**Modeling the Value to Retailers Due to Redesigning the Grocery Supply Chain**

by

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Bachelor of Science in Chemical Engineering, Cornell University (1998)

Submitted to the Department of Civil and Environmental Engineering and the Sloan School of Management in partial fulfillment of the requirements for the degrees of

***Master of Science in Civil and Environmental Engineering***
***and***
***Master of Science in Management***

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**Abstract**

ES3, a wholly owned subsidiary of C&S Holdings, is a third party grocery and consumer goods distribution company operating a large distribution facility in York, PA. Under the traditional model for grocery distribution, manufacturers ship products to their manufacturing distribution centers (MDCs), where several products from the same manufacturers are combined in shipments and sent to retail distribution centers (RDCs). The distributors operating the RDCs combine product from several manufacturers to be shipped to individual retail outlets. Currently, in Phase I of its operations, ES3 improves on this model by replacing MDCs from several manufacturers with a single facility, consolidating orders from several manufacturers and reducing lead time and optimal lot sizes for distributors. Eventually, ES3 will reach Phase II of its operations, where certain products will bypass RDCs completely and be delivered directly to individual retail outlets.

This thesis is concerned with efforts to build a model to quantify the benefit distributors receive from using ES3 in both Phase I and Phase II of its operations. The model was built using shipping, receiving, operations, and transportation data from C&S under the assumption that C&S was a good proxy for other distributors which are potential customers for ES3. The purpose of building the model was two-fold. First, ES3 would like to recruit distributors as customers and charge them for its services. The model will help demonstrate the savings these distributors can achieve. Second, distributors' savings increase as the number of manufacturers stored at ES3 increases. ES3 hopes to demonstrate this effect through the model and momentum for growth.

The model quantifies savings in inventory costs, transportation costs, and operations costs as a function of the number and types of products the user chooses to source from ES3. These savings vary dramatically depending on the size of the distributor using the model, but can be very significant, especially for large distributors.

**Acknowledgements**

I would like to thank C&S Wholesale Grocers and ES3 for providing me with the opportunity to study their companies and their businesses, for access to the information throughout the companies, and for their support of my internship and the LFM program at MIT. I received help from many employees at both companies to learn the basics of the business and to track down the information I needed. I am especially thankful to my supervisor, Leon Bergmann and my project champion Reuben Harris. I also am very grateful to the many other employees who took time to work with me including John McGonigle, Dave Labelle, Sam Garland, Mike Berg, Wendy Acerno, Dave Badten, Phil Crowley, Walter Pong, and Charles Kirk.

I would also like to thank Don Rosenfield and David Simchi-Levi for their help as my advisors, and Don for all of his hard work as director of the Leaders for Manufacturing Program. I am also indebted to my classmates at MIT from whom I have learned so much and who were very helpful and supportive throughout the internship and thesis process.

I would also like to recognize the entire LFM program for its support of my thesis and for the opportunity to study at MIT.

Finally, I dedicate this thesis and all of my academic work at MIT to the memory of my father, Martin Amati, whose love and example are directly responsible for all I have accomplished.

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*Chapter 1: Industry and Company Background*

## 1.1 Grocery Distribution Industry

Distribution of consumer goods is perhaps the industry most underappreciated by the American consumer for the benefits it provides to quality of life in this country. Americans are fortunate to enjoy a wide array of choices in almost every product category imaginable, including goods as diverse as electronics, clothing, pharmaceuticals, sporting goods, appliances, home goods, music, books, and consumables. While consumers are conscious of important factors such as product design, quality of manufacture, brand image, and price when making purchase decisions, likely a relative few are aware of the complicated infrastructure and industry necessary to deliver those goods from their numerous points of origin across the country and the world to their countless final retail destinations. Distribution is especially important and impressive in the grocery industry, where profit margins are low, product diversity is high, and shelf life is often limited by spoilage. Despite these challenges, American grocery distribution has made available and affordable to American consumers across the continent fresh produce and numerous permutations of common products. Further, grocery goods can be purchased in retail outlets of all sorts, from gas stations to small corner stores to large grocery mega-stores, and product choice is virtually as varied everywhere in the country, from a rural New England town to downtown Los Angeles.

The breadth and efficiency of the distribution channels in the United States is the result of necessity. Diverse consumer needs demand a large selection of products and manufacturer are anxious to profit by delivering. The result is pressure on the distribution industry to deliver any product, anywhere, any time, and to do so cheaply. Retail sales in the United States exceeded $3.5 trillion in 2002.[1] Sales in grocery stores alone surpassed $440 billion,[2] creating a need for an extensive grocery distribution system. Until recently, major players in the grocery distribution industry have primarily been regional companies, though recently consolidation has given the largest players

[1] US Department of Commerce, http://www.census.gov/prod/2003pubs/br02-a.pdf, pg. 15
[2] US Department of Commerce, http://www.census.gov/prod/2003pubs/br02-a.pdf, pg 15

something closer to a national presence. As of 2003, the three largest players in the industry were Minneapolis based Supervalu, with sales in 2003 approaching $20 billion, C&S Wholesale Grocers, a Brattleboro, VT based company with 46 facilities in 13 different states, 737 customers in 23 different states, and 2003 sales over $11 billion, and Nash-Finch, based in Edina, Minnesota with 2003 sales of approximately $4 billion .[3,4,5] Competition among players is intense, and contracts with retailers are typically signed for periods of 4-5 years.

