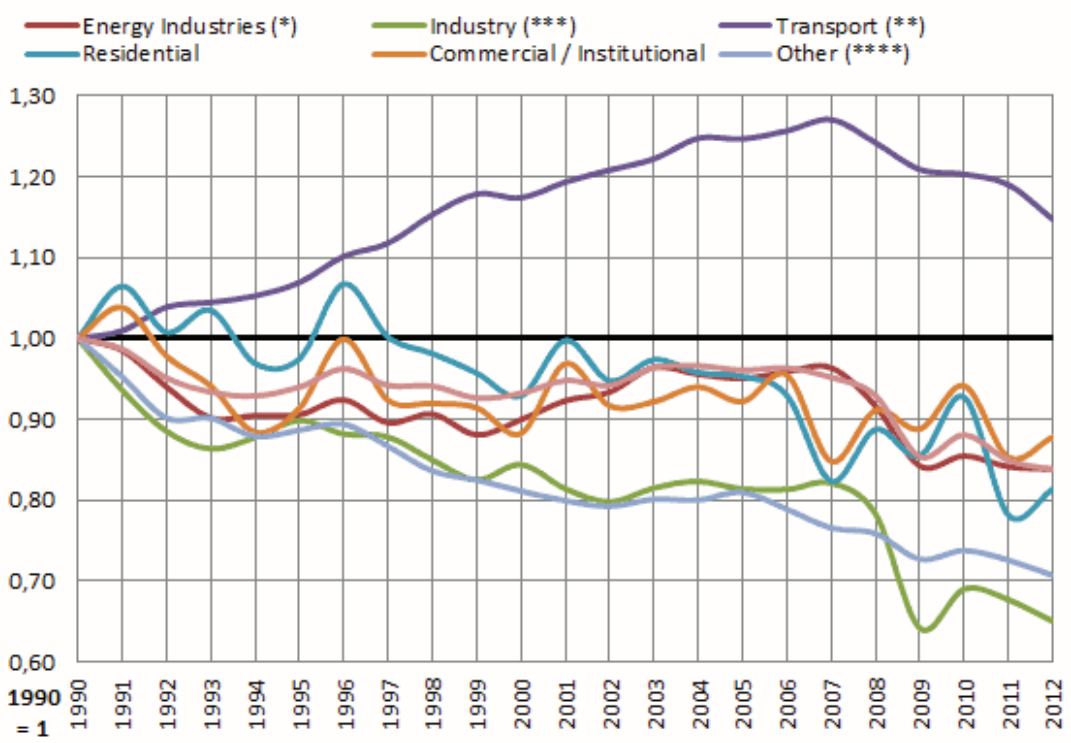


Figure 1. EU greenhouse gas emissions from transport and other sectors, 1990-2012 (Source: European Commission, 2016)

In the United States, road transportation accounts for ~30% of greenhouse gas emissions (GHGs) and it is the fastest-growing major source of GHGs, and in the European Union (EU) it accounts for more than 65% of EU transport-related GHGs and over 20% of the EU's total emissions of CO_2. In addition, studies show that the GHGs in other sectors have decreased 15% between 1990 and 2007, but emissions from transport have increased 36% during the same period (see Figure 1).

This increase has happened despite improved vehicle efficiency because the amount of freight transport has also increased due to more logistics operations.

Truck Assignment for CO_2 Emissions Reduction[1]

A study directed by Dr. Josué Velázquez-Martínez that helps companies to assign the proper vehicle to a delivery area with the aim at minimizing the fuel consumption. The approach consists in two phases: 1.) Characterizing and clustering the delivery areas based on the conditions that affect the performance of the vehicles, such as store densities, average speed, and topology. This analysis identifies common and different regions from the logistics perspective. 2.) Studying the historical performance of the trucks over time when delivering in different areas within the city. Figure 2 shows the comparison (Kg of CO_2/Km) of the same types of truck when delivering in different areas (clusters).

This information can then be used to formulate a mathematical model that assigns optimally the fleet to minimize the global CO_2 emissions, and thus, the fuel consumption.

