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Introduction

Welcome to the 2010 Master of Engineering in Logistics (MLOG) Research Journal!

The six projects included in this journal were selected from twenty-two projects submitted by the MLOG Class of 2010 at the Massachusetts Institute of Technology. The articles are written as executive summaries of the master’s thesis and are intended for a business, rather than academic, audience. The purpose of the executive summaries is to give the reader a sense of the business problem being addressed, the methods used to analyze the problem, the relevant results and the insights gained. The complete theses are, of course, much more detailed.

The articles included in this publication cover a wide selection of interests, approaches, and industries. These projects were developed in partnership with companies ranging from an early stage startup like XL Hybrids to the world’s largest retailer Walmart. The topics address traditional areas such as transportation, inventory management, and production planning; but they often address novel questions such as how traffic patterns and driver behavior drive deviation from delivery plans, how inventory policy affects shrinkage of perishable produce, and how to produce a product mix that improves your customers’ financial results. One article focuses on the broader objective of environmental and social sustainability.

We’ve also included a complete list of this year’s MLOG theses with short descriptions at the end of this journal. You can view executive summaries of all theses on the MIT Center for Transportation & Logistics (CTL) website: http://ctl.mit.edu/pubs.

The 9-month MLOG 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. The class size is limited each year to 30-40 students from around the globe and across all industries. The thesis project integrates knowledge from students’ coursework and enables students to pursue ideas in greater depth. The projects described in this journal reflect the variety of opportunities available to MLOG students. Most of the projects are conducted in conjunction with a sponsoring company through the MIT Supply Chain Education Partners program.

I hope you enjoy the articles. If you wish to discuss any other aspect of the program or wish to find out how your company can interact with students, please do not hesitate to contact me directly.

Happy reading!

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Analysis of Demand Variability and Robustness in Strategic Transportation

By Ahmedali Lokhandwala
Thesis Advisor: Dr. Chris Caplice

Summary: This project incorporates demand variability in the creation of a long-term transportation planning process for Wal-Mart Stores Inc. Using a combination of stochastic metrics and simple heuristics, the analysis proposes a robust operations strategy that is easy to execute on a weekly basis, is capable of handling demand uncertainty over the distribution network, and is cost-effective.

KEY INSIGHTS
1. Demand variability is a critical aspect that needs to be addressed while creating a transportation strategy.
2. A robust long-term transportation plan should incorporate the trade-off between cost savings and ease of execution at an operational level.
3. Stochastic methods and simple heuristics can be effectively used to create a robust planning strategy that is close to the optimal solution.

Introduction
Trucking plays a pivotal role in the US economy, hauling 68.9% of all freight transported and generating $660 billion in revenue during 2008. All private and for-hire carriers within this industry are faced with the fundamental task of anticipating shipping requirements and creating a strategic transportation policy to fulfill customer needs at the lowest cost, while ensuring a high level of service quality. This transportation policy dictates the firm’s long-term decisions, such as fleet acquisition, infrastructure development, and hiring of drivers; it also lays down the framework for short-term decision making, such as allocating fleet capacity to optimal tours and developing relationships with for-hire carriers for certain lanes. Hence, it is crucial that the long-term plans are in alignment with the actual execution strategy.

Motivation
In the creation of such a plan, however, we are faced with two fundamental challenges:

1. Demand variability: Addressing the uncertainty associated with demand occurrence over transportation lanes creates a gap between planned strategy and execution.
2. Ease of execution: It is important that the operational strategy dictated by the long-term plans be easy to execute by the floor-level managers. Complex plans that are difficult to execute in practice create a further gap between planned strategy and execution.

Large-Scale Optimization Model
In order to address these challenges, the project followed a two-pronged approach. The first part involved creation of a large-scale optimization model that addresses the demand variability on transportation lanes within a network using past lane demand information. Led by Dr. Francisco Jauffred, the Freight Lab team at MIT CTL has created a Freight Network Optimization Tool (FNOT). FNOT uses stochastic methods for allocating the loads occurring on a transportation lane to an optimal mix of private fleet and for-hire carriers. This optimal mix is calculated based on the costs associated with hauling a load on the private fleet versus for-hire carrier costs, using a modification of the Newsvendor model. For the loads allocated to the private fleet, FNOT also decides the optimal routing for the trucks in the form of tours.

Using this methodology, FNOT optimally allocates all weekly expected demand over the distribution network to create a planning strategy. However, a limitation associated with FNOT is that it is a steady state model. This means that, based on the lane demand information available, it can optimize the allocation of loads on a weekly basis. However, in reality, it would be impractical to have the operational flexibility of re-optimizing the distribution network on a weekly basis, since it would
introduce much more complexity during weekly execution. Hence, we need a robust planning strategy that would incorporate the variability within the network and at the same time have minimal operational flexibility.

**Weekly Operations Scenarios**

In order to test the robustness of the planning strategy proposed by FNOT, it is critical to analyze its performance in the presence of randomly occurring weekly demands. If we can prove that the proposed weekly plan created from FNOT can be repeated week after week without major changes and is close to optimality in terms of costs, we can overcome the deficiencies of the existing models. This brings us to the second part of the research—which involves testing the plan proposed by FNOT in an operational scenario. This is done using the hierarchy shown in Figure 1.

As seen in Figure 1, long-term annual planning can be carried out using either stochastic or deterministic methods. Deterministic planning strategies are unable to handle demand variability and thus are not addressed in this thesis. As mentioned earlier, FNOT provides us with a stochastic annual plan with which we shall be working.

In order to analyze the performance of the stochastic plan in real time, we need to simulate random weekly demands over the lanes within the network through a combination of historical demand information over the lanes and Monte Carlo simulations. The random demands are generated for a 52-week period for all the lanes within the network.

1. **Complete Operational Flexibility**: In this case, the volume allocation over the network is re-optimized every week, giving us the best possible assignments on a weekly basis.

2. **Zero Operational Flexibility**: In this case, the weekly demand occurring over the network is expected to be fulfilled by only using the tours proposed by the stochastic plan. Remaining demand goes to for-hire carriers. The potential tours are ranked with respect to the empty percentage miles in order to assign the best tours with the most volume. The demand assignment to tours can be carried out in two ways:
   a. **Minimum Volume Assignment**: The minimum demand occurring over the lanes comprising a tour is assigned as tour volume. Excess demand is assigned to for-hire carriers.
   b. **Maximum Volume Assignment**: The maximum demand occurring over the lanes comprising a tour is assigned as tour volume. Excess demand is assigned to for-hire carriers.

The volume assignment can be explained graphically using the sample tour shown in Figure 2.

Using the aforementioned methodologies, we have created three different operational plans that can be analyzed for their performance across a variety of metrics at various levels of aggregation.