## 1.2 C&S Wholesale Grocers

C&S was founded in 1918 by Israel Cohen and remains privately held by Cohen's grandson, Rick Cohen, who ascended to the position of company president and CEO in 1989. Prior to its acquisition of Fleming, C&S's operations were entirely in the Northeast, stretching as far west as Ohio, and the mid-Atlantic, stretching as far south as Virginia. Under Rick Cohen's leadership, C&S has grown from a successful, but modest, wholesaler to the 8th largest privately held company in the United States. Even prior to the Fleming acquisition, the company had 29 warehouses and served 112 different customers at over 3000 different retail outlets.[6] Sales have mushroomed from $300 million in 1986 to over $11 billion in 2003.[7]

Much of this success is due to C&S's commitment to innovation in an industry with tendencies towards slow change and reluctant acceptance of new technology. In 1991, C&S revolutionized warehouse operations by introducing self-managed teams. By eliminating the old system of minimum quotas for employee productivity and replacing it with a system which financially rewards each employee for productivity and accuracy in product selection, C&S was able to reduce total labor costs by 20% and increase employees' average compensation by increasing the average employee productivity.[8]

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[3] C&S website, www.cswg.com
[4] Supervalu website, http://www.supervalu.com/index.html
[5] Nash-Finch website, http://www.nashfinch.com/about.html
[6] E-mail interview with Reuben Harris, 3/11/04
[7] C&S website, www.cswg.com
[8] C&S website, www.cswg.com, e-mail interview with Reuben Harris, 3/11/04

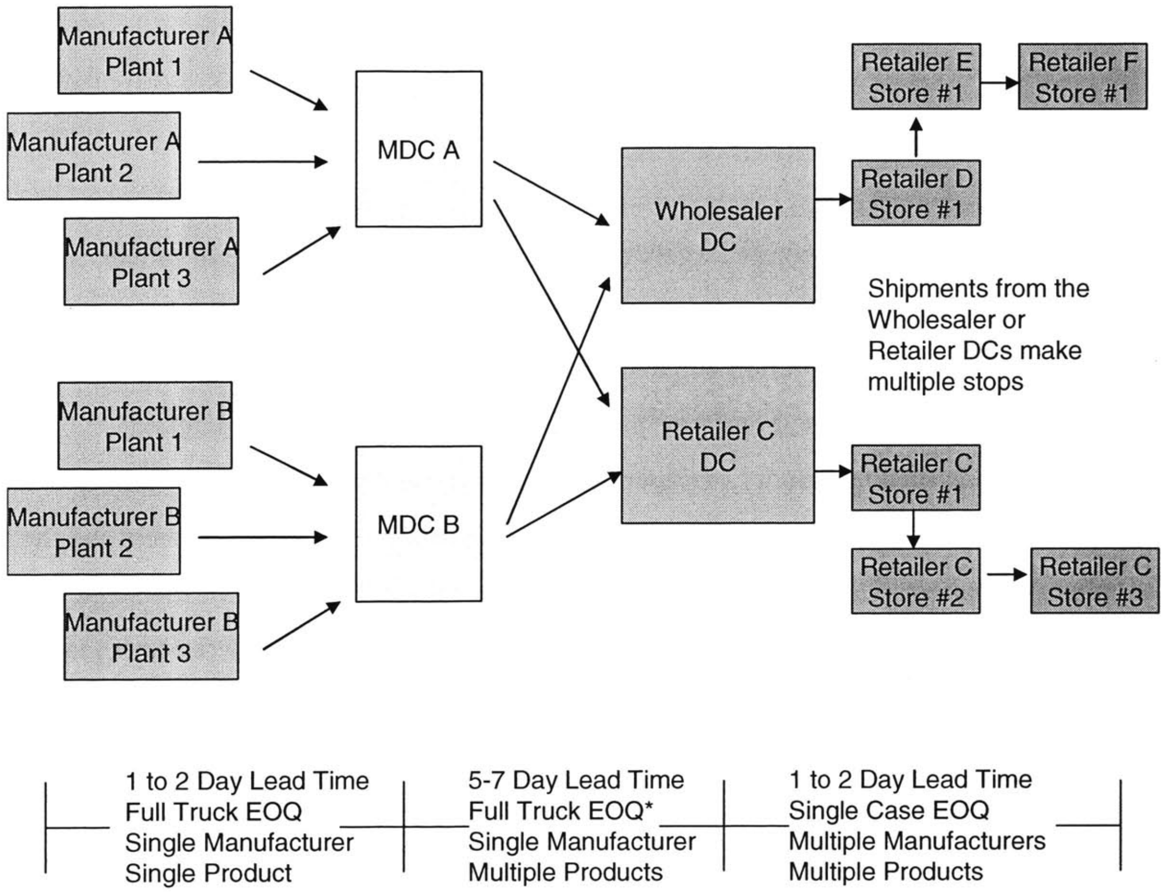
This innovation has been instrumental in C&S achieving average annual sales growth of over 22% for the past 6 years.

## 1.3 Traditional Grocery Supply Chain Model

C&S and its competitors operate largely under the same basic supply chain model, with each competing on its ability to control costs while meeting contractual service obligations. Grocery distribution ships a wide variety of products, some of which (produce) are grown or raised on farms and others (dry foods such as cereal and consumer goods such as laundry or paper goods) which are manufactured at factories. In both instances, the supply chain extends beyond these facilities to their suppliers and their suppliers' suppliers. However, the suppliers of these companies are out of the scope of C&S's contact, so for the purposes here, the supply chain will be considered to begin at the manufacturer or grower. Secondly, for the sake of simplicity, the term manufacturer will be used to refer to both manufacturers and growers. With this understanding, the traditional model has 4 basic steps.