We have conducted a variety of applications in multiple companies (Parcel, CPGs, etc.)

[1] Velázquez-Martínez, J.C., et. al. (2016). "A New Statistical Method of Assigning Vehicles to Delivery Areas for CO2 Emissions Reduction." *Transportation Research Part D: Transport and Environment*. 43 133-144.

Figure 2. Average emission factors per type of truck per cluster. (Source: Velázquez-Martínez et. al., 2016)

Engage

Please contact Dr. Josué Velazquez-Martinez (josuevm@mit.edu) for more information. We are looking for companies to engage with us on:

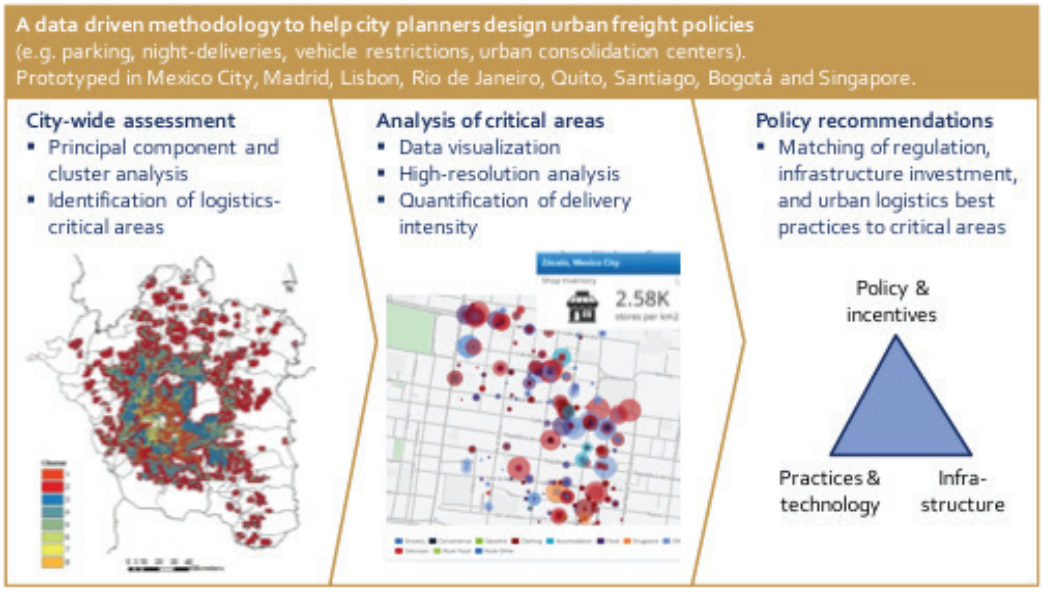
1. Research projects to study their potential savings in CO_2 emissions via better logistics decisions (truck assignment, routing, facility locations, etc.)
2. Industry and/or government experiments to evaluate carbon-efficient logistics policies.
3. Funding to continue research development of carbon-efficient logistics decision models.

Megacity Logistics Lab

Principal Researcher: Dr. Matthias Winkenbach, Director
Other Team Members: Dr. Sergio A. Caballero, Yin Jin Lee, Daniel E. Merchán, Dr. Eva Ponce
Affiliated Research Staff (* indicates currently at MIT): André Alho (IST, Portugal), Andrés Bronfman (UNAB, Chile), Prof. Adriana Gabor (QU, Qatar), Prof. Lino Marujo (UFRJ, Brazil), Dr. Christopher Mejía (TU/e, Netherlands), Dr. Daniel Mota (Mauá, Brazil), Dr. Kitti Setavoraphan (CIL,Thailand), Andre Snoeck* (TU/e, Netherlands), Nathalia Zambuzi (USP, Brazil)

Key Insights

1. Changing demographics and retail trends are making urban last-mile delivery more complicated and triggering new strategies to get goods into packed city centers.
2. Changing demands put a premium on innovative distribution models that are efficient, flexible, and resilient, and create an omni-channel delivery experience.
3. The new emphasis is on multi-tier systems that employ different combinations of transportation modes and technologies.
4. Future last-mile logistics networks will leverage urban transshipment points.
5. Logistics big data analytics create value by high-resolution last-mile performance visibility and learning to inform strategic network design and operational planning.