**Analysis of Weekly Operations Scenarios**

The main purpose of the analysis is to compare the scenarios generated at varying levels of network aggregation to see if the stochastic plan executed under a zero flexibility environment is robust enough to provide a near-optimal solution on a weekly basis. This comparison is carried out at various levels using the metrics shown in Figure 3.

An analysis of Network Level statistics indicate that the Minimum Volume Assignment scenario, despite having minimal operational freedom, is very close to the Complete Flexibility operations in terms of total costs.
Additionally, the standard deviation on most of the metrics for the Minimum Volume Assignment case is smaller, indicating a tighter bound on weekly operations. The Facility Level metrics also mirror the behavior observed at the Network Level, which indicates that there is no loss of generality in the behavior of metrics.

While performing the Tour Level Analysis, we compare the occurrence of tours proposed by the stochastic plan to the ones that occur in the Complete Flexibility operations. We notice three important factors that are critical to proving robustness:

Out of all the tours generated on a weekly basis during complete flexibility operations, only 10% are consistent in nature (Figure 4).

Out of these consistent tours, 91% are present within the stochastic plan proposed by FNOT (Figure 5).

Out of the weekly tours generated in the complete flexibility operations, 71% are part of FNOT’s stochastic plan (Figure 6).

Additionally, the Lane Level Metrics also portray some interesting results. Overall, it is seen from Figures 7 and 8 that most of the inbound lanes are consistently assigned to for-hire carriers, since outbound loads are inconsistent in nature. On the other hand, most outbound lanes are consistently assigned to the private fleet, since volume on these lanes is consistent. This is a generic characteristic of any retail network, and the variability associated with it is well captured through our model.
Figure 8: Behavior of Lanes Assigned to For-Hire Carriers

Conclusions
Thus, the analysis has shown that the stochastic plan created by FNOT can effectively handle demand variability. Through the use of simulations, it is proven that the Minimum Volume Assignment scenario is operationally viable, since:

- It handles 71% of demand variability
- It is easy to execute, since it requires zero operational flexibility on a weekly basis
- It is within 6% of the optimal cost solution

Providing an easy-to-handle planning module that does not need much ad-hoc decision making can reduce the chances of suboptimal localized decisions and can maintain the network at close to system-optimal levels. This directly translates into lowering the gap between the expected transportation costs proposed by the strategic plan and the actual costs incurred during execution.
Aftermarket Vehicle Hybridization: Designing a Supply Network for a Startup Company

By Marcus Causton and Jianmin Wu
Thesis Advisor: Dr. Jarrod Goentzel

Summary: We develop models for XL Hybrids, a startup company that hybridizes aftermarket vehicles, to plan four aspects of their supply chain: production scheduling, capacity planning, inventory policy, and component distribution. In addition, we recommend strategies for capacity expansion and strategic sourcing for key components, while distilling supply chain strategies that can be applied to other startup companies.

Introduction
Planning a supply chain strategy for a company involves considerations such as sourcing, distribution, demand forecasting, and capacity planning. Supply chain planning for a startup company has similar complexities to those of established companies—with the added challenges of demand uncertainty, as well as financial and human resource constraints. Typically, companies do not comprehensively think about supply chain issues at the startup stage due to resource limitations, something that can hurt a startup company’s chances of success. However, we show that by implementing supply chain management strategies early on, startups can conserve cash, better cope with uncertain demand, proactively determine outsourcing strategies, and maximize internal resources to increase the likelihood of company success.

We worked with XL Hybrids, a new company that converts low-MPG commercial vehicles into fuel-efficient hybrids. We developed models to help plan four aspects of the company’s supply chain:

1. Production planning
2. Capacity expansion
3. Component sourcing
4. Distribution

Our models focused on the three most important and highest cost components from XL Hybrids’ hybrid conversion product: the battery, the controller, and the electric motor.

Furthermore, due to a lack of research publications and articles on the subject of supply chain planning for...
startups, we have developed a supply chain framework for startup companies based on lessons learned from our work with XL Hybrids.

Production Planning
Production planning converts any company’s sales or orders into an operations schedule. For XL Hybrids, we used Microsoft® Excel with Risk-Solver Platform Add-in to construct a mixed integer linear program that optimizes a production schedule from a set of forecasted sales. The objective was to minimize XL Hybrids’ costs of adding capacity, maintaining capacity, and postponing conversions. Adding capacity entails capital costs, such as those to open up a facility. Maintaining capacity involves paying for the maintenance of a facility and the labor cost of its employees. Postponing conversions is a service cost which is incurred when the conversion is performed after the customer order due date.

The output from the model is a production schedule which lists the number of vehicles that XL Hybrids needs to convert each month. This schedule smooths out any fluctuations found in the sales order. Figure 1 shows the optimized production plan for one of XL Hybrids’ demand scenarios.

Capacity Expansion
Capacity expansion for any company entails determining how and when to increase capacity. For XL Hybrids, we used Microsoft Excel with Risk Solver Platform Add-in to construct a mixed integer linear program that optimizes for the least expensive capacity expansion schedule based on the production plan optimized in our production planning model. Our capacity expansion model looks at four different methods that XL Hybrids has to increase capacity:

1. Increase hours of operation by adding shifts.
2. Expand the current facility by adding bay(s). Bays are stations that allow technicians to work on vehicle conversions.
3. Open a new conversion facility.
4. Add a mobile van team that does vehicle conversions at the customer’s site.

All four methods add capacity in different increments, and have varying capital and operating costs. They are also subject to different constraints. For example, there can be no more than three bays per XL Hybrids facility, because each conversion center has finite space. The output lists the type of capacity, as well as the month and year that it should be added.

Figure 2 shows how the model optimizes for the capaci-
ity expansion method based on the production schedule from Figure 1. The x-axis on Figure 2 shows the date, and the quantity of each capacity type is reflected on the y-axis. For example, in April 2011, one shift needs to be added to bring the number of active shifts from one to two. This model is used in conjunction with the production planning model.

Component Sourcing and Distribution

Component sourcing for any company requires an understanding of what to source, who to source from, and how large a quantity is sourced. Distribution for any company involves knowing how the components move from the supplier to the customer. For XL Hybrids, we developed a simulation model using Microsoft Excel to determine the optimal order quantity and the total relevant landed cost for procurement, and to decide between warehousing and transshipment for distributing components to the conversion centers. Total relevant landed cost includes costs associated with volume discounts, transportation, storage, inventory holding, and cost of capital.

Warehousing aggregates the three components at a central stocking point before being distributed to the different branches of XL Hybrids when needed. Transshipment splits the shipment of components at the port and routes them to the XL Hybrids conversion centers. Our model simulates warehousing and transshipment scenarios when the following four variables are changed: distribution method, order quantity, monthly demand, and number of active conversion centers. Given a demand forecast, the model is then able to determine the optimal order quantity and distribution method for each time period. Due to significant savings from volume discounts, our model recommends that XL Hybrids order in large quantities.

