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A Comparison of Brick-and-Mortar and Online Last Mile Delivery Networks

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Submitted in Partial Completion of the
Requirements for Interdisciplinary Honors in Management and Geography

Bridgewater State University

May 10, 2017

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Abstract

Driven by the rapid growth of e-commerce, last mile delivery has become an increasingly necessary strategy for retailers to stay competitive. The locations of distribution centers and the capacity of vehicles have profound effects on transportation costs. Demand for same-day delivery services is expected to increase in popularity as new technologies, such as drones and automated transportation, evolve and become cheaper to develop. Organizations that design their logistic network efficiently hold the largest competitive advantage. Amazon is currently an industry leader in shipping and delivery logistics by utilizing its online ordering process. Brick-and-mortar stores such as Walmart and Best Buy are trying to keep pace by similarly offering online ordering and curbside delivery using outsourced delivery services. When considering the most effective method of delivery, one consideration is whether a delivery system can balance its ability to drive down the distance driven by its fleet while increasing the density of packages that are to be delivered. In this regard, modeling and simulation software can be used effectively to run sensitivity analysis to understand key performance indicators of transportation costs, enabling organizations to estimate the most effective ways to deliver products to consumers. Additionally, simulation can be used to make larger organizational decisions relating to the supply chain. In this thesis, logistic simulation modeling software, anyLogistix, is combined with Geographic Information System (GIS) technology to investigate the most cost efficient mode of delivery network. The results of this study demonstrate that a network with fewer distribution centers will have higher transportation costs due to a greater distance to cover.

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1. Introduction

1.1. Background

An in-depth understanding of last mile deliveries in a supply chain is of strategic importance for stakeholders in the retail industry. The ‘last mile’ is a term used in logistics to describe the final stages of a supply chain in which parcel packages are delivered to the doorstep of the consumer. The last mile accounts for the majority of a shipment's cost and complexity (Walsh, 2006). A responsive last mile stage allows retailers to meet customer demands and respond to seasonal demand more appropriately. Use of GIS applications such as OpenStreetMap, Waze, ArcGIS, or other technologies have the potential to help plan more effectively for traffic and road network issues.

Originally, there were discussions about the strategic approach to online and traditional brick-and-mortar retail during the early 2000s dot-com era. It became evident that online access would likely increase the demand for shipping and delivery of products for consumers. In recent years, advances in mobile technology and the widespread availability of online access has made delivery at the tap of a button a commonplace occurrence. Having a well-conceived logistical strategy to meet this increase in delivery demand has become an area of growing significance for retailers. The cost of maintaining brick-and-mortar infrastructure is significantly higher than the cost of maintaining a low-overhead, e-retailer's infrastructure (Enders & Jelassi, 2000). Recently, Walmart has stated that it plans to reduce “empty miles” driven by its fleets to reduce costs (Walmart, 2017). Reducing empty miles includes insuring merchandise is moved in responsible, sustainable ways and that drivers follow the most efficient routes to destinations. This is an important consideration because brick-and-mortar retail giants continue to face strong competition from e-retailers such as Amazon, who, in 2015, took a quarter of all U.S. retail sales (Tabuchi, 2015). Amazon has traditionally used third party organization such as UPS, USPS, and

FedEx to deliver its packages. Recently however, shipping costs have pushed the company to begin to develop its own delivery network (Vuong, 2016) in order to increase its capacity during busier times of the year. The objective of this study is to simulate Amazon's and Walmart's last mile delivery network in Massachusetts over the course of 365 days in order to compare the transportation costs of each network. The Amazon network consists of a single distribution center (DC) in Fall River, whereas the Walmart network consists of multiple distribution centers (DCs) spread out across many cities and towns. A centralized network is hypothesized to generate higher transportation costs due to the large area to cover.

The cost of driving many miles to deliver a package to the consumer has to be offset by delivering as many packages as possible during many deliveries. Based on the following principle, the cost of delivering a package can be calculated by dividing the miles driven by the number of packages within a delivery unit (i.e. truck). Trucks that travel 100 miles and drop off 200 packages will cost more than trucks that travel 100 miles and drop off 300 packages. When many deliveries are made over a short period of time by decreasing the distance between deliveries, the cost per delivery will be low. Amazon minimizes costs per delivery by using vans that are able to carry more packages over a very large area. Walmart minimizes costs per delivery by using smaller vehicles but covering a smaller area. Using DCs as starting points, this study looks at whether Company A, starting from a single DC with trucks that can carry a large number of packages and travel more miles, will have lower transportation costs than Company B, having trucks carrying less packages and traveling shorter distances.

The convenience of shopping online continues to drive consumers away from physical retail stores. Online shopping cuts down on fuel and time for the customer. However, there are advantages to operating physical locations. Consumers consider in-person inspection necessary for large products such as TV sets, those that are costly to return and products with varying sizes

such as clothing (Enders & Jelassi, 2000). Apple and Best Buy are examples of organizations that use their physical stores to advertise products and to provide customer support. Brick-and-mortar retailers have begun to compete with online retailers, taking advantage of operating multiple store locations spread throughout large geographic locations as an option for rapid service. This method is known as an omnichannel supply chain, one in which customers have access to multiple means of browsing, buying, and returning products. Supply chains involving an omnichannel structure incorporate 3rd party logistics (3PL) providers to incorporate mobile access and brick-and-mortar retail locations to provide customers with more service related flexibility. Despite the continued usage of brick-and-mortar retailer service options, online ordering and speed of delivery has become an increasing expectation of consumers. Kacen et al. (2013) states that the immediate delivery of items is one of the most important attributes possessed by online stores to determine the likelihood of purchasing a product from an online store compared to purchasing from a traditional store. Not surprisingly, Amazon has recently released a 1-hour delivery service, Amazon Prime Now, in select metropolitan areas. This increase in demand for speed of service will continue to require additional studies into issues facing large and third-party organizations that wish to learn from past difficulties and to develop new technologies to solve the issues affecting delivery speed.