The MIT Megacity Logistics Lab conducts innovative theoretical and applied research to help companies operate better logistics for cities and governments to design better cities for logistics.

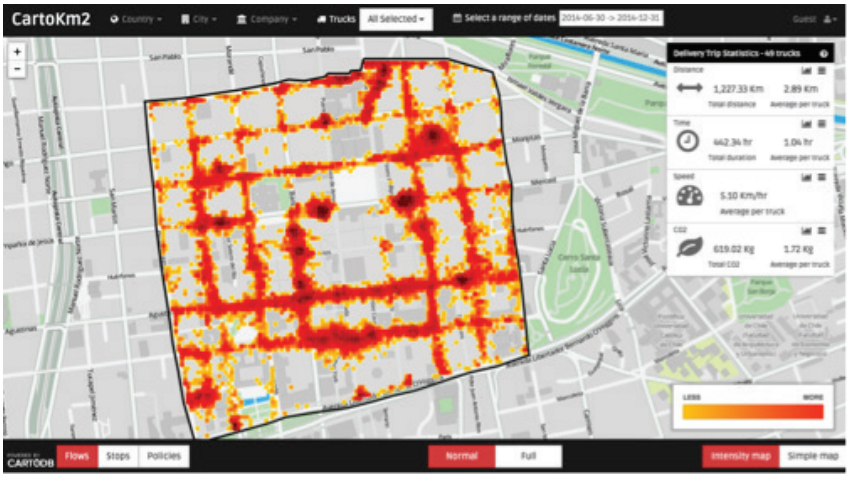
Why a Megacity Logistics Lab?

Designing urban logistics operations requires in-depth understanding of consumers and channels combined with high-resolution, data-driven modeling. There are three major drivers of increased complexity of urban logistics networks.

First, urbanization is progressing at a fast pace. While in 1950 only 54.5% of the population in developed countries lived in urban areas, this number had risen to 77.7% by 2011 and is projected to reach 85.9% by 2050. Moreover, 25% of the world's population and almost 60% of the world's gross domestic product will be found in the world's 600 largest cities by 2025.

Second, the growth of Internet and mobile phone-based electronic commerce is triggering an increasing amount of direct shipments from manufacturers and retailers to individuals. Direct deliveries do not only increase complexity of last-mile urban transportation networks, they also lead to fragmentation of shipments and higher complexity and greater need for coordination between consumers, retailers, and manufacturers to distribute goods efficiently.

Finally, on-going efforts from cities to invest in public transportation, limiting road access and parking spaces in favor of pedestrian and public transit infrastructure, disproportionally impact logistics operations. Since urban freight also generates an important share of congestion, pollution, and other negative



externalities, city logistics activities are always under pressure from regulatory actions.

Urban Logistics Toolkit and Best Practices

The growth of e-commerce is pushing the limits of existing logistics network designs. We are reimagining future urban logistics networks that support omni-channel retail models, smaller store formats, increased intensity of deliveries, coordinate multiple transshipment points, and engage a wider range of vehicle technologies—including cargo bikes, and electric and autonomous vehicles. We are developing a toolkit for the city-wide identification and analysis of logistics-critical areas and how they can be matched with suitable urban freight policies, operational best practices, and infrastructure improvements. The toolkit is being prototyped in seven cities: Mexico City, Madrid, Lisbon, Rio de Janeiro, Santiago, Bogotá, and Singapore.