For our model, we limited the order quantity to a maximum of three months worth of demand. Figure 3 shows how the total relevant landed cost and order quantity/frequency changes for one demand scenario: As the demand increases, the optimal order quantity also increases, which reduces the total relevant cost of a unit. The optimal order quantity maxes out at 500 units for this demand scenario, since maximum volume discounts have been achieved. Our model also recommended that XL Hybrids begin with transshipment but quickly switch to warehousing, because this is the more cost-effective option at higher volumes and also allows XL Hybrids to focus on its core operations of converting vehicles rather than managing time-intensive transshipment-related tasks.

We also used the model to simulate individual and annual volume discount order contracts. Individual volume discounts are where volume discounts are negotiated based on the volume required for each order, while annual volume discounts means that volume discounts are negotiated based on an annual volume commitment. This comparison was done to quantify the benefits of negotiating annual volume discount contracts over existing individual volume discount order contracts. Figure 4 shows the yearly cost savings attainable for a demand scenario.

Our results show that an annual volume discount contract allows XL Hybrids to move toward a Just-In-Time (JIT) system due to increased order frequency. How-
Even if the responsibilities are outsourced, startups still need to think about supply chain concepts, as these concepts will impact fundraising, hiring, expansion, and sourcing decisions.

Generally, we recommend that startup companies need to keep their supply chain plans flexible, because startups face greater financial and human resource constraints, and have greater uncertainty in demand. Startups should also identify lever points in their long-term plan so that they know how and when to expand capacity, switch distribution methods, or change suppliers.

From our work with XL Hybrids, we have identified the following management insights for how a startup company should plan its supply chain.

**Production Planning and Capacity Expansion:**
- Use production planning models to understand how operations will run and thus be able to plan capacity expansion and maximize utilization of resources. Capacity planning models allow startups to understand when additional funding is needed for capacity expansion.

- Use models to identify and assess all costs associated with increasing capacity, maintaining capacity, holding inventory, and postponing production. Comparing the various types of capacity expansion options is necessary to determine a cost-efficient approach to increase capacity aligned with the company strategy.

- Be conservative and plan for a shorter time horizon when expanding capacity to avoid overcapacity if sales fall short of projections.

**Component Sourcing and Distribution:**
- Balance between economies of scale of ordering in large quantities versus business risk and having cash tied up in inventory.

- Determine when it is optimal to switch the distribution network and plan for the change.

- Determine whether and when to open the business to multiple suppliers via an RFP process. Startups usually begin with a smaller, more expensive, but more responsive supplier. However, as they grow, they should consider engaging more suppliers to yield cost savings as well as to reduce redundancy.

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**Figure 5: Supply Chain Framework for Startup Companies**

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ever, by Year 3, the order frequencies for both contracts start to converge, and cost savings become negligible. Hence, XL Hybrids can consider sourcing for suppliers through a Request for Proposal (RFP) process, as there are no longer any benefits in having an annual contract with the first supplier.
Multi-Echelon Inventory Management for a Fresh Produce Retail Supply Chain

By Thomas Hsien and Yogeshwar D. Suryawanshi
Thesis Advisor: Dr. Amanda Schmitt

Summary: Chiquita, a fresh produce distributor with a multi-echelon supply chain, wants to develop an optimal inventory policy that results in the lowest inventory costs, while maintaining 95% service levels at each echelon. We developed a simulation model to determine the optimal inventory policy. The model’s input parameters include inventory holding costs, shrinkage costs, lost sales costs, forecast accuracy, and service levels. After using the model to determine the optimal inventory policy, we tested the sensitivity of the multi-echelon supply chain under the optimal policy with respect to forecast errors and transportation lead time.

Introduction
Perishability presents a challenging problem in inventory management for the fresh produce industry, since it can lead to higher inventory costs and lower service levels. If a supply chain has multiple echelons, that further complicates the issue, because companies have an added risk of not having the right amount of product at the right location at the right time. Additionally, the volatile demand of the fresh produce products at the retail level makes the issue even more challenging.

Developing better order and inventory policies requires an understanding of the impacts of the product’s limited lifetime, the interactions of multiple inventory locations, and the trade-off between the relevant costs and the customer service levels.

We conducted our research on one of Chiquita’s Fresh Express supply chains. Using Arena® simulation software, we developed a simulation model to analyze the impact of perishability on total relevant costs. Our research focused on determining the optimal inventory policy for the multi-echelon system considering inventory holding costs, shrinkage costs, lost sales costs, forecast accuracy, and service levels. We tested the sensitivity of the system under the optimal policy with respect to forecast errors and transportation lead time. Due to confidentiality concerns, all the numbers used throughout the thesis are for illustrative purposes only and are not necessarily indicative of actual performance at Chiquita.

KEY INSIGHTS
1. Lowering the target on-hand inventory levels at the distribution center and retail stores to 0.5 and 1.5 days, respectively, reduces total relevant cost for the system by 31% and maintains high service levels above the required 95%.
2. The multi-echelon supply chain under the optimal policy is sensitive to forecast errors. Total relevant cost for the system is more sensitive to forecast errors at the distribution center, while item fill rates are more sensitive to forecast errors at the retail stores.
3. Chiquita should continue to minimize transportation lead time from the plant to the distribution center to maximize the product’s available lifetime and reduce shrinkage.

Research Objective
The objective of our research was to develop an inventory policy that minimizes costs for the system, while maintaining high customer service levels at each echelon. The research answered the following three questions posed by Chiquita:
In our simulation model, we made the following assumptions: no raw material shortage or capacity constraints at the plant; stochastic and normally distributed demand; First-in-First-out policy at the DC and retail stores; transportation lead time from the DC to retail stores is always one day; and transportation lead time from the plant to the DC is deterministic and constant for each simulation.

In our simulation model, we considered the following input parameters: target days on-hand (DOH) inventory level, shrinkage probability for each day (up to 14 days), forecast error, product unit cost, lost sales cost, inventory holding cost, shrinkage cost, transportation lead time, and production lead time.

Figure 2 shows how the input parameters are used in the model and the flow of information in the supply chain. We generated the random daily demands for each retail store using the mean and standard deviation obtained from the Point-of-Sale data. We then applied the forecast error to this demand and errantly obtained the demand forecast. The demand forecast was used to calculate the order up to level (OUL) for each retail store. For the DC, the daily demand was obtained by aggregating individual orders from each retail store. The forecast error was applied to this aggregated demand from the retail stores to obtain the demand forecast. The order quantity for each echelon was determined by comparing the OUL with its inventory position.