Immediate delivery refers to same-day or next-day delivery and both offer advantages and disadvantages to consumers. The topic has made headlines in the popular press in recent years as more and more options become available. Same-day delivery is appealing to consumers because it saves time driving to the store, finding parking, finding the product and returning home (Tuttle, 2012). Compared to the simple click of a mouse, the time spent in physical stores might seem like an extraordinary opportunity cost on behalf of the consumer. Next-day delivery has been offered for free by online retailers, such as Amazon, an appealing option for budget

conscious consumers. However, according to The State of the Retail Supply Chain report by Auburn University (2016), retailers continue to pursue cost-efficient last-mile strategies that include weaning customers off of free shipping expectations. Studies into the future of same-day delivery may involve the use of drones. Drone logistic strategy may be highly relevant in the future as it involves balancing very small densities (a single package) with flying very long distances and investing in large drone fleets.

Amazon and Walmart differ by the amount of and placement of DCs. Amazon's last mile logistic network is centralized around a single DC where orders are picked, packed, and sent out to customers. Walmart's last mile logistic network is decentralized in that it has multiple store locations by which packages can be shipped out to nearby customers based on proximity. The two companies also differ in the vehicle sizes of their fleet. Amazon uses UPS and FedEx to deliver packages that in turn use box trucks. Walmart has stated that because of the success of their online grocery service, they plan a last-mile delivery test through such services as Uber, Lyft, and Deliv (Bender, 2016). The service would involve a request for a driver from one of these services to come to the store, pick up the customer's order, and take it directly to the customer's location.

Simulation modeling has been used in previous studies to understand supply chain logistics networks of organizations. Simulation has been used to evaluate sales of new store locations and how they could affect additional stores (Lv et al., 2008). Modeling of a logistics system requires tasks such as determining the correct parameters to simulate a real world situation and gathering the appropriate data that best represents the situation. There have been multiple studies concerning different types of vehicle routing methods (Azi et al., 2012). Other studies look at success rates comparing modes of delivery such as reception and delivery boxes (Punakivi et al., 2001). For the current study, customer delivery address points are based on the

zip codes of towns of Massachusetts. The decentralized network model will be based on retail locations for Walmart. The model of the centralized system will be based on the location of Amazon's DC in Fall River.

Online retail giant Amazon has offered same-day delivery on a limited number of items in its inventory. Alba (2015) speculates that the company has waited to offer same day delivery on a wider array of products until it is able to build up its infrastructure. Delivery products can be classified as high-value, medium-value, and low-value. The company has invested large amounts of capital into building large fulfillment centers and DCs near major metropolitan areas. Many online consumers have come to expect a highly dependable free delivery service for their products. There are many factors to consider when designing a cost efficient and dependable delivery service. Amazon's Prime strategy works by having its customers pay a subscription fee giving the company a steady flow of income which it can spend towards expanding its infrastructure of fulfillment centers and delivery vans. Other retailers charge a flat fee per delivery. The e-grocery sector is another area where same-day delivery is growing in popularity. E-grocery services such as Peapod and Walmart Grocery charge a delivery fee depending on the amount of groceries provided while Amazon Fresh charges a monthly subscription service (Enright, 2016). While these low unit value products represent a growing delivery section, for the simplicity of this study, these types will not be included in the models researched.

Same-day delivery service was previously promoted by several organizations during the dot-com era in the late 90's. However, many companies (e.g. Webvan, Kozmo.com) went bankrupt due to poor financial planning by rapidly building national delivery services in multiple markets (Slaton, 2001). Recent technological advances have finally given organizations incentives to develop their last mile delivery infrastructure in order to make same-day delivery feasible. Customer behavior has changed as mobile apps such as Uber, Seamless, and Airbnb

have begun to offer quickly accessible types of services. Brick-and-mortar services must be able to adapt to the expansion of online app services and the changing attitudes of consumers. As consumers demand shorter delivery windows from next day to same day to within the hour, companies will need to understand how to deliver packages at a lower cost per mile.

The last mile is considered an expensive part of the supply chain (Gevaers et al., 2011). However, there is sparse literature comparing different approaches to managing last mile delivery networks. This thesis models two types of delivery structures in order to compare transportation costs under simulated conditions. The modeling simulation software used is anyLogistix. The primary research question is whether a decentralized network composed of low density deliveries and short travel distance is more cost efficient than a centralized network composed of high density deliveries and long travel distance. There are many variables (i.e. parameters) to consider when creating a simulation model. Factors related to time affect delivery rates. For example, facilities closing at 8pm must load as many packages as possible onto a delivery vehicle before the end of the day to minimize losses. Another variable is the cost related to delivery vehicles. Fixed costs such as vehicle insurance and variable costs, such as fuel, affect the overall cost per kilometer to deliver a package. The size of the vehicle is another factor: the delivery vehicle may be a small van or a large box truck. The use of a truck has advantages over the use of a van, most notably the additional package density it provides. The number of vehicles per fleet as well as the size, weight, category, and value of packages all impact delivery efficiencies. Additionally, the type of cost calculation provided by the simulation software (e.g. distance-based, weight-based, fixed cost-based, or volume-based), may also effect transportation costs. These variables were entered into the two simulation models, (referred to by anyLogistix as scenarios), to determine the most accurate depiction of each case. After running experiments, the scenario with the lowest transportation cost will emerge.