Urban Distribution Network Design

Cities are growing in both size and complexity, especially in developing economies. In an effort to curb traffic congestion and pollution levels, local governments are restricting the movement of commercial vehicles in city centers. At the same time, urbanization leads to a continuous increase in the demand for goods to be delivered to inner city areas. The explosive growth of e-commerce is changing consumer buying preferences, and disrupting traditional, truck-based delivery services. In the near future, improving technology will only add to the demand for delivery in densely-packed city centers as more and more vendors invest in mobile commerce and omni-channel retail strategies. These changes put a premium on innovative distribution models and optimally designed last-mile distribution networks that are efficient, flexible, and resilient. The new emphasis is on multi-tier systems that leverage the concept of transshipment and employ different combinations of transportation modes and technologies. We support companies in designing such networks, understanding their performance trade-offs, and implementing innovative delivery models with the help of mathematical network optimization and simulation models.

Urban Logistics Big Data Analytics

Companies collect tens of thousands of data elements every day from a variety of systems and sensors in their logistics operations. Often, this data is archived and not used to improve or redesign their last-mile activities. Leveraging recent advances in data analytics, mobile computing, and low-cost sensor technology, we are developing and prototyping new algorithms that process GPS and cellphone traces to extract information on congestion, stop times, and route choices. Our data analytics tools create high-resolution visibility of companies' last-mile delivery processes and performance. When we combine geospatial with transactional datasets, our tools enable companies to extract value from their data by learning from it to improve the strategic design, operational planning, and daily execution of their last-mile operations.

Engage

Please contact Dr. Matthias Winkenbach (mwinkenb@mit.edu) or visit **http://megacitylab.mit.edu** for more information. We are looking for industry or government partners to engage with us on:

- City-Level GPS, cellphone CDR, and/or transactional datasets for analysis and algorithm development.
- Case studies to design future last-mile delivery networks in large urban areas, optimize their performance in terms of cost, service level, CO_2 footprint, etc.
- Case studies to develop interactive decision support tools to simulate and visualize delivery network performance under uncertainty of demand, traffic, etc.
- Experiments to pilot and evaluate urban freight policies and practices.
- Funding for open source tool development, including the City Logistics Toolkit.

Partnership

Corporate Partners

- **47** Supply Chain Exchange Partners
- **5** Strategic Partners: BASF, Intel, Procter & Gamble, Starbucks, and UPS

Supply Chain Exchange Events, March 2015-March 2016

- **March 25, 2015:** *Crossroads 2015* focused on innovations that are driving another decade of revolutionary change in the supply chain world. The conference featured experts from MIT speaking about the technologies that will likely impact supply chain management in the future.
- **March 26, 2015:** The *6th Annual Partners Meeting* convened key contacts from MIT CTL's partner companies for a review of research and customer feedback and input sessions.
- **May 12, 2015:** *End to End Visibility* Roundtable
- **May 22, 2015:** *Research Fest 2015* of student thesis final presentations
- **June 9-12, 2015:** Executive Education course, *Supply Chain Management: Driving Strategic Advantage*
- **October 27-28, 2015:** *Supply Chain Finance* Workshop
- **October 28-29, 2015:** *Quantifying Resilience* Roundtable
- **November 3, 2015:** *The Race to Trace: Integrating Profits, Planet, and Precaution* Roundtable
- **December 2-3, 2015:** *Innovation Summit* hosted by Flex
- **January 19-22, 2016:** Executive Education course, *Supply Chain Management: Driving Strategic Advantage*
- **January 20, 2016:** *Research Expo 2016*. Over 100 students from all MIT SCALE Network programs (MIT CTL, ZLC, CLI, and MISI) presented over 60 thesis projects to sponsoring companies.

Hosted Speakers

- **Jay H. Walder**, President & CEO, Motivate
- **Chris Jephson**, Director of Learning, formerly of Maersk Line
- **Wendy Landman**, Executive Director of WalkBoston
- **Brent Beabout**, Senior Vice President, Walmart.com
- **Ralf Busche**, Head of Supply Chain Management, BASF SE
- **Matthew Winterman**, Senior Vice President, Supply Chain Strategy, GlaxoSmithKline
- **David Wheeler**, Senior Vice President of Global Supply Chain, Cintas Corporation
- **Yannis Skoufalos**, Global Product Supply Officer, Procter & Gamble
- **Tony Milikin**, Chief Procurement Office, AB-Inbev
- **Jeffrey Dorko**, Assistant Administrator and Head of Logistics, FEMA
- **Paola Corrado**, Head of Logistics for Ethiopia, UN World Food Programme
- **Steve Sensing**, President of Global Supply Chain Solutions, Ryder
- **Jim Barch**, Director of Research and Development, Seventh Generation