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Additionally, our review of academic literature on inventory management for perishable products and discussion with Chiquita’s supply chain managers showed that none of the analytical methods existed in the literature could produce the shrinkage profile experienced by Chiquita in reality. We determined that shrinkage probabilities experienced by Chiquita in reality are best fit by an exponential growth model. This means that even for
products that are less than 14 days old, an exponentially increasing fraction of inventory is discarded at the end of each day due to perishability. We used Microsoft® Excel Solver to obtain these exponentially growing shrinkage probabilities. Then, we ran the simulation for the base scenario with these shrinkage probabilities and validated that these probabilities indeed produce aggregated total shrinkage volume at the retail stores within the valid range observed by Chiquita.

Simulation Results
After we verified and validated our simulation model, we conducted tests to determine how different target DOH inventory levels at the DC and retail stores would impact total relevant costs and service levels. We tested ten different target on-hand inventory levels in increments of ½-integer values for the DC and retail stores, respectively, a total combination of 90 different scenarios. We tested increments of ½-integer values, because those are the smallest possible increments with which Chiquita operates. For each scenario, we conducted the simulation for 20 replications, and each replication consisting of 365 days.

The results of simulations show that lowering the target on-hand inventory levels at the DC and retail stores to 0.5 and 1.5 days, respectively, reduces total relevant costs by 31% and maintains high customer service levels above the required customer service level of 95% at each echelon. The optimal inventory policy improves the IFR at the DC from 91.74% to 95.24%, while the IFR at the retail stores decreases from 99% to 97%. Although the IFR at the retail stores decreases by approximately 2%, 97% is still considered a high customer service level. The 31% cost savings are significant enough for Chiquita and the retail stores to consider replacing the current inventory policy with the optimal inventory policy obtained through our re-

![Figure 2: Information Flow in the Model](image-url)
becomes less accurate and the shrinkage volume at the DC increases as DC’s forecast accuracy deteriorates. This affects the availability of the inventory at the DC and hence its ability to fulfill orders received from the retail stores.

For the DC’s forecast error less than 25%, the inventory level at the DC is reduced. However, retail stores still have their own forecast error, so they tend to order more from the DC. Thus, the IFR at the DC deteriorates because the retail stores order more than they need, suggesting the presence of the bullwhip phenomenon.

Sensitivity Analysis

We tested the sensitivity of the multi-echelon system under the optimal inventory policy with respect to forecast error at the DC, forecast error at the retail stores, and transportation lead time from the plant to the DC.

As illustrated in Figures 3 and 4 below, the total relevant cost in the system is more sensitive to the forecast errors at the DC than to the forecast error at the retail stores. The current forecast error at the DC and retail stores is 25%. The sensitivity analysis reveals that increasing the forecast accuracy at the DC by 20% would reduce total relevant costs in the system by 16%. Increasing the forecast accuracy by 20% at the retail stores would reduce the total relevant costs in the system by 7%.

Figures 5 and 6 show that the IFR at the DC is more sensitive to the forecast error than to the IFR at the retail stores. The IFRs at both the DC and the retail stores decrease as the DC’s forecast accuracy deteriorates beyond 25%. This occurs because the OUL for the DC, which is dependent upon the DC’s forecast,
relevant cost of the system increases. Additionally, improving the forecast accuracy at the DC alone may not sufficiently address the issue, because the DC’s inventory is ultimately impacted by the orders and forecasts created by the retail stores. The IFR at the DC is more sensitive to the forecast error at the retail stores than to the DC’s forecast error. To maximize the cost savings and improve the performance of the whole system, we recommend that Chiquita work with the retail stores to simultaneously improve the forecast accuracy at both the DC and the retail stores.

The system is sensitive to the transportation lead time, since it directly impacts the lifetime of the products at the DC and at the retail stores. Our model demonstrates that as the transportation lead time increases, the shrinkage in the system significantly increases. This further results in increased lost sales at the retail stores and reduced IFR at the retail stores and the DC. Since the system is sensitive to the transportation lead time, Chiquita should continue to keep the transportation lead time as short as possible to maximize the products’ available lifetime at the DC and the retail stores.

Conclusions
We concluded that for multi-echelon perishable inventory management problems, simulation can be extremely helpful. Our research demonstrated that simulation modeling can quantify various trade-offs involved in making inventory management decisions for perishable products. It is extremely valuable to simulate reality and test the sensitivity of the system before managers make their decisions. Simulation modeling can lead to optimal solutions that would significantly reduce the system costs, while significantly improving the system performance.

Our research not only answered the three key questions originally posed by Chiquita, but also provided a simulation model that enables Chiquita to analyze different scenarios in order to make effective strategic decisions for its multi-echelon supply chains.
Incorporating Traffic Patterns to Improve Delivery Performance

By Melody J. Dickinson and Jillian Y. Leifer
Thesis Advisor: Dr. Jarrod Goentzel

Summary: Evidence suggests that incorporating travel time data in route plan development produces improved solutions compared to standard, deterministic approaches. A holistic approach was used to evaluate the delivery process, determine why differences exist between route planning methods, examine the impact of drivers’ actions, and consider opportunities for further exploration.

KEY INSIGHTS
1. Vehicle routing technology can be improved by utilizing a new data set based on historical travel speeds to more accurately predict expected travel time.
2. When comparing historical travel speeds to deterministic travel speeds, it is easy to see where and when the existing model can be improved. It may also encourage drivers to buy into a new system by offering travel shortcuts.
3. Using onboard tracking devices provides a second way to uncover travel time model flaws.

Introduction
Traffic, construction, and road hazards impact the performance of delivery fleets. Impediments to on-time performance are frequently treated as being beyond one’s control. However, some impediments to traffic flow are regular occurrences that have measurable effects. Our research describes a method for incorporating these measured effects into delivery operations to improve on-time performance. We demonstrate how using historical travel data compares with standard, deterministic methods by exploring the impact on both planning and overall delivery efficiency.
customers, drivers are also responsible for merchandising. This entails stocking the shelves and ensuring the customer is satisfied with the service. If a driver is running late, merchandising suffers and so does the customer relationship. Unsatisfied customers may switch to a competitor, resulting in lost sales. Therefore, ensuring on-time delivery is a pressing operational aim for BevCo.

For the past three years, the CarTel group within the Computer Science and Artificial Intelligence Laboratory (CSAIL) at the Massachusetts Institute of Technology (MIT) has been compiling measurements of travel times in coordination with a private livery fleet in the Greater Boston Metropolitan area. The data has been carved into hourly time buckets from which the mean travel time for a given road segment can be calculated. This enables route planning that accounts for historical traffic patterns regardless of the cause.