2. Literature Review

2.1. Overview

Retailers are challenged by their ability to balance the amount of mileage their fleets are able to cover versus the density of the packages that are deliverable. Understanding the specifications of the last mile logistic network is required to provide the best methods for producing the most cost efficient deliveries possible. There are several topics to consider when strategizing for last mile delivery. The first is an investigation of the last mile of the supply chain and what specific variables affect transportation costs. The second is an examination of the centralized and decentralized delivery networks and what is necessary for low transportation costs. The third consideration is what tools to use to plan for the creation and development of a delivery network, such as spreadsheets or simulation modeling. There is a great deal of literature on supply chain management but less so on last mile delivery strategy, as it is a relatively new topic. Much of the literature on last mile deliveries can be found in trade magazines and blogs, as opposed to academic sources.

2.2. The Last Mile

A standard logistics chain is organized into several stages. In the first stage raw materials are converted into a finished product. In the next stage the finished product is shipped to storage facilities such as warehouses or DCs. After this point the product gets shipped to retail outlets or directly to consumers. The final stage, where deliveries are shipped directly to consumers, is known as the 'last mile'. The last mile is considered to be one of the most expensive parts of the entire logistics chain (Gevaers et al, 2011). Reasons for this are inherent factors related to home

delivery that include more emissions by inefficient vehicles, lack of critical mass of customer densities in some regions, and multiple repeated trips made due to undelivered packages.

2.3. Brick-and-Mortar Issues

There are several issues to contend with when modeling a delivery network for a brick-and-mortar retailer. Determining the correct density of customers in a geographic region is necessary to understand the correct demand and average delivery distances. A study conducted by Boyer et al. (2009) determined that greater customer density in a region and longer delivery windows facilitate greater efficiency. It would be advantageous to determine accurate population densities of regions where DCs are widely spread apart and where customers are less likely to live. This would normalize the random set of customer addresses according to population densities and likely favor the cost efficiencies of brick-and-mortar stores in a given region. Other factors to consider are storage cargo space of vehicles (Gibson et al., 2016) and fuel efficiency. Walmart has stated that 70% of Americans live within 5 miles of a Walmart.

As Walmart continues to seek cost reductions, it has sought multiple methods to improve upon logistics. Recently, it has decided to outsource its delivery fleet to Uber and Lyft (Perez, 2016). The company began using the service for groceries and also for parcel delivery at its largest warehouse store, Sam's Club. Members pay a fee of \$7 to \$10 for the service. Walmart plans to grow this service to additional cities over time. For the scope of this thesis, Walmart's delivery vehicle will be assumed to be an Uber XL sedan such as a Toyota Camry.

2.4. Online Issues

Delivery systems of online e-commerce and brick-and-mortar can be described as either centralized and decentralized networks. There is substantial literature relating to online versus brick-and-mortar commerce preferences (e.g. Kacen, Hess, & Chiang, 2013, Camelia, 2015). However, there has been limited research describing the advantages and disadvantages of each mode of e-commerce and the impacts related to costs.

2.5. General Delivery Issues

There are a number of potential issues with delivery that can be problematic. Studies conducted on pick-up and delivery problems show failure rates due to unsigned packages for high-value products (Berbeglia et al, 2010). This can result in multiple return trips for couriers and sunken fuel costs on the part of the delivery service. Incorporating a delivery window for customers addresses this problem. Customers are, on average, more willing to wait for higher value products, even with a large delivery window. This leads to the issue of fuel costs and thus, cost per delivery.

Studies of delivery windows can be used to determine the viability of same-day deliveries, which have gained popularity among consumers and retailers. Recently, stakeholders within supply chains report trying to lower customer expectations of free same-day delivery service (Gibson et al., 2016) that has been provided by companies such as Amazon. The literature on same-day delivery is scarce. Anderson (2015) reports that merchants are struggling to meet the costs associated with same-day delivery such as fuel, labor, parking, and infrastructure. In May of 2015, Amazon announced free same-day delivery service for its Amazon Prime customers (Amazon, Order with Prime FREE Same-Day Delivery, 2015). Amazon has a history

of success offering services before profits, and consumers in turn expect the same treatment from other retailers.

When determining rates of successful delivery it is necessary to consider the importance of the types of products using a classification system. An inventory control method known as ABC analysis can be used to determine the level of importance for specific types of delivery products. In order to better understand proxy variables affecting successful deliveries, an innovative classification approach for delivery products has been proposed by Gevaers et al., (2011) which divides products into three types: (1) high-value (i.e. computers), (2) medium-value (i.e. textbooks), and (3) low-value (i.e. groceries). This classification will aid the delivery model in characterizing factors that affect delivery rates. For the scope of this thesis, packages were categorized into low value items equalling 1 dollar.