First, the product is manufactured at the manufacturer's facility. From there, it is sent to a manufacturer distribution center (MDC). In the MDC, different products from the same manufacturer are combined and shipped to either a wholesaler's distribution center (like a C&S facility) or a retail distribution center for retailers, like Wal*Mart or Kroger, who are self-distributing. In both instances goods from several manufacturers are combined at these RDCs and sent to individual retail outlets, the final stage of the supply chain. Of course, goods are then purchased by consumers for personal use. While a few companies, perhaps most notably Coca-Cola, have models which are exceptions to this traditional model, the vast majority of companies, including C&S, use this supply chain model as the basis for their operations. The chart on the next page illustrates the traditional model.

*Figure 1.3.1 – Traditional Grocery Supply Chain*




*RDCs must order a full truckload from a single manufacturer, though there may be more than one product on the truck, making the effective EOQ for a single product below a full truck.

While this supply chain model has been effective in making products readily available across the country, it is inefficient in many respects. Lead times are fairly long, especially the lead time between the MDC and RDC. Self-distributing retailers and wholesalers, who are collectively referred to as distributors[9], must wait a week (or more in some cases) to replenish out of stock items, causing either service level hits or high inventory levels. Further, manufacturers set prices to encourage distributors to order full truckloads from a single manufacturer. This large optimal lot size, or EOQ, increases cycle stock and adds costs to the system. For the purpose of this thesis, EOQ is taken as the optimal lot size for a distributor to order. A third limitation of the model is the number of locations where inventory must be stored. For each product, there is inventory

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[9] Appendix 1 is a glossary with definition of terms as they are defined for the purposes of this document.

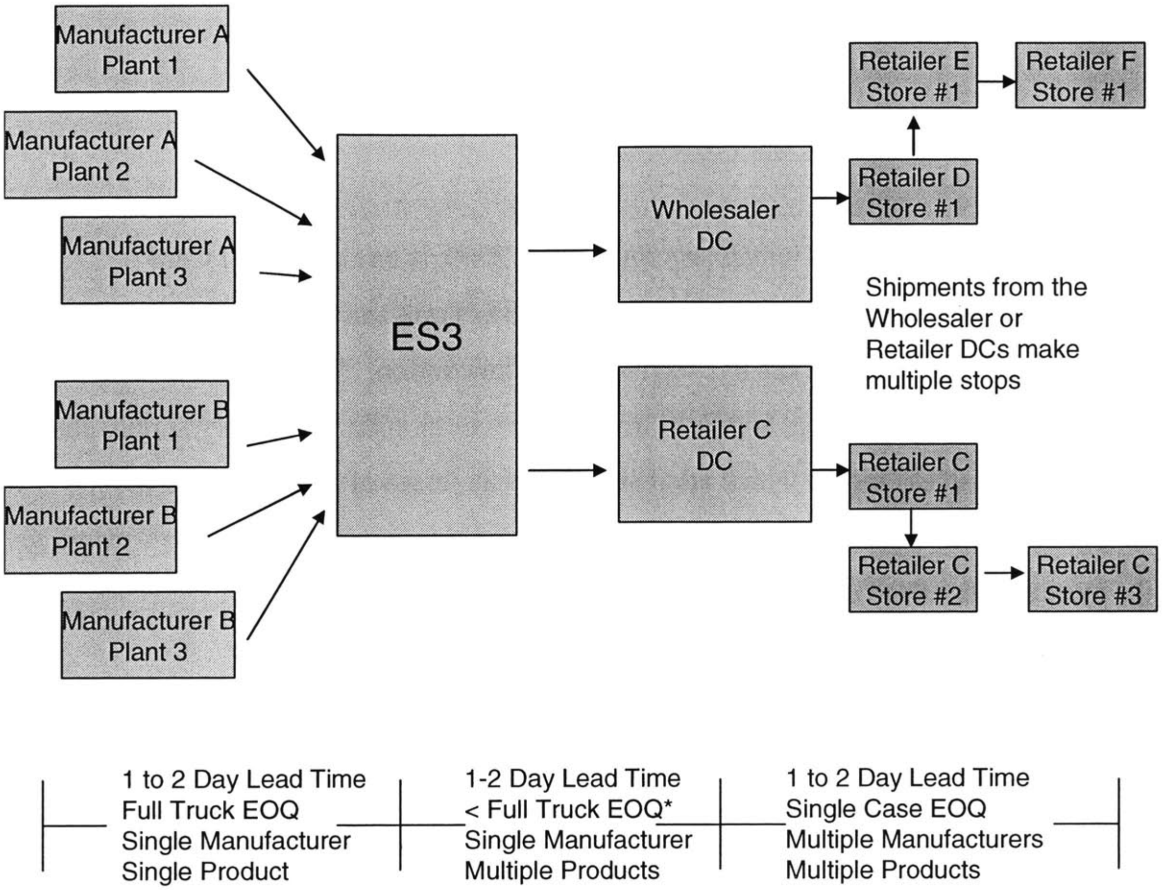
in as many as 4 sites along the chain. Finally, the system is not transparent to manufacturers, who lose track of their products once it leaves their MDCs.

## 1.4 The Grocery Supply Chain Model at ES3

ES3, a wholly owned C&S subsidiary founded in 2000, is an example of C&S's commitment to continue or accelerate its rapid growth rate and to continue to be an industry leader in both process and technological innovation. The mission of ES3 (Efficient Storage, Shipping, and Selection) is to revolutionize the grocery supply chain by use of a business model which addresses the weaknesses of the traditional model. The ES3 model aims to reduce lead times, EOQs, and inventory levels in order to streamline the system and reduce costs to all players.

ES3 plans to take its supply chain model through two phases. In the supply chain model for the first phase, under which ES3 operates as of December 2003, a single ES3 facility replaces multiple MDCs. The supply chain in this stage is diagramed in Figure 1.4.1.

*Figure 1.4.1 – ES3 Phase I Supply Chain Model*




*Wholesalers and retailers still generally order a full truckload of product, but with many manufacturers at ES3, EOQ of a specific product is smaller than in the traditional model.