Our analysis contrasts route plans developed by a common commercial routing software tool, projections using historical traffic data, and actual routes run by drivers. In addition, we explore why those differences exist, and explain how each system buffers uncertainty.

Driver Experience
BevCo relies on a combination of OptiRoute and the expertise of its front-line workforce to execute the delivery process. Drivers have some flexibility in determining when they begin their day. Some drivers arrive as early as 4:30 AM and others arrive as late as 6:30 AM. Each morning, drivers receive their route plans as generated by OptiRoute. Start times are staggered to decrease the amount of time a driver spends at the depot.

Manifest compliance is low, as few drivers follow the stop order as provided. Upon receiving the manifest, the first criterion that drivers use for determining stop order is the time window. Information on time windows originates from three sources: salespeople’s notes, an exception input to OptiRoute (i.e., deliver before noon), and drivers’ field knowledge about customers.

After the drivers get a sense of the constraints placed on the route by time windows, they sequence the stops. Wherever possible, stops located close to one another are grouped together unless it is contraindicated by a given time window. For example, a driver may begin the day by making a delivery to a large hotel, because this customer accepts deliveries at any time of day. Although other customers may be located on the same street, the driver must return later in the day, because the other customers are not yet open to receive deliveries. If drivers have difficulty executing their route, they can call the dispatch for support.

Analysis
OptiRoute estimates both driving time between customers and stop time at each customer location. Each daily route can be considered the sum of driving time and stop time. To compare the OptiRoute to CarTel, we compared estimated driving times. In addition, we compared these estimates to actual observed performance acquired through Automatic Vehicle Location (AVL) devices. These devices are connected to the truck’s on-board diagnostic system and collect information such as GPS coordinates and ignition on and off signals.

OptiRoute gives a good approximation of the total route time. This is important, as there are travel restrictions on the number of hours a driver can work each day. OptiRoute does not perform individual forecasting tasks effectively. It is a poor predictor of time spent driving and time spent servicing. Figure 1 shows the breakdown of time a driver spends driving and servicing. It can be seen that the majority of the driver’s day is spent at customer locations.

Understanding how the estimation of travel time by OptiRoute compares with the actual driving experience is critical to improving the routing process.

In order to make recommendations on underlying road travel times, we compared OptiRoute and CarTel’s time estimation for both road segments and entire routes. By looking at each route segment, a very close correlation is seen between OptiRoute and CarTel’s travel time esti-

![Figure 1: Driver activity breakdown comparing estimates made by OptiRoute with times measured by AVL](image-url)

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mations. Additionally, a regression was performed and the p-value was 0.000, confirming the statistical significance. See Figure 2 below for the graph of the segments.

Another important consideration is the influence of time of day on OptiRoute’s performance. CarTel collects and separates time estimates for road segments by each hour of the day. A comparison was made between segment travel times estimated by OptiRoute and those estimated by CarTel between 5:00 AM and 3:00 PM. Table 1 shows the R-squared values of the regressions between OptiRoute and CarTel.

<table>
<thead>
<tr>
<th>Hour</th>
<th>Count</th>
<th>R-Squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>05:00</td>
<td>50</td>
<td>0.98</td>
</tr>
<tr>
<td>06:00</td>
<td>354</td>
<td>0.98</td>
</tr>
<tr>
<td>07:00</td>
<td>399</td>
<td>0.96</td>
</tr>
<tr>
<td>08:00</td>
<td>413</td>
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<tr>
<td>09:00</td>
<td>451</td>
<td>0.90</td>
</tr>
<tr>
<td>10:00</td>
<td>460</td>
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</tr>
<tr>
<td>11:00</td>
<td>381</td>
<td>0.96</td>
</tr>
<tr>
<td>12:00</td>
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<td>0.92</td>
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<td>13:00</td>
<td>85</td>
<td>0.97</td>
</tr>
<tr>
<td>14:00</td>
<td>22</td>
<td>0.99</td>
</tr>
<tr>
<td>15:00</td>
<td>15</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Table 1: Time of Day Comparison

The most significant discrepancy between the travel time estimations of CarTel and OptiRoute occurred during morning rush hour, specifically from 8:00 AM to 10:00 AM. A second noticeable drop occurs at 12 Noon when many people leave for lunch. By graphing the R-squared values, the change in correlation between predictors can be more clearly seen, as evidenced by Figure 3.

Management Insights and Recommendations

An invaluable insight provided via interviews and site visits is that drivers currently do not follow the route plans they are given each morning. Instead, when drivers receive their route plans, they proceed to sequence the stops using their own field knowledge about local traffic patterns and customer delivery preferences.

Two areas where BevCo can effectively improve its current operational processes are the vehicle routing process and the delivery process. In order to improve the vehicle routing process, BevCo needs to replace the navigation portion of OptiRoute with CarTel. This will give a more accurate prediction of the drive portion of the route. In order to improve the delivery process, a manifest compliance requirement needs to be instituted. If drivers do not follow route plans, no level of improvement—incorporating traffic or otherwise—will improve actual performance. In addition, a mechanism needs to be developed that allows drivers and dispatchers to share information that includes road conditions, traffic, and customer preferences. This information must be easily accessible to both dispatchers and drivers.

An area for further study holds the potential to further improve vehicle routing efficiency. Tapping into the stochastic data collected by CarTel would allow BevCo to plan a route and assign a confidence level to the driver’s ability to arrive on time. This allows BevCo to utilize actual travel time probabilities in route development.
Measuring Environmental and Social Sustainability in the Apparel Supply Chain

By Sophie Agbonkhese
Thesis Advisor: Edgar Blanco

Summary: Companies engaged in sustainable supply chain management face the challenges of selecting sustainability initiatives, measuring those initiatives, and assessing their overall progress toward sustainability. Three hundred sustainability initiatives implemented by eight apparel companies were compiled to explore the metrics of individual initiatives and provide a system for assessing sustainability programs.

Two barriers to the successful implementation of sustainability programs are unawareness of the drivers and issues relevant to the industry and uncertainty about metrics. How can we raise the level of understanding in the apparel industry about which issues are important, how to address them, and how to measure success?

Methodology
To address the first barrier, the sustainability programs of eight apparel companies were reviewed. The companies studied were Adidas, Gap Inc., H&M, Mountain Equipment Co-op, Nike, Patagonia, Puma, and Timberland. A four-tier classification scheme was used to categorize their sustainability initiatives as symbolic actions, quick wins, strategic projects, or game changers. The individual initiatives were synthesized in a Structured Query Language (SQL) database and categorized by supply chain stage, sustainability dimension (e.g., energy, waste, water), and classification. An online version of this database was created for interested parties to reference. See www.agbonkhese.com/apparel_sustainability.html.