2.6. Centralized Network

The centralized network, also known as the internet pure-play distribution system strategy (Metters & Walton, 2007), is most often associated with online e-commerce in which there is a main central DC where all orders are picked on site and sent out to be delivered, typically by truck to customers. The most well-known centralized network is Amazon. There has been a lot of discussion recently about the “Amazon Effect” and how it is reshaping the supply chain industry with the many kinds of services that it offers. The centralized fulfillment center type of system is growing in popularity because of Amazon’s success. Walmart planned to invest \$900 million into e-commerce technology and fulfillment centers in 2015 to compete with Amazon (Nash, 2015). The centralized network warehouse uses a pick-and-pack operation with narrow aisles and short shelves where humans find items and pack into outgoing delivery orders (Metters & Walton, 2007).

2.7. Decentralized Network

The decentralized network, also known as the traditional system strategy, is one in which there are many retail stores housing products that customers have ordered online and are picked, packed and shipped to customers. In this type of network, there are multiple store locations serving many customers.

According to Metters & Walton (2007), in addition to delivery difficulties, traditional systems have warehouse operational limitations that impede logistics. These limitations include limited floor space and limited personnel to pick, pack and ship products. In the decentralized

network an omnichannel supply chain is utilized. The omnichannel supply chain gives customers access to more options such as buying, viewing and exchanging their products. Additionally, a decentralized network may take advantage of operating multiple locations in densely populated markets.

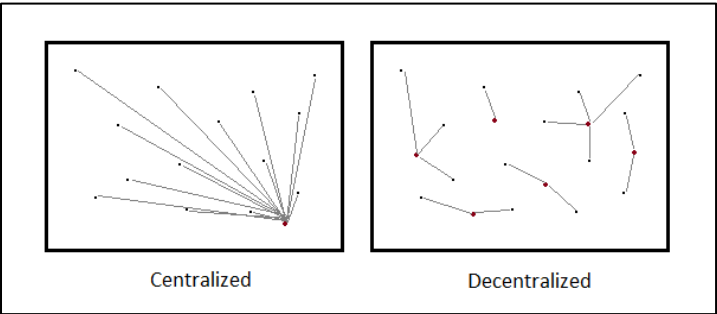


Figure 1 – Types of Networks

Centralized		Decentralized	
Advantages	Disadvantages	Advantages	Disadvantages
Less overhead costs	Dependent on route efficiency	Vehicles travel less	Deliveries with less than efficient capacity
Better variety of packages under one warehouse	Higher costs associated with larger vehicles	Delivery is more easily outsourced to 3rd parties	Smaller inventory space at warehouses

Figure 2 – Advantages and Disadvantages of Network Types

2.8. Modeling and Simulation

A common approach to modeling a supply network is the use of spreadsheets. Spreadsheets are simple and easy to use, however they do not provide proper support for the dynamic layout of a supply network and do not provide complex features to deal with routing issues.

An alternative approach is simulation modeling which may incorporate delivery system variables. The main advantage of using simulation in place of spreadsheets is the calculation of vehicle routing on street networks. Spreadsheets infer an “as-the-bird-flies” delivery that may oversimplify and distort costing data. The “vehicle routing problem” has been studied in supply chain management for over 50 years. In one study, a modeled system looked at vehicle routing that involved multiple deliveries throughout the day (Azi, et al., 2012). The success rate of deliveries was a factor that contributed to increased costs. Success rates were affected by delivery windows and customer density (Boyer et al., 2009) and whether packages required a signature from customers.

The use of GIS technology to account for environmental changes such as traffic, building entrances and constantly changing road conditions enhances the results of simulation modeling (Lv et al, 2008). GIS is frequently used in the construction and engineering industry with an emphasis on supply chain management. In one study by Irizarry et al. (2013), the materials of a construction project were traced through a supply chain. The advantage of using a GIS in this type of supply chain management is that more information can be provided by connected online

databases to update models and provide quick access to information such as as-built plans to users.

Hybrid simulation/analytic modeling has been used to understand uncertainty in supply chains and emergency management. Using location data of reprocessing centers of items such as construction equipment, it is possible to determine the most effective routes to return equipment throughout a large geographic region (Suyabatmaz et al., 2014). The specifications of the supply chain are entered into the simulation model and the results are analyzed by experts. In another example of simulation and GIS use, traffic flow patterns were used to evaluate mass evacuation routes and traffic flows during crises involving humanitarian efforts (Özdamar & Ertem, 2015). The simulation model showed how partitioned road segments were able to optimize traffic flow in travel lines for vital personnel such as nurses and doctors.

3. Methodology

The anyLogistix software package was chosen as a suitable simulation modeling tool for this study in order to gather the transportation costs of each type of delivery network. anyLogistix is a logistics-focused extension of the general purpose simulation software, AnyLogic. Learning how to properly use anyLogistix required testing of inputs of datasets using trial and error in order to gain an understanding of what its capabilities were and how to gain the necessary results for comparison. The software generates results using a two step process. First, a scenario must be created. This is completed by importing tables ('worksheets' or 'tabs' in Excel) of data values through Excel or by entering them manually through the anyLogistix dashboard. Once the values have been correctly formatted, they can be imported into the scenario which can then be run as an experiment. There are several kinds of experiments that anyLogistix is capable of running, such as Greenfield Analysis, Network Optimization, and Simulation etc.

A simulation experiment was determined to be the most suitable for this study. When the simulation has been loaded and processed, it can be run for 365 days. After the 365 day run, the results can be read and analysed.