Executive Summits

Supply Chain Sustainability at Procter & Gamble

The Procter & Gamble Company generously hosted thirty Supply Chain Exchange Partners on January 12-13, 2015 in Cincinnati, Ohio for an exceptional company introduction and Sustainability Roundtable discussion. The event started with an overview of the P&G Corporate Sustainability Vision, a tour of the archives, and a demonstration of P&G's Children's Safe Drinking Water Program. The day ended with a fantastic evening dinner and program at The Cincinnati Zoo, recently voted the greenest zoo in America.

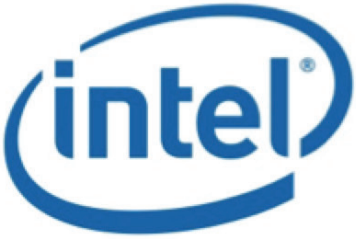
The Sustainability Roundtable kicked off the next morning with an introduction by MIT CTL researcher Dr. Edgar Blanco, and five session topics were considered throughout the day. Virgine Helias of P&G, Eunice Heath of Dow, Dirk Hopmann of BASF, and Rhonda Clark of UPS each provided an introduction to one of the sessions, making for a rich and productive event.

Supply Chain Innovation at Flex

The third MIT CTL Senior Executive Summit was hosted by Flex in December 2-3, 2015, in Silicon Valley. The theme of this summit was Supply Chain Innovation. The first day included an introduction by Flex CEO Mike McNamara and a tour of the Flextronics Innovation Center, Lab IX Accelerator, and Pulse Center. The day was capped off with a special dinner at Flex Headquarters, created by their in-house executive chef.

The next day, the Innovation Summit was kicked off by MIT CTL Deputy Director Jim Rice and featured presentations from Gordon Downes – Founder & CEO, New York Shipping Exchange; Mani Janakiram Director, Supply Chain Strategy, Intel Corporation; and Frank Perez – VP Engineering, Global Logistics & Distribution, UPS Supply Chain Solutions.


BASF
The Chemical Company


intel

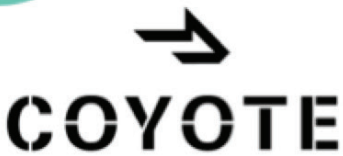

ABInBev


ARMADA
There's a better way.


B2W
DIGITAL


C.H. ROBINSON


CINTAS
THE SERVICE PROFESSIONALS


COYOTE


DELHAIZE


DOW
Dow AgroSciences


evergreen
packaging


GOODYEAR


GENERAL MILLS


LOJAS AMERICANAS


Johnson&Johnson


MICHELIN


OnProcess
TECHNOLOGY


PBC


niagara
TASTE THE PURE DIFFERENCE!


TJX
THE TJX COMPANIES, INC.


Unilever


P&G
ups
BNSF RAILWAY
CardinalHealth
CAT Logistics
CSX TRANSPORTATION
CVS CAREMARK
DAMCO
DELL
FedEx
flex LIVE SMARTER
Genentech IN BUSINESS FOR LIFE
gsk GlaxoSmithKline
HERSHEY'S
Johnson Controls
MHI
Matson
MAERSK
Ryder
Schlumberger
Verisk Analytics
Walmart Save money. Live better.
UNITED STATES TRANSPORTATION COMMAND
WEFT