ES3 is able to replace several manufacturers DCs with a single facility by the use of an extraordinarily large warehouse in York, PA. The first of several planned facilities for ES3, the York facility is 110 feet tall, has capacity to load and unload a total of 700 trucks an hour, and can store over 9,000,000 cases.[10] To accomplish the enormous challenge of unloading, storing, selecting, and loading so many cases in such an immense facility, ES3 has employed revolutionary information and robotic technology. Much of the facility is automated. Project putaway and retrieval is accomplished by 15 cranes, 110 feet high each, which place pallets in their correct slots.[11] As of December 2003, ES3

[10] E-mail interview with ES3 manager Leon Bergmann, 3/11/04
[11] E-mail interview with ES3 manager Leon Bergmann, 3/11/04

had filled 75% of capacity at the first tower (of three planned) at the York site and had 18 customers.[12]

Under its current supply chain model, ES3 has already significantly reduced inefficiencies from the traditional model. Lead time to distributors and EOQ are reduced because the multiple manufacturers in the facility allow consolidation of several manufacturers on a single truck. Additionally, ES3's cutting edge IT and robotic technology allow it to operate the York facility more efficiently than most manufacturers operate their MDCs, reducing operating and shrinkage costs.

As ES3 grows and continues to add manufacturers to its customer base, EOQ's will continue to decline as more and more consolidation opportunities become available. Eventually, ES3's management hopes to reach the second phase of its business model and operate under an even more streamlined supply chain. In this phase, products will be delivered directly from ES3's facility to their final retail destinations. EOQ will be reduced as low as a single case, and lead time will be cut as low as 24 hours. Figure 1.4.2 outlines the supply chain under ES3's direct to store delivery (DSD) model.

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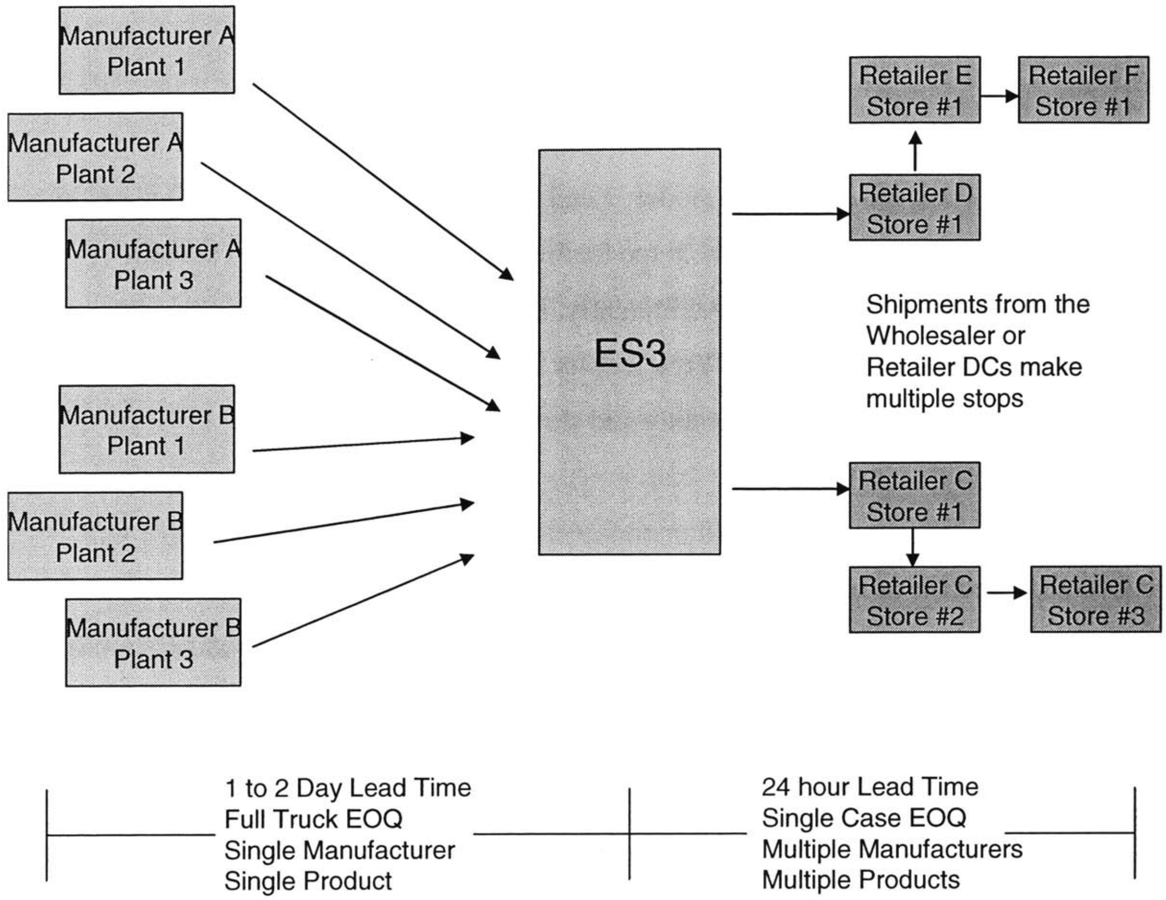
[12]E-mail interview with ES3 manager Leon Bergmann, 3/11/04

*Figure 1.4.2 Direct to Store Delivery Supply Chain Model*




ES3 does not intend that under the DSD model its facilities would completely replace wholesalers like C&S or RDCs at self distributing retailers. Instead, it will target these companies as potential customers who will outsource distribution of a portion of their items to ES3. Because the savings ES3 will create will be substantial enough to reduce costs for the distributor even after paying ES3 for its services, DSD will be an attractive option for these companies. ES3 intends that distributors will be most interested in outsourcing all but the fastest-moving items. For these products, full-truckload shipments represent more weeks of movement than for fast- movers, making cycle stock a larger percentage of the inventory on hand and making the reduction to a single case EOQ more beneficial.