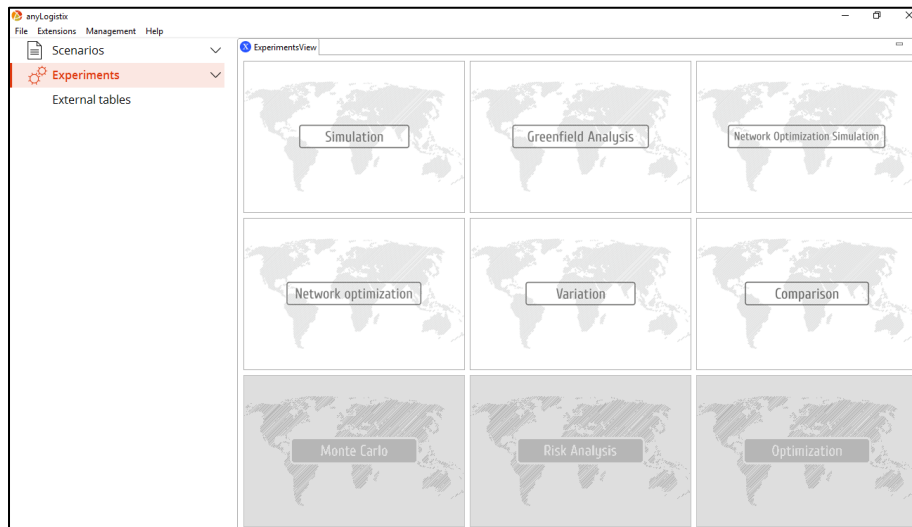


Figure 3 – Types of anyLogistix Experiments

Several steps were required to prepare the scenario for experimentation. First, relevant delivery network data were identified, such as vehicle and package dimensions, vehicle operation cost per kilometer, customer demand, spatial locations of customers and DCs. Measurements were converted from imperial to metric. Next the data were input into Excel in the proper format. The complete Excel file was then imported into anyLogistix as a scenario and run as an experiment for 365 days resulting in total transportation costs. After the experiment was run, the results of the two experimental runs were compared for analysis.

3.1. Delivery Network Assumptions

3.1.1. Base Cost

Cost per mile to operate each type of vehicle is an important factor to take into account. anyLogistix provides various options to calculate transportation costs based on weight, volume and distance (Figure 4). Volume-based transportation cost and distance-based cost were examined. However, in the present study, transportation costs are calculated based on the distance. Therefore effective transportation cost is calculated as cost per/km or mile multiplied by distance where cost per/km is the cost of transporting 1 kg of product to a distance of one kilometer or one mile irrespective of weight and distance travelled.

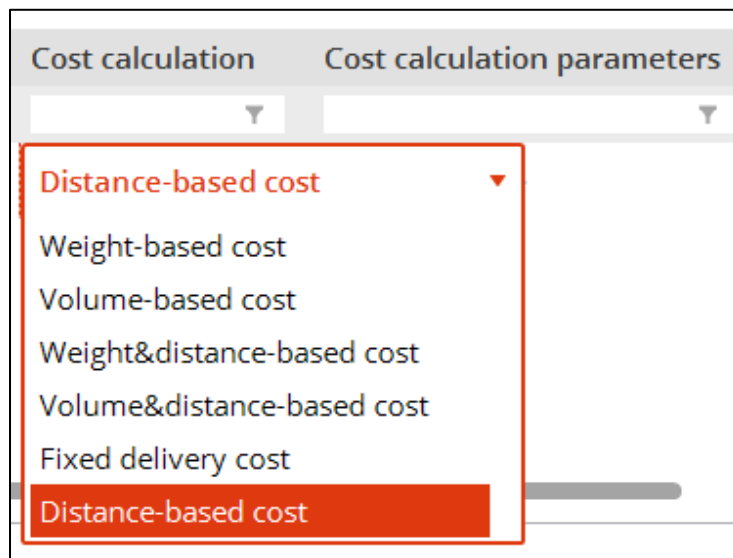


Figure 4 : Cost Calculations

3.1.2. Vehicle Package Carrying Capacity

Using such data as vehicle size, fuel per mile of delivery vehicle, and package dimensions (Table 1) the cost analysis of Amazon and Walmart's delivery network was performed. After reviewing Amazon box sizes, the dimensions of an average size package was set to 10 inches x 10 inches x 5 inches = 500 inches³ (0.0082 m³)¹. Using information from Wang (2015), the weight of an average Amazon package was about 5 pounds or under. For Amazon we assume a cargo van, such as the Ford Transit Connect standard model which is a 169-hp 4-cylinder van. It has 21 miles per gallon in city mileage and payload capacity of 1,600 pounds and the Long Wheel Base model has a cargo capacity of 168.5 cu ft (4.77 m³)². Under the Uber model we consider a Toyota Camry which has in city fuel average of 25 miles/gallon.³ If we assume a gas price of \$2.50 per gallon, we can transport 53 packages for \$2.50 per mile. This gives us a cost of transporting one package as \$0.047 for a mile under a full truck load capacity. For a cargo van we can transport 581 packages for \$2.50 per mile. This gives us a transportation cost of \$0.0043 per package. For a cargo van we can transport 581 packages for \$2.50 per mile. This gives us a transportation cost of \$0.0043 per package. These calculations assume a full truck load (FTL) policy which is not appropriate for the same day delivery model under the assumption that the delivery has to be made even if there is not a full truck load. Therefore alternative methods to calculate transportation costs were explored which are detailed in the next section.