Education

The MIT Supply Chain Management Program

Class of 2015

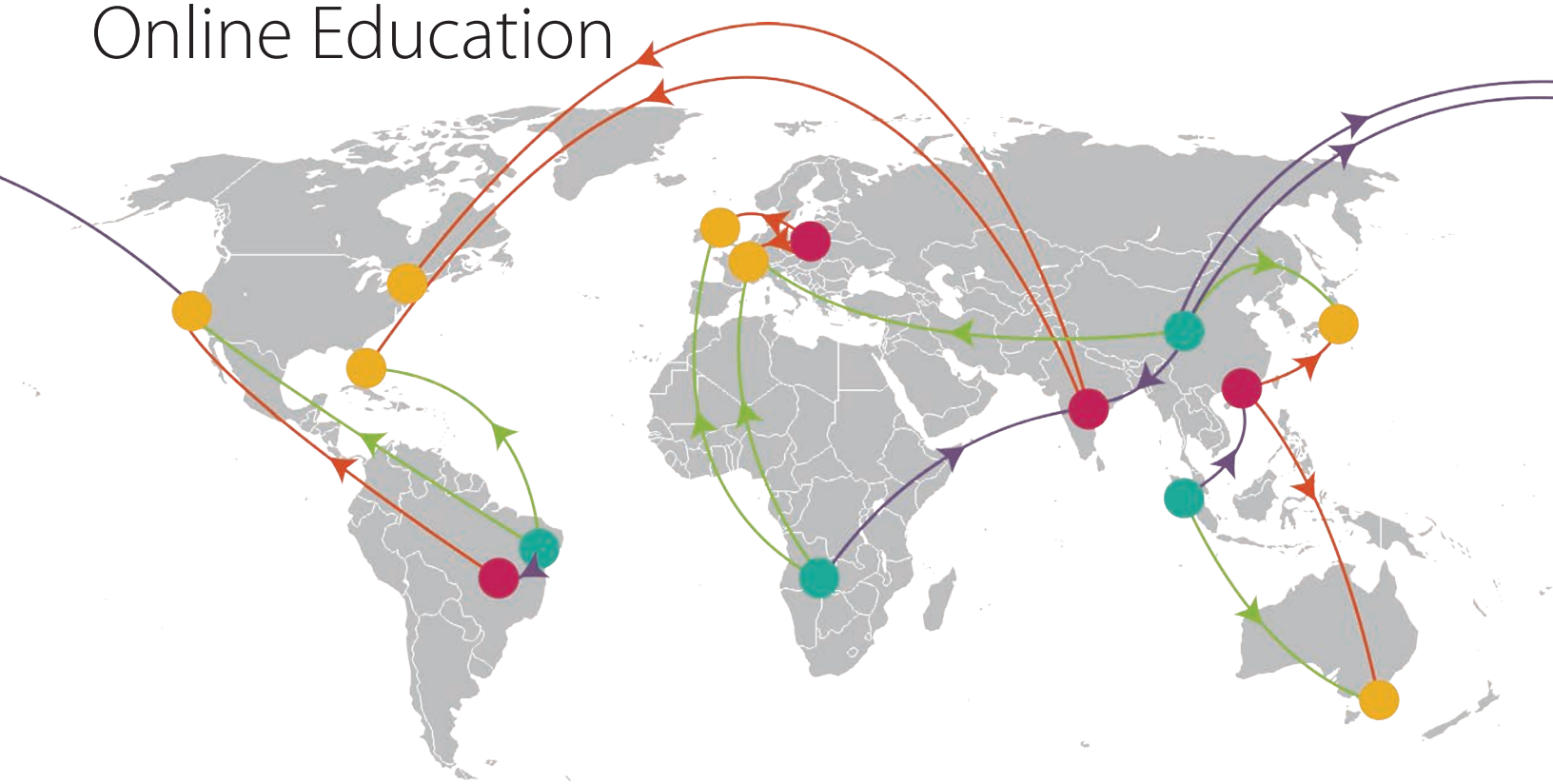
40	Students
20	Countries
22%	Female
78%	Male
60+	Companies recruiting (March 2015)
60%	Have 1 or more job offers (March 2015)
19	Thesis Research Partners

Class of 2016

35	Students
13	Countries
43%	Female
57%	Male
60+	Companies recruiting (March 2016)
64%	Have 1 or more job offers (March 2016)
21	Thesis Research Partners

To learn more, please visit **http://scm.mit.edu**

Online Education



On October 7, 2015, MIT President Rafael Reif announced the launch of the MIT MicroMaster's Credential in Supply Chain Management. This is a new educational certification program that offers learners from around the world a brand new way to gain and demonstrate expertise in the growing field of Supply Chain Management.