Because ES3 is targeting distributors as customers, there are three reasons the company must have an understanding of how much distributors stand to save if they outsource to ES3. First, ES3 must know what it can charge for its services. Second, before distributors will agree to become ES3 customers, they must be convinced that the savings are real and have a good understanding of the amount and causes for the savings. Third, because distributors' savings increase as the number of manufacturers sourced from ES3 increase, ES3 hopes to demonstrate this benefit and create momentum for further growth. The LFM internship for 2003 was focused on answering the question of how much distributors will save under the DSD model. The end result was a model which estimated savings based on input from potential customers, which will serve as a sales tool for ES3 as well as helping ES3 understand the benefits it provides.

## 1.5 Previous Efforts at Grocery Supply Chain Cost Reduction

Efforts to increase efficiency in the grocery supply chain are not new. In the 1980s and early 1990s senior managers became especially interested in reducing lead times by introduction of Quick Response (QR) to customer demand.[13] Quick Response, a term borrowed from the fashion industry, is a general concept aimed at reducing lead times throughout the supply chain. In the 1990s in the grocery industry, lead time reduction programs took the form of efforts at "time compression, efficient consumer response (ECR), and fast flow replenishment systems."[14] ECR efforts were largely a response to Wal*Mart's success in its entry into food retailing.[15] ECR consisted of better information sharing across the supply chain to enable better prediction of demand, reduce inventory across the chain, improve product mix on store shelves, and reduce the number of stockouts.

[13] Fernie, John "Quick Response: An International Perspective." International Journal of Physical Distribution & Logistics Management, 1994.
[14] Fernie, John "Quick Response: An International Perspective." International Journal of Physical Distribution & Logistics Management, 1994
[15] Stewart, Hatden and Steve Martinez. "Innovation by Food Companies Key to Growth and Profitability."Food Review, Spring 2002, pg. 28.

Retailers have also sought to improve efficiency through mergers and acquisitions in order to spread fixed costs across more products and reduce average product costs and increase their power to negotiate contracts with distributors. The trend toward larger chains has pushed the nationwide percentage of retail sales attributed to the four largest retailers from 17% in 1987 to 27.4% in 2000.[16] Consolidation has been accompanied by an increasing number of large retailers operating their own distribution centers; in 1999 47 of the 50 largest retail chains were self distributors.[17]

However, the savings from both quick response efforts and consolidation differ from the savings potential represented by ES3. Quick response and efficient customer response are general terms which have been applied to many efforts to reduce inefficiencies in the grocery supply chain, but all of these efforts are aimed and improving the same basic structure through better communication and technology. Though systems savings can be realized, they depend on consistent communication across the chain and are not the result of structural changes to the supply chain. Consolidation or retail chains also can represent some system savings because fixed costs are spread across the industry, but the buyer power resulting from consolidation does not create true system savings but simply pushes costs from one player to another. In contrast, ES3's streamlined supply chain model creates true structural system savings which can be shared among all players.

[16] Stewart, Hatden and Steve Martinez. "Innovation by Food Companies Key to Growth and Profitability."Food Review, Spring 2002, pg. 28.
[17] Stewart, Hatden and Steve Martinez. "Innovation by Food Companies Key to Growth and Profitability."Food Review, Spring 2002, pg. 28.

*Chapter 2: Project Description and Early Efforts*

## 2.1 Overall Project Objective

In short, the objective of the project was the development of a model to quantify the value ES3 can have for distributors in both its current supply chain model (Phase I) and in the DSD model (Phase II). The model had the following basic requirements:

- Results must be tailored to an individual retailer.
- Input from user must be simple and readily available within the company.
- Calculations must be easily defensible using real world data, not simply theory.
- Model must be useable and well understood by representatives from a variety of functions. (Finance, warehouse operations, senior management, etc.)
- Model must be developed using a simple software platform, such as MS Excel, because no IT support or financial assistance is available.

The model will serve three purposes at ES3. First, it will be used as a sales tool to help explain the benefits of DSD to potential customers and demonstrate the type and magnitude of those savings. Second, the model will be used to give ES3 some idea of what it will be able to charge retailers for the DSD service. While actual fees and contracts will have to be worked out in detail with each individual customer, the model will be used as a starting point for ES3 to determine how to approach these negotiations. Finally, the model will be used to show the impact of increased scale to foster additional growth, as distributors recognize their savings increase with the number of manufacturers at ES3.

## 2.2 Basic Approach

Though the ultimate objective of the project was well defined, the details were very ambiguous. Little direction was given regarding the types of savings which would likely exist, the mechanism for quantifying these savings, or final form and appearance of the model itself. However, ES3's management was very clear that it was important that all results from the model were very defensible and based on real world results and data rather than simple theory. Ideally, detailed data from each potential customer would be analyzed individually and accurate results would be given for each. In reality, distributors typically will not spend the time and resources to provide and analyze large amount of detailed data. Therefore, the following basic approach was adopted early in the project. Because C&S is the parent company of ES3, I had access to all data at C&S. Because of C&S's large size and numerous facilities, this data provided insight into how operations change with facility size. Further, C&S operates its supply chain in a manner similar to most of its competitors. For these reasons, C&S data was used as the basis for the model. The basic approach was to calculate what the savings would be in the case of C&S, and then to adjust the results rationally based on simple inputs from the user. This framework was readily accepted by ES3 management.