¹ <https://incompetech.com/gallimaufry/amazonboxes.html>

² <http://www.autotrader.com/best-cars/the-6-best-cargo-vans-for-your-business-226694>

³ <http://www.caranddriver.com/reviews/2017-toyota-camry-in-depth-model-review-2017-toyota-camry-cargo-space-and-storage-review-car-and-driver-page-7>



	Amazon Delivery Van: Ford Transit Connect	Uber Model: Camry Sedan
Volume	4.77 m ³	0.436 m ³
Average Package Volume	0.0082 m ³	
Average Vehicle Capacity	581 packages	53 packages
		

Table 1 – Vehicle and Package Specifications

3.1.3. Cost per Mile or Kilometer

The cost calculation based on miles driven for each delivery is difficult in anyLogistix as there is no way to determine dynamic costs for each delivery. We found that mileage for each of the vehicles in both models is around 21-23 miles per gallon which is not a substantial difference. Additionally, the cost per mile calculation is difficult due to other factors such as the purchase price of vehicles, insurance, and regular maintenance costs which would require additional financial information outside the scope of this study. Therefore an appropriate alternative for this rate was determined to be the U.S. 2017 Standard Mileage Rates for Business, available on the IRS government website (IRS, 2016) and found to be 53.5 cents (rounded up to 54) per mile. According to the IRS, this rate applies to the standard mileage rates for the use of a cars, vans, pickups or panel trucks. The rate is based on an annual study of the fixed and variable costs of operating an automobile. Although different sized vehicles may have different costs per

mile, for the simplicity of this study cost per kilometer was considered the same for both scenarios. The average speed during delivery of both vehicles was set to 30 miles per hour or about 49 kilometers per hour (Table 2). In the present study, total transportation costs are calculated based on the total distance travelled (embedded in the formula). Effective transportation cost is calculated as cost per kg per km multiplied by distance. Where cost per km is the cost for transporting 1 kg to a distance of one kilometer or one mile irrespective of weight and distance travelled.

	Cost per Mi	Cost per Km
Cost per Distance (IRS Rate)	\$ 0.54	\$ 0.34
	Mi per Hr	Km per Hr
Average Vehicle Speed	30	48.28

Table 2 – Cost per Distance Rates

3.1.4. Order Handling Policy

anyLogistix provides two kinds of transportation policy for the handling of orders. The two policies are Less than Truck Load (LTL) and Full Truck Load (FTL). Transportation policy is important in the case where distributors do not want to ship if orders are less than the vehicle's capacity. In the current study we consider FTL policy too unrealistic to follow primarily because orders may need to be dispatched as soon as they are received. Therefore, an LTL policy is selected so that an order of any amount can be shipped.

The path of deliveries were set to non-straight to follow actual road networks from the anyLogistix router server. A straight path follows the travel distance that is calculated as the geodesic distance between points, or, in other words, an 'as-the-bird-flies' path to customer

locations. A straight path parameter setting could be a suitable scenario for a simple analysis of drone deliveries in a future study.

3.1.5. Customer Demand and Lead Time

To create the most realistic customer demand of a delivery network under the simplest possible conditions, two demand methods were considered. The first method uses a historic demand type under which the quantity and frequency of product requests from customers have predetermined values. This captures the essence of point of sale data which is frequently collected in e-commerce. The same point of sale data will be used for both scenarios. The second method uses a periodic demand type under which the quantity and frequency of product requests from customers follows a triangular probability distribution. A triangular random distribution demand simulates customer demand in a more realistic way. The minimum number of orders was set at 1, the max was set at 15 with customers being able to order every 5 days. Using demand randomness captures the dynamic nature of real world conditions most accurately. Traditional analytical tools only provide average values. True randomness can only be taken into account using simulation modeling.

Each time a simulation is run under the periodic demand scenario, the output statistics will vary due to probabilistic distribution. Therefore to come up with a mean value, several iterations of the experiments are necessary. For this purpose another experiment, called variation, is run for 5 replications.

The lead time is the number of days in which the ordered product is expected to be received by the customer. This parameter is what specifies a same-day type of delivery scenario. A one day lead time is set to ensure that a customer receives the package one day after ordering.

3.1.6. Other Costs

The carrying and facility costs associated with the operation of a distribution center are significant. However, in the present study these costs are set to zero. Also, inbound and outbound processing costs are not considered here, they would most likely be determined in a more in depth study of the two models.

3.2. Datasets

Independent and dependent variable datasets for the development of each scenario were created. This task required the development of two datasets consisting of two types of location lists, also known as tables (Figure 5).