The MicroMaster's Credential in Supply Chain Management consists of five online courses covering a wide range of supply chain areas:

- CTL.SC0x - Supply Chain Analytics
- CTL.SC1x - Supply Chain Fundamentals
- CTL.SC2x - Supply Chain Design
- CTL.SC3x - Supply Chain Dynamics
- CTL.SC4x - Supply Chain Technology

Students who successfully complete all five courses are invited to take a Final Capstone exam in order to earn the MicroMaster's Credential. As opposed to other programs, there is no formal enrollment in or admissions criteria for the MicroMaster's Credential. A student only needs Internet access and the dedication to complete the work! MIT CTL is leading the democratization of education—specifically in the supply chain space.

Additionally, students earning the MicroMaster's Credential have the opportunity to apply those credits to earn a Master's Degree at MIT through the Blended Supply Chain Management Master's Program that last just 5 months at MIT. This is the first time MIT has ever awarded credit for an online course. We expect our first class of Blended SCM students in January 2018.

The response for the online courses has been overwhelming so far. As of the end of February 2016, we have had over 70,000 students from over 176 countries register for our courses. Over 4,000 successful certificates have been awarded for various courses over the last 18 months. To put this in perspective, the MIT SCM program graduates between 30 and 40 students per year—so this is over 100 years worth of students!

To learn more, please visit **http://scm.mit.edu/micromasters**


Sarah
Pankaj
Susan
Manish

Executive Education

June 2015-Jan 2016 Attendees

- **June 2015:** 51 attendees
- **Jan 2016:** 32 attendees

Supply Chain Executive Education

Every January and June for the past several years, MIT CTL has delivered supply chain and logistics-focused education and research to executives through our popular executive education course, *Supply Chain Management: Driving Strategic Advantage*. This intensive four-day course features a comprehensive array of management simulations and case studies, interactive lectures and discussion sessions, and presentations by distinguished lecturers and MIT CTL faculty. What's even better than that? Every Supply Chain Exchange partner company is given one complimentary seat to this course every year as well as options for larger group discounts.

Interested in learning more? Visit **http://ctl.mit.edu/execed**

Custom Courses

MIT CTL regularly partners with organizations to provide customized executive education experiences to individual enterprises and consortia. Custom courses give organizations the opportunity to direct intensive efforts at specific issues crucial to their company goals, such as business continuity strategy, scenario planning, and competitive alignment.

If you're interested in having MIT CTL design a custom education course for your organization, please reach out to **Jim Rice, Deputy Director,** at **jrice@mit.edu**.

Blended Customer Executive Education Courses

NEW IN 2016: MIT CTL is the first center at MIT to offer a blended Executive Education course to our Supply Chain Exchange partner companies.

What is a blended course? We're taking the innovative approach of allowing students to conduct a portion of their work online prior to the beginning of the in-person class. This enables all students to start the course with a common knowledge base, allowing them to get more out of their learning experience and communicate better with their peers. The digital component is developed closely with your company and then made available to students prior to the course. Facilitators are able to track student progress and address gaps prior to the live portion of the course.

Custom blended courses can be created around a variety different supply chain topics, for example:

- Forecasting
- Inventory
- Transportation
- Network Design
- Finance
- Sourcing
- Planning
- Demand Management
- Process & Organizational Design

Plans are underway to incorporate this learning tool into future workshops and our standard Executive Education Course. If you are interested in our blended custom offerings, please reach out to **Jim Rice at jrice@mit.edu**.

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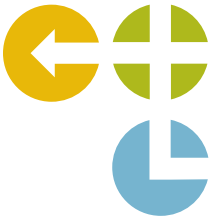

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