To address the second barrier, lack of sustainability metrics, I reviewed the business literature and corresponded with company officials to document the metrics associated with sustainability initiatives. Adapting the works of corporate social responsibility experts, I applied a hierarchical framework of sustainability positions to the eight companies as a means of assessing their sustainability programs.

Classifications of Initiatives
Sustainability initiatives vary in regard to scalability, cost, rewards, potential for impact, and certainty of outcome. Therefore, it was necessary to develop an initiative classification system to determine how sustainable the eight companies are. Simply counting the number of initiatives implemented would not be sufficient, because 10 low-cost, low-risk initiatives could be less impactful than one large-scale, game-changing initiative. Adapting a model used by Wal-Mart, I defined four classifications. Figure 1 outlines these classifications.
The pyramid in Figure 1 represents the percentage of all initiatives accounted for by each classification. For a given set of environmental sustainability initiatives, symbolic actions and quick wins represent the largest portions, while strategic projects and game changers are rarer. This trend does not apply to social responsibility initiatives, which are predominantly symbolic actions and strategic projects.

Corporate Sustainability Positions

I used the number of each type of initiative implemented by the eight companies to determine their sustainability positions. Then, I assigned weights to the classifications and found the weighted average of each company’s initiatives to approximate their sustainability positions. Each symbolic action earned one point, each quick win three points, each strategic project six points, and each game changer 30 points. This weighting scheme accounts for the much higher levels of commitment and uncertainty associated with game-changing initiatives.

Table 1 shows four sustainability positions (adapted from the work of Terry Porter). A Compliant firm has a weighted score ranging from 0 to 29. These firms have little or no interest in sustainability. Opportunistic firms (or what Porter calls “instrumental” firms) engage in win-win initiatives with short-term financial benefits. Their scores range from 30 to 59 points. Good Citizen firms address issues that are important to their stakeholders and engage in multiple strategic projects. Their scores range from 60 to 160 points. Finally, Intrinsic firms are the most committed to sustainability. They embed sustainability into their mission, strategy, and values, and focus on long-term issues like resource depletion. Their scores range from 161 to over 400. To qualify as Intrinsic, firms must have at least one game changer.

Three of the eight companies studied were found to be Intrinsically sustainable, while the rest qualified as Good Citizens.

Sustainable Supply Chain Initiatives

The eight companies cumulatively reported 295 supply chain sustainability initiatives, 213 of which are unique. Table 1 displays the distribution of these initiatives by sustainability dimension and supply chain stage. The total number of initiatives in the table is higher than the actual number of initiatives, because some are implemented in more than one supply chain stage or impact more than one dimension of sustainability.

Social responsibility initiatives in the production stage of the supply chain account for 36 percent of the total. These initiatives, which revolve around factory working conditions and human rights advocacy in contract factories, have proliferated due to accusations of child labor and unfair working conditions in apparel factories.

While factory audits constitute a significant part of social responsibility efforts, the eight profiled companies take it far beyond that. For example, H&M offers a factory development program to increase factory productivity and decrease overtime. Puma trains factory workers to understand their basic rights and the benefits to which they are entitled, to calculate their wages, to sign labor contracts with employers, and to claim workplace injury compensation. Timberland offers continuing education, food assistance, parenting courses, and micro-
finance to its contract factory workers. These initiatives are creating a more educated, safer, healthier, and more empowered workforce, which benefits the apparel companies in terms of lower turnover, higher productivity, and better supplier relations.

In addition, 92% of all the initiatives occur in the materials, production, and distribution segments of the apparel supply chain. Significantly less emphasis has been placed on the transportation, use, and disposal segments. Transportation, which does not constitute a significant portion of an apparel product’s environmental impact, need not be a key focus area for apparel industry sustainability programs. However, the use stage accounts for 80% of energy consumption in the life cycle of a garment, and is an area where apparel companies can make major reductions in their environmental footprints.

<table>
<thead>
<tr>
<th>Sustainability Dimension</th>
<th>Supply Chain Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Materials</td>
<td>Production</td>
</tr>
<tr>
<td>Energy/Emissions</td>
<td>6</td>
</tr>
<tr>
<td>Water</td>
<td>16</td>
</tr>
<tr>
<td>Waste</td>
<td>3</td>
</tr>
<tr>
<td>Materials</td>
<td>47</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>16</td>
</tr>
<tr>
<td>Total</td>
<td>86</td>
</tr>
</tbody>
</table>

Table 2: Distribution of Sustainable Supply Chain Initiatives

Energy/emissions initiatives account for 21 percent of all initiatives, but 41% of all initiatives with metrics. Conversely, social responsibility initiatives account for 41% of all initiatives, but only 8% of those measured. One explanation is that energy/emissions initiatives are easier to measure than social responsibility initiatives. For example, it is simple to calculate the benefit of using renewable energy to power corporate headquarters, but it is difficult to measure the benefits of helping suppliers create their own sustainability reports. Another possible explanation is that there are more benefits to knowing the impact of energy/emissions initiatives. For example, if a cap-and-trade system is implemented, companies will need to account for their emissions and will benefit from knowing precisely how much they can reduce their emissions.

Ultimately, companies will need to find ways to measure all of their sustainability initiatives if they seek to track, report, and build on their progress.

Conclusions
As apparel companies strive to become more sustainable, they must place more emphasis on the post-consumer segments of the product life cycle. Strategies for further reducing the impact of the apparel supply chain include:

1. Creating products that are reversible, that can be worn in more than one way, or that can be upgraded to extend their useful life
2. Offering repair or replacement services throughout the product’s lifetime to extend its useful life
3. Enhancing traceability of raw materials and using high-grade recyclable or biodegradable materials so products can be recycled at the end of their useful lives
4. Using materials that can be cleaned by energy- and water-efficient means; encouraging spot treatment of stains and infrequent washing of garments
5. Developing systems for breaking down products into their components and finding creative ways of reusing the resulting materials
6. Extending social responsibility initiatives up the supply chain to the farmer level and down to the community level

<table>
<thead>
<tr>
<th>Sustainability Dimension</th>
<th>Percent of All Initiatives</th>
<th>Percent of Initiatives with Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy/Emissions</td>
<td>21</td>
<td>41</td>
</tr>
<tr>
<td>Materials</td>
<td>23</td>
<td>26</td>
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<tr>
<td>Water</td>
<td>11</td>
<td>14</td>
</tr>
<tr>
<td>Waste</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Social Responsibility</td>
<td>41</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 3: Initiatives by Sustainability Dimension as a Percent of Initiatives and as a Percent of Initiatives with Metrics
Modeling the Supply Chain Benefits of Efficient Assortment

By Marta Lew
Thesis Advisor: Stephen C. Graves

Summary: This project developed an assortment-planning tool that allowed a consumer goods manufacturer to assess its product mix from the perspective of cooperating retailers. Thanks to the tool, the manufacturer can rationalize its product portfolio in a way that increases the utilization of its clients’ supply chains and improves their financial results.