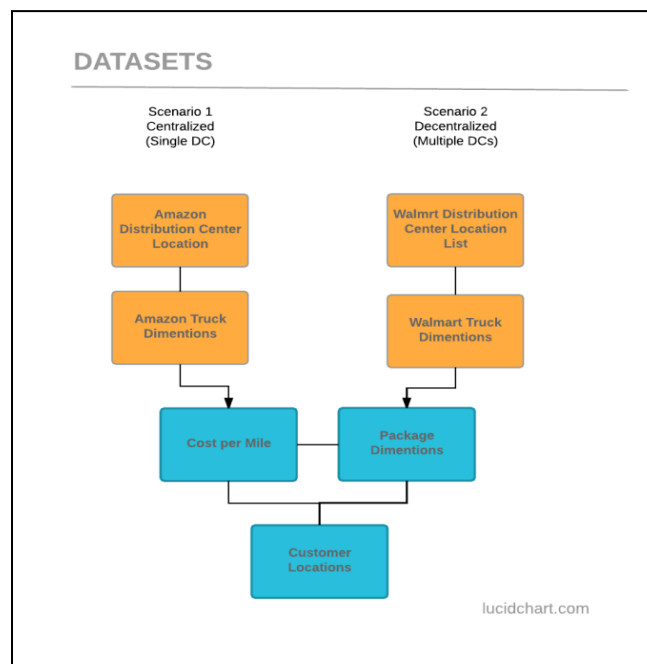


Figure 5 – Dataset Diagram

The first table contained DCs of Walmart and Amazon in Massachusetts. These DCs served as starting points from which products would be shipped to consumers. The list of Walmart DC locations was found using the Walmart store finder and the Amazon DC was found from Google Maps. Walmart stores were determined to be acceptable locations to serve as DCs. The street address, town, and zipcode of each DC was copied into Excel and cleaned using macros. The Walmart location list served as the variable for the decentralized model and the Amazon location, located in Fall River, served as the variable for the centralized model. In total, there were 49 Walmart locations and 1 Amazon location.

The second table contained a simple set of customer locations. The table was created by collecting every zip code in Massachusetts with latitudes and longitudes from USPC.com, downloaded as an Excel file. Therefore, in this study, 700 zipcodes represent 700 customers. Once the DCs and customer location tables were created and organized into the properly formatted tab style, the Excel tables file of Walmart and Amazon were imported into anyLogistix as scenarios.

3.3. Formatting

The anyLogistix data import feature required data to be imported in a precise format. To follow an exact format, a network optimization example scenario was edited as an appropriate base template. Data in several tables were removed and replaced with customer and delivery network data. Due to inaccuracies of the software's address geocoding, the Walmart DC location table required that we supply the latitude and longitude coordinates. To solve this issue, the street addresses of each Walmart address were loaded into an address-to-zip-code converter app via the USPS website. Once the addresses had been consolidated into zip codes, customer and DC

locations were uniquely labeled to avoid duplication errors. Finally, the tabs of the tables were configured to match the accepted format of anyLogistix.

3.4. Experimental Run

The experimental run produced a map (Figure 6) showing the links of customer deliveries (blue icons) to the Amazon Fall River DC (red icon).

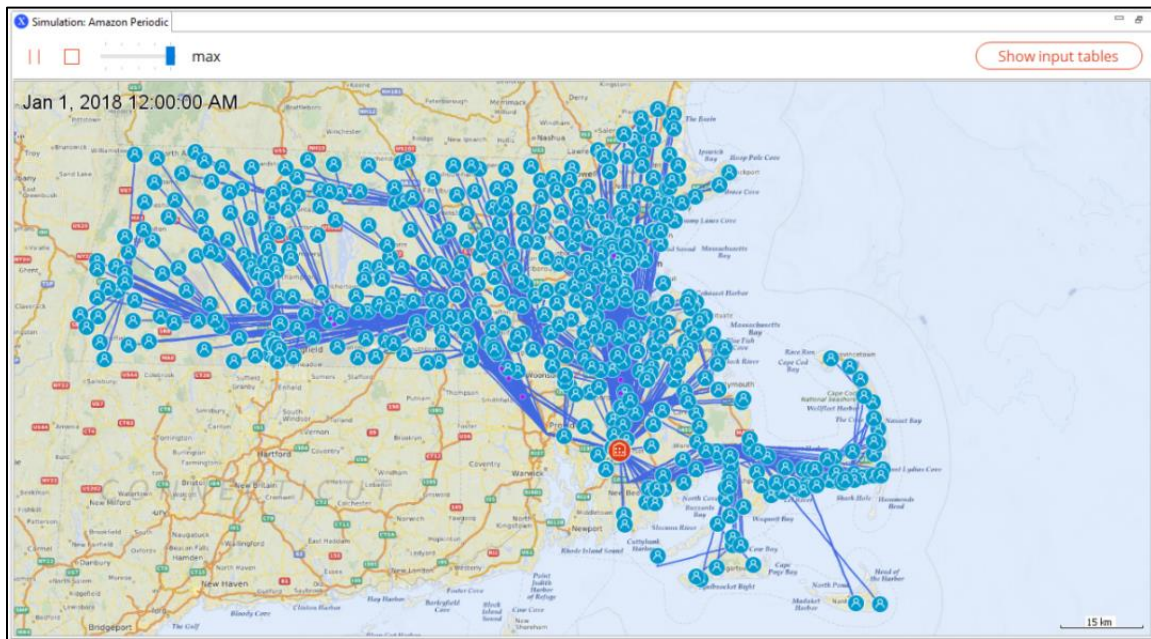


Figure 6- Amazon Scenario (Single DC)

To draw comparisons between the two kinds of networks, a model of the Walmart network was run, producing a map (Figure 7) of the simulated network.