## 2.3 Learning the System and Areas for Savings.

In order to model savings to the retailer, it was necessary that I understood the supply chain at some level of detail and identify potential areas where savings would occur. My first few weeks were spent meeting with employees at C&S and ES3 to compare the two models and to enumerate potential savings. I met with Sam Garland, warehouse operations manager at C&S, John McGonigle, Vice President of Transportation at C&S, Peter Nai, Vice President of Procurement at C&S, Dave Labelle, a buyer in Peter Nai's department, Dave Badten, in ES3's customer service department, and my manager on the project, Leon Bergmann, ES3's senior director of economics. By speaking with these individuals, I was able to compare business operations in the current C&S system with the current ES3 system and the vision for how operations would work under DSD. From these discussions, I generated a list of potential benefits ES3 would have and who was most likely to benefit. At this point I had no idea if these savings were real or quantifiable, but this list served as the starting point in my development of the model. This list is reproduced in Figure 2.3.1.

*Figure 2.3.1 – Potential Areas for Savings*

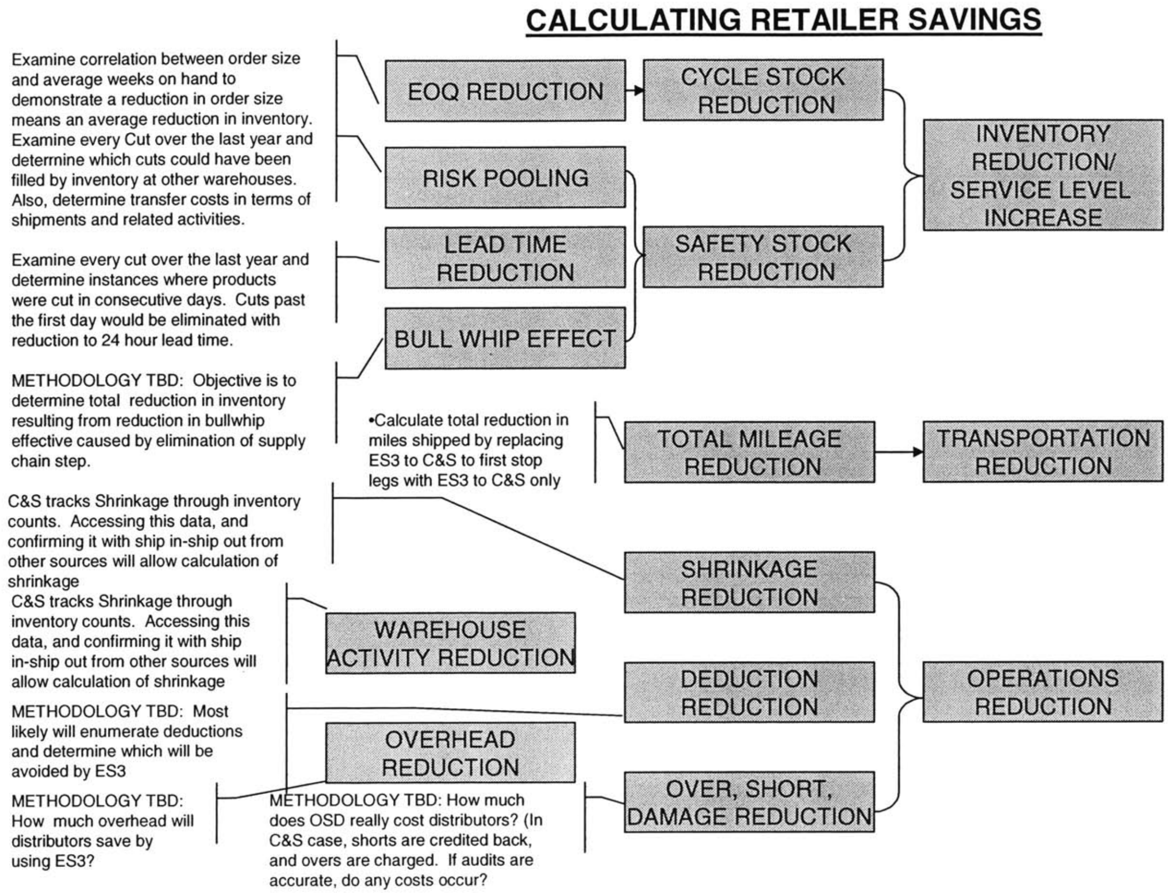
| Savings | Supply Chain Step | Benefactor |
|---|---|---|
| ES3's scale will allow more attractive shipping contracts with third party shipping companies. | Factory to MDC, RDC to outlet | Manufacturer and Distributor |
| ES3's will be able to pick up product from multiple manufacturer's, reducing number of LTL (less that truckload) shipments | Factory to MDC | Manufacturer |
| ES3 will replace multiple MDCs (reducing shipping miles in some instances) | Factory to MDC | Manufacturer |
| Elimination of transportation costs between MDC and RDC | MDC to RDC | Manufacturer and Distributor |
| Reduction in deductions paid to manufacturers due to elimination of MDC to RDC shippind | MDC to RDC | Distributor |
| Redution in shipping miles to indivudual outlets because ES3 will be serving multiple retailers in one location. | RDC to outlet | Self Distributing Retailers |
| Reduct fron in LTL trucks to individual retail outlets. | RDC to outlet | Distributor |
| Higher Labor Productivity at ES3 | At MDC, At RDC | Manufacturer and Distributor |
| Reduction in shrinkage at MDC due to improved technology and better efficiency | At MDC | Manufacturer |
| Elimination of shrinkage at RDC. | At RDC | Distributor |
| Reduction in Overhead (administrative labor, etc.) | At MDC, eliminated at RDC | Manufacturer and Distributor |
| Increased Selector productivity at ES3 reduces labor costs | At MDC | Manufacturer |
| Improved selection quality reduces overs, shorts, and damages in shipments | At MDC | Manufacturer |
| Elimination of all operations at RDC | At RDC | Distributor |
| Risk pooling reduces safety stock | Systematic Savings | Distributor |
| Reduction in lead times reduces safety stock | Systematic Savings | Distributor |
| Reduction in lead time allows reduction in Eoq and cycle stock | Systematic Savings | Distributor |
| Improved information sharing due to elimnation of step will reduce uncertainty in demand to manufacturer | Systematic Savings | Manufacturer and Distributor |

At this point, these potential savings were only speculation. No data had been used to test if savings would exist, nor was is clear if data existed to perform such a test, but this list served as the basis for analysis going forward.