GoodsCo—a major manufacturer of consumer goods ranging across numerous categories of merchandise—sells its products through multiple retailers present in several channels, including drug chains, mass merchandisers, grocery stores, and discounters. Because of GoodsCo’s diverse client requirements and stricter performance monitoring, management of its wide portfolio of SKUs became a daunting task for the supplier.

To better cope with the growing complexity of its product mix, GoodsCo wanted to reinforce its assortment management process with insights from data provided by cooperating retailers. Considering the amount of data and the range of relevant considerations, such insights required a new analytical model. Additionally, years of close collaboration with clients had given the manufacturer’s team a good understanding of the strategies that they pursued and the goals that they expected each category of merchandise to support. Hoping that the new model would incorporate this knowledge, GoodsCo enabled its management to view the product portfolio through the perspective of the supplier’s downstream partners.

Modeling of Efficient Assortment
The capability of evaluating product assortment through the retailers’ lens was established in the form of the Efficient Assortment Model. This tool utilizes the point-of-sale, operational, and financial data of GoodsCo’s downstream partners, as well as information about individual products captured through functional attributes. Based on the data, it recommends assortment changes at the item, category, and cross-category levels. The recommendations are accompanied by projections of financial and operational results.

So that the model can be used for all GoodsCo merchandise categories, this research addressed three product groups representing different demand seasonality, degree of variety (number of SKUs, and diversity of functional attributes), sales velocity, and profitability. To address the needs of all retailers, regardless of channel, objectives, inventory management arrangements, and replenishment logistics, the model was developed for two distinct retailers—a mass merchandiser and a drug channel.

Introduction
The economic downturn of 2008 created a challenging environment for companies in the retail sector and for their trade partners. Initiatives undertaken by retailers to recover their former financial results—eliminating unproductive inventory, reducing unnecessary complexity, and dedicating more space to their own private labels—increased pressure on their suppliers. Greater focus on assortment management brought on stricter monitoring of the actual contribution of each carried stock keeping unit (SKU). Store operators began to require that vendors justify the introduction of new products through business cases, including projections of incremental sales and changes in their revenues and profits.

KEY INSIGHTS
1. Reductions in product assortment can significantly improve financial results for retailers.
2. Assortment reductions based on analyses of sales, financial, and operational data can improve the efficiency of supply chain and reduce logistics costs—without sacrificing sales.
3. Collaboration between supply chain partners—the sharing of transactional data and information about processes and objectives—is vital for successful assortment management.
Figure 1 illustrates how the Efficient Assortment Model transforms input data into suggestions regarding the product set that should be carried by a selected retailer in each category, and the retailer’s shelf composition. First, the 11 key performance indicators (KPIs) listed in Table 1—each quantifying a decisive factor in retailers’ assortment evaluations—are computed for every SKU within a category. To assess the risk of lost sales by accounting for the demand transferred to similar products, as well as to capture such benefits of portfolio rationalizations as improved management of out-of-stocks or lower handling cost, the model recalculates all KPIs each time the assessed assortment is modified.

The dynamically calculated SKU evaluation criteria are then weighted to properly capture the retailer’s goals for the evaluated category, and combined into a comprehensive score. Together with relevant qualitative factors, such as information about items that enjoy high levels of customer loyalty, the score determines the “best” assortment in the category. Results—sales, profits, and inventory turns—are then used to define

<table>
<thead>
<tr>
<th><strong>Criterion</strong></th>
<th><strong>Criterion</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Annualized Recorded Sales Volume</td>
<td>Potential volume of sales if SKU is maintained in assortment (annualized and net of out-of-stocks)</td>
</tr>
<tr>
<td>Demand Trend</td>
<td>A score reflecting the potential of a given SKU (growing/level/decreasing share in category sales)</td>
</tr>
<tr>
<td>Annualized Recorded Sales Amount</td>
<td>Potential amount of sales if SKU is maintained in assortment (annualized and net of out-of-stocks)</td>
</tr>
<tr>
<td>Average Unit Margin</td>
<td>Average margin realized by a retailer per unit of given SKU</td>
</tr>
<tr>
<td>Annualized Profit</td>
<td>Profit realized by a retailer from sales of given SKU (annualized)</td>
</tr>
<tr>
<td>Margin</td>
<td>Profit realized by a retailer from sales of given SKU net additional cost-to-shelf from DC to store (holding, handling, and transportation)</td>
</tr>
<tr>
<td>Net Cost to Shelf</td>
<td></td>
</tr>
<tr>
<td>GMROI</td>
<td>Average General Margin/Return on Investment per SKU</td>
</tr>
<tr>
<td>GMROI Trend</td>
<td>Year-to-year trend displayed by GMROI</td>
</tr>
<tr>
<td>Incrementality</td>
<td>Percentage of SKU sales accounting for demand which had previously not been captured by any product from the assortment</td>
</tr>
<tr>
<td>Shelf Space Productivity</td>
<td>Margin per linear foot of retail space</td>
</tr>
<tr>
<td>Inventory Turns</td>
<td>Number of times inventory is sold over a period of one Year</td>
</tr>
</tbody>
</table>

*Table 1: SKU Evaluation Criteria*

Figure 1: The schematic above illustrates how the Efficient Assortment Model processes point-of-sale, financial, and operational data to arrive at the best assortment across categories.
The Efficient Assortment Model can help GoodsCo detect which products in its portfolio are most profitable for retailers by considering the costs of storing, shipping, and handling. Gross margin does not account for logistics costs that occur after goods are delivered to retailers’ distribution centers (DCs) and therefore does not reflect their actual contribution. The model assesses these additional costs for each SKU, and estimates the portion of remaining margin—the Profit Net Cost to Shelf (see the example shown in Figure 2).

The tool allows the manufacturer to determine which of its products are likely to be successful given the retailers’ objectives for their category of merchandise. It also enables GoodsCo to simulate which SKUs will be most robust against changes in these objectives and which items various retailers will approve. Figure 3 illustrates how modifying the category strategy (Strategy A is focused on sales volume; Strategy C promotes high margins) can affect the retailers’ decision regarding which SKUs to maintain or eliminate. GoodsCo can use this capability to identify the products which are worth investing in, those which require efforts such as promotion or advertising, as well as those which should be discontinued.

Results of Efficient Assortment
The Efficient Assortment (EA) Model assesses the risk of lost sales; quantifies possible improvements in product availability, efficiency of retailers’ operations, and utilization of supply chain assets; and also projects their revenues and profits. This new capability enables GoodsCo to support its clients’ goals through adjustments in its product portfolio, as well as through sharing new data-based insights and suggestions regarding shelf management.