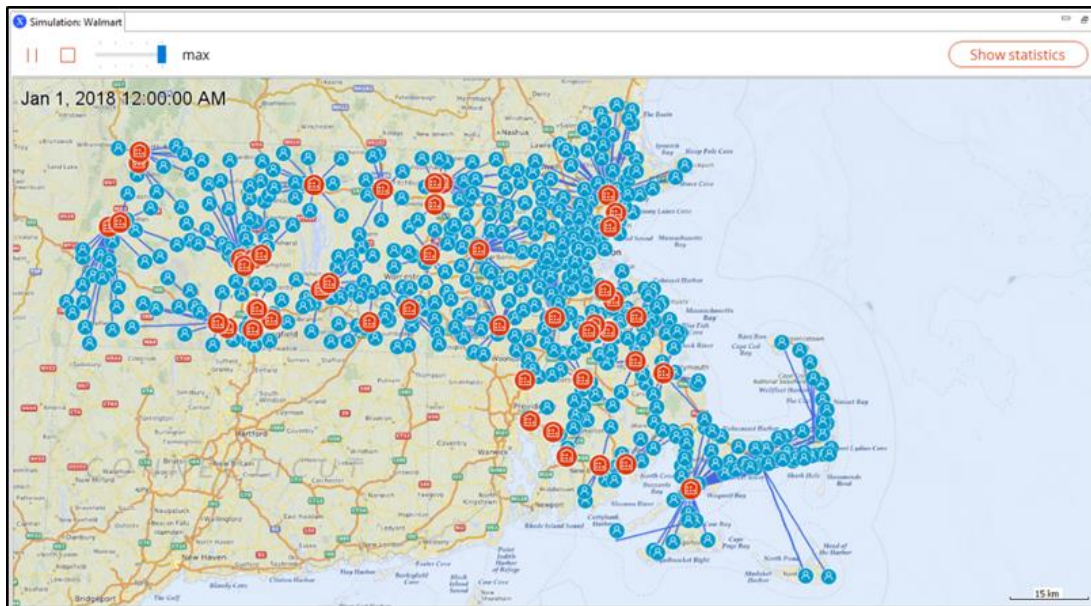


Figure 7 – Walmart Scenario – (Multiple DCs)

The map displays the links between customer locations and the nearest Walmart location. Customer density was not normalized relative to population. This may have resulted in producing higher-estimated costs to Walmart DCs in western Massachusetts and under-estimated costs to Walmart DCs in eastern Massachusetts.

anyLogistix provides numerous statistics which can be used to collect corresponding data during simulation experiments based on items in the scenario. The tracked statistics include collected data of money, volume, quantity, ratio, and histogram values (Figure 8). In depth analysis of facility costs such as the DC's generated revenue and incurred expenses may be

performed in future studies. The current study looks at transportation costs of which the data is updated with every sent shipment and calculated according the delivery path's parameters.

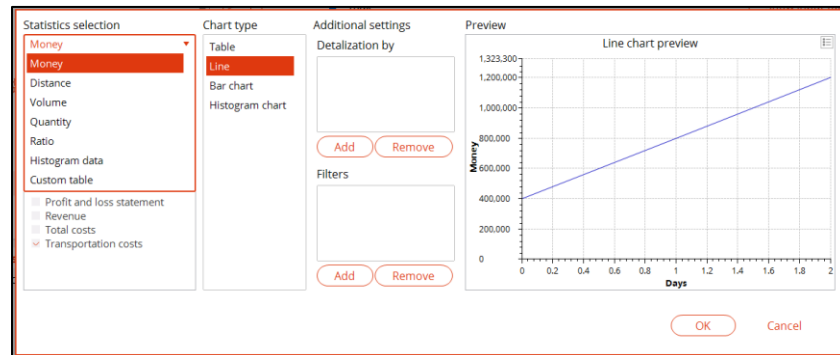


Figure 8 – Transportation Costs

4. Conclusion and Future Research

4.1. Conclusion

Despite the growth of last mile delivery services and emerging technology, little research has been conducted comparing types of last mile delivery networks. Greater demand and advances in technology will continue to compel organizations to alter their logistic strategies. This thesis aims to understand the differences in transportation costs and what factors affect those costs based on simulated conditions.

Under the historic demand Walmart scenario, running for 365 days, the transportation cost resulted in a value of \$4,169. Under the historic demand Amazon scenario, running for 365 days, the transportation cost resulted in a value \$27,111. The periodic demand Walmart scenario yields \$215,516. The periodic demand Amazon scenario yields \$1,400,775. The periodic demand type provided the most realistic real-world values. The transportation costs of Amazon, under both demand types, were 6 times greater than those of Walmart. The extra miles driven by the Amazon model were more costly. Several factors may explain this large difference, such as the

large distance that Amazon trucks are required to travel in order to meet demand. The spread of Walmart DCs proved to significantly favor the decentralized network. When accounting for carrying costs of DCs, the cost differences may be less.

The above analysis raises some important questions. Why is Amazon winning in a centralized setting even with higher transportation costs? Is this an operational or logistics problem or is it a shift in consumer's shopping habits? A possible reason for decentralized problems may be an issue with higher setup costs associated with facilities at multiple locations pared with other overhead.

4.2. Future Research

Work to further this study would likely include the refinement of model parameters to better simulate a more realistic real world scenario. This might include a refinement of Walmart and customer coordinate locations and normalization of customer locations based on populations of towns of Massachusetts. A more precise cost per mile parameter for the different vehicle types could be calculated. A study into drone routing may be performed using the straight path parameter under similar experimental runs and determine if long distance drones have a cost advantage over short distance drones. Changing the cost calculation type to weight and distance based costing, volume based costing, or fixed delivery costs may produce an alternative set of results that better emphasizes effects of package to vehicle policies. Actual data of Amazon or Walmart's historical demand could also be used to analyze a particular year or to determine if seasonality exists between customer deliveries and different regions. As demand for same-day delivery increases, a better understanding of such factors will provide companies with greater competitive advantage.

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