The next step in the process was to determine which of these criteria would be developed in the model. The first criterion was that there must be some savings to the distributors, since the objective of the model was to quantify their savings. Secondly, the data must be available which would test and support the hypothesis. Finally, the savings must be easily understood by the potential customers.

After investigating the data availability, I grouped the areas of savings as shown in Figure 2.3.2.

*Figure 2.3.2 – Categorized Savings due to ES3.*




EOQ reduction is the reduction in optimal lot size which leads to reduction in inventory. Risk pooling is a reduction in inventory due to reduced variation in demand by combining multiple stocks of inventory into one facility. Reducing lead time, the amount of time between a distributor's order placement and fulfillment reduced variation in demand while waiting for an order, allowing a decrease in inventory. The bull whip effect is the tendency for orders received upstream to fluctuate much more than final demand. Reducing the bullwhip effect reduces inventory held because demand can be better predicted. Warehouse activity and overhead are labor costs incurred in warehouse through actions directly or indirectly related to receiving and shipping orders. Total mileage represents the transportation costs incurred from shipping product to retail outlets. Shrinkage is costs from lost or stolen product. Deductions are costs distributors incur due to correcting orders received from manufacturers which contain the wrong items, wrong number of items, or are charged at the wrong price. Over, shorts, and damages are costs incurred by the distributor for incorrect shipments sent by distributors. Each area was evaluated based on the three criteria. The chart below represents the assessment based on each criteria listed above.

*Figure 2.3.3 – Determining Areas to Model*

| | Likely Level of Savings | Availablity of Data to Allow Ease of Modeling | Understandable/Believable by Audience | Expected Challenges |
|---|---|---|---|---|
| Warehouse Activity Reduction | Very High | Readily Available | Very Believeable | How to demonstrate increase efficiency by reduction in volume through DSD |
| Overhead Reduction | Moderate | Fairly Available | Moderately Believeable | leads to reduction in warehouse overhead; defining warehouse overhead |
| Bull Whip Effect | Very High | Not Readily Avail | Low Believeability | cooperation throughout supply chain; benefit is most directly to manufacturer. |
| Safety Stock - Lead Time Reduction | Very High | Readily Available | Very Believeable | Determining safety stock at each facility |
| Over, Short, Damage Savings | Moderate | Fairly Available | Very Believeable | Demonstrating a reduction at ES3. |
| Safety Stock - Risk Pooling | Moderate | Readily Available | Moderately Believeable | Convincing audience of risk pooling benefits |
| Cycle Stock | Very High | Readily Available | Very Believeable | Determining average order size |
| Deduction Reduction | High | Fairly Available | Moderately Believeable | Demonstrating a reduction at ES3. |
| Shrinakge Reduction | High | Fairly Available | Low Believeability | Demonstrating a reduction at ES3. |
| Transportation Reduction | High | Readily Available | Very Believeable | Determining which eliminated miles should be credited to the retailer. |

Based on this analysis, the 5 shaded areas were chosen to be included in the model. These areas are:

- Warehouse Activity Reduction (Operations)
- Safety Stock
- Cycle Stock
- Transportation Reduction

While several of the others represent real savings to the retailer, the challenges in modeling in an accurate and convincing way presented too much of a challenge to accomplish within the time frame of this project. They will be mentioned in all sales presentations as additional savings beyond what is included in the model. Additionally, the model estimates the increase in profits distributors will realize by operating at a higher service level due to improved service from ES3.

## 2.4 Data Collection

Once the decision to model safety stock, cycle stock, transportation, and operations savings was made, the next challenge was to collect the data necessary. This proved to be the biggest challenge of the internship because the necessary data was stored in several locations throughout the company and required help from the C&S IT department to access. Persistence and help from senior management eventually allowed me to obtain most of the data I needed. A more detailed list of data collected is listed in Appendix 2, but the most important pieces of this data are summarized below. Exact dates are withheld at the request of ES3.

- Order and shipment information throughout all northeastern C&S facilities for 416 items for 26 weeks in 2003. These items were chosen so they were spaced evenly throughout the range of average weekly movement, from the slowest movers to the fastest.
- Transportation information on all outbound shipments from northeastern C&S facilities, including distance to each stop, for eight months in 2003.
- A snapshot of all items in the system from a single day the autumn of 2002. This information included balance on hand, average movement for the past 8 weeks, and promotional movement for the last 8 weeks.
- Operating information at all New England Warehouses for 6 months in 2003. This information included number of employees at each site, productivity per employee, and equipment on hand at each facility.

The scattered nature, limited availability, and limited support from IT made working with data from different time periods necessary.

## *Chapter 3: Model Overview*

This chapter is intended to give a high level overview of the operation of the model. It describes the input the user is required to provide, the types of output generated, and the basic format used to present the data. Little detail is provided about how the calculations are performed. This topic is discussed in detail in chapters 4-9.