Figure 3: The decision to keep or eliminate a SKU depends on the goals that the company has defined for the category. A retailer will select a different subset of the category portfolio depending on which of the four strategies (A, B, C, or D) it applies to the category.

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Conclusion

The new decision model reinforced GoodsCo’s capacity to support the objectives of its clients, while pursuing its own goal of offering end-customers products that they need and trust. The extended partnership between the supplier and its clients will help channel funds and creativity to the most popular items. Additionally, the manufacturer’s involvement in the Efficient Assortment initiative will support more successful product development, thus helping in retaining its portion of store shelves. Finally, proactively managing the assortment will eventually allow the company to free its manufacturing and logistics network from servicing items that do not create much value to clients and customers.

This new tool can also be useful in testing more complex scenarios and in finding more intricate solutions. Figure 4 illustrates a decision involving multiple categories of merchandise. The Efficient Assortment Model realigned the available shelf space among categories Fresh, Healthy, and Clean so as to maximize retailers’ profits. The recommended change—extending the shelf space currently assigned to category Fresh, while reducing the area where items from categories Healthy and Clean are displayed—suggests the retailer can increase its income by almost 50 percent.

Figure 4: According to the Efficient Assortment Model, if a portion of shelf space previously dedicated to categories Healthy and Clean is reassigned to category Fresh, the retailer will observe substantial improvement in annual profits earned from the entire shelf.
Managing Growth of a Non-Profit Healthcare Supply Chain in Haiti — This project developed a model that uses historical consumption data of Partners in Health’s (PIH) drugs and medical supplies to forecast demand over the next three years. This demand data is then used to compare PIH’s current annual order policy with ordering policies having more frequent reviews. Our model shows that more frequent orders will drastically reduce warehouse space requirements for PIH.

Biofuel Supply Chain Challenges and Analysis — Renewable feedstocks can be used to produce fuels such as ethanol and biodiesel, which are replacements for petroleum derived fuels. We show that switchgrass is not competitive in price compared with gasoline at current prices, and we identify challenges the biofuel industry must deal with to narrow the price gap with petroleum based fuels.

Costs, Risks and Variables to Consider in Sourcing Decision Models for Globally Dispersed Manufacturers — Automobile manufacturers need to make sourcing decisions very early in the vehicle planning process. A cost/risk assessment that weighs costs, risks and variables in a single sourcing strategy decision model could ensure delivery of the lowest total landed cost.

Development of Panama as a Logistics Hub and the Impact on Latin America — The feasibility of developing a logistics hub in Panama was studied by analyzing the key characteristics of Singapore and Dubai’s successful development of logistics hubs. We then used these key characteristics to determine the short-term effects of a Panamanian logistics hub on the Latin American port system.

Distribution Network and Inventory Strategies for Rapid and Cost-Effective Deployment of Oilfield Drilling Equipment — This project develops a simulation model of the distribution network of a large oil and gas services company and evaluates two alternative delivery network configurations – pure hub-and-spoke and hub-and-spoke with postponement setups. The hub-and-spoke with postponement design is shown to be superior in terms of total logistics costs and timely deliveries of oil well drilling equipment.

Distribution Network Consolidation and Optimization for a Large Industrial Conglomerate — This project developed an optimization model as a decision tool, using a Mixed Integer Linear Programming (MILP) approach, to help an industrial conglomerate redesigning its warehouse networks. The redesign included warehouses consolidation of 3 of company’s business units and the changing of products flow patterns. The result showed that about 44 million Baht of the total product distribution cost could be saved if the company implement the new networks suggested by the model.

Environmental, Operational and Financial Sustainability of Packaging Methods by Delivery Businesses — The thesis focuses on three areas of the downstream order fulfillment cycle from the retail delivery company to the customer. The first is materials innovation, the analysis of suitable alternative materials. The second involves waste elimination, the reduction and reuse of packaging material. Lastly, we address implementation, strategies that affect the success of sustainability initiatives.

How to Utilize Hedging and a Fuel Surcharge Program to Stabilize the Cost of Fuel — This project focuses on the impacts of fuel price volatility and its distribution throughout the supply chain, with the goal of stabilization. Hedging and fuel surcharges are analyzed as tools for stability, with research including: a market benchmarking survey, fuel surcharge component sensitivity testing and a simulation of varying derivative coverage lengths.

Impact of Bidding Aggregation Levels on Truckload Rates — This project developed a model to evaluate the cost effects of lane aggregation in long-haul, truckload trucking in the United States. The model provides simple guidelines for determining how shippers should bid out lanes to elicit the best rates from carriers.

Impact of Demographics on Supply Chain Risk Management Attitudes: Prevention Vs Response — Using a large-scale worldwide, online survey conducted by the MIT Global SCALE Initiative as a base, this thesis analyzed the relationship between attitudes towards Prevention vs. Response (the dependent variable) and demographics (the independent variables). The analysis shows that the demographic factors of country of origin, gender, primary field of study, and job function can help predict how people manage supply chain risk.
Impact of Demographics on Supply Chain Risk Management Practices — Most supply chains today cut across multiple countries, languages, income levels, and industries, meaning that there are differences in supply chain risk management behaviors or attitudes. Do demographic factors play a role supply chain risk management decisions? The data show that geography and firm size fundamentally drive risk management practices.

Risk from Network Disruptions in an Aerospace Supply Chain — This project determined the effects of risk from supply chain disruptions using a space vehicle production process as the example, primarily through the use of a computer simulation model and various disruption scenarios. Output of the model was used to develop confidence percentiles for the complete duration times.

Suggested Strategies and Best Practices in Private Supply Chain Disaster Response — Why are some companies more effective within disaster relief supply chains than others? Our research explores and consolidates best practices applied by companies effectively during past disasters. We conclude with a framework of nine best practices and suggest how to apply it across a range of ten industries.

Using a Total Landed Cost Model to Formulate Global Logistics Strategy in the Electronics Industry — This project developed a total landed cost model to analyze the cost from raw material to the customer for one sample Electronics Company, Tel Co. The total landed cost model was also used to predict the impact of global supply chain risks. The result assists firms make a strategic decision on selecting manufacturing locations, and distribution strategy.

WFP Supply Chain Capacity in Ethiopia: An Analysis of its Sufficiency, Constraints & Impact — The WFP’s transport of food aid to Ethiopia’s landlocked population is constrained by transshipment processing bottlenecks at the port, and limited availability of trucks for inland transport. We analyzed the quantitative and qualitative factors used in selecting routes and mitigating port bottleneck issues. Our results will be used by the WFP and other humanitarian organizations which aid distressed populations.