### 3.1 User Input

The model was designed with ease of use in mind. It is an Excel spreadsheet with several tabs. The user is required to input data into three tabs. The first tab with overall general input on the company, such as number of facilities to receive product from ES3, cost of capital, service level, average value of a case (industry average can be used), and average lead time.

The second tab requires the user to enter more detailed information on each of the user's facilities. On this tab, the user enters the name and location of the facility, volume, number of employees, wages (industry average can be used), and transportation information about shipments from the facility. Most of this information will be well known by most users, though in some cases, such as distances traveled on outbound shipments, estimates are expected. The model will prompt reasonable answers and the overall results will not be significantly affected by inaccurate estimates.

The third and fourth tabs where user input is required are used to estimate the percentage of weekly volume that will be sourced from ES3. They are described in more detail in the volume calculation section in chapter 4.

## 3.2 Output

*3.2.1 – Savings for 4 scenarios*

The model calculates savings for each area (safety stock, cycle stock, transportation, operations, and profit increases from reduced lost sales) for each of four scenarios. ES3 currently holds inventory for 18 manufacturers. ES3 management wants to be able to estimate the savings retailers would realize by sourcing from these manufacturers. As more manufacturers are added, the model can be updated to include these manufacturers. ES3 management is also interested in enlisting retailers in its efforts to recruit more manufacturers. As a result, ES3 management also wanted the model to estimate what savings would be in a best case scenario where all manufacturers were available, and the retailer was able to source its slowest moving items from ES3. These two scenarios are referred to as Current Manufacturers and Best Case, respectively. For each of these two scenarios, the model gives a savings estimate for both Phases of ES3's supply chain development. Phase I is under the current supply chain model, where ES3 replaces distribution centers from several (18) manufacturers. Phase II is the direct to store delivery model. In summary, the four scenarios for which the model estimates retailer savings are Current Manufacturers – Phase I, Best Case – Phase I, Current Manufacturers – Phase II, and Best Case, Phase II. Figure 3.2.1 graphically summarizes the 4 scenarios.

*Figure 3.2.1 – Four Scenarios Modeled*

| | Phase I | Phase II |
|---|---|---|
| Best Case | Modeled as if all products are available at ES3. Current ES3 supply chain assumed. User Defines which products will be outsourced. | Modeled as if all products are available at ES3. Direct to Store Delivery supply chain assumed. User defines which products will be shipped DSD. |
| Current Manufacturers | Model assumes manufacturers currently stored at ES3 will be sourced from ES3. Current ES3 supply chain is assumed. | Model assumes only manufacturers currently stored at ES3 will be sourced from ES3. Direct to Store Delivery supply chain assumed. |

### *3.2.2 – Output Presentation*

The output in the model is presented several ways. Each of the 4 areas has a detailed results tab where savings are enumerated for each of the retailer's facilities for each of the four scenarios. Each area also has a "Dashboard" tab where the key information is presented as a sum for all of the facilities for each of the four scenarios. Finally, and overall savings summary tab gives the most topline results for each of the four scenarios. This tab is expected to be of the most interest to most users.

### *3.2.3 - Databases*

Several regression relationships, constants, and charts of data are used to calculate each of the savings. This information is stored in tabs that are hidden and locked from the user. These tabs do not contain all the raw data used to calculate savings because the amount of data obtained from C&S would be far to large to store in an excel spread sheet. Instead, these tabs contain the only results of the calculations from the C&S data necessary to do the calculations required for the model.

*Chapter 4: Volume Calculation*

One of the most important aspects of the model is to determine what portion of a facility's volume will be sourced from ES3 because the all of the savings calculated will depend heavily on this volume. This section details the method used to determine volume for both the Current Manufacturers scenario and the Best Case scenario. For both scenarios, the volume will be the same for both Phase I and Phase II operations at ES3.

## 4.1 Current Manufactures Scenario

The method used to determine volume outsourced is very straightforward for the Current Manufacturers scenario. The user selects which of the 18 manufacturers to source from ES3. The strategic planning department at C&S provided total movement by cases and by dollars for an 8 week period in 2003 broken down by manufacturer. These figures were used to calculate the percentage of movement in a typical facility represented by each manufacturer at ES3. Appendix 3 gives this information for each of the manufacturers. The sum of the percentages for the manufacturers the user chooses to outsource is the estimate for the percentage of volume to be outsourced. This estimate is certainly far from perfect. Some of the manufacturers have products of a seasonal nature. Due to IT limitations, it was not possible to get snapshots from throughout the year. Also, the assumption is being made that the percentage at another retailer will be close to at C&S. This assumption, that other retailers behave similar to C&S, is made many times in the model. There is no strong way to measure its validity without access to data from another retailer, but because C&S is similar in nature to other retailers, it is likely it is an accurate enough assumption for the purposes here. If the user chooses to source all 18 ES3 manufacturers, the estimated volume coming from ES3 is 14.3%, and the estimated percentage of items is 15.4%.

## 4.2 Best Case Scenario

*4.2.1 - Overview*

In the Best Case Scenario it is more complicated to estimate the percentage of volume that will be sourced from ES3. In addition to the universal assumption that other retailers behavior is similar to C&S, it is assumed that whatever percentage of volume will be outsourced will consist of the slowest moving items required to meet that volume. This assumption is reasonable because the main benefits of ES3 (reduced cycle stock due to reduced EOQ, reduced safety stock due to lead time reduction) are most beneficial to slow moving products where cycle stock and demand variation is high. However, even though the per case benefit is greatest for slower-moving items, absolute savings increases with volume sourced from ES3. ES3 expects to eventually source all but the fastest moving items.

The data used to estimate volume in the Best Case scenario is the snapshot of movement from a single day in fall 2002 for 90,174 item codes at C&S totaling an average weekly movement of just over six million cases. An item code is a unique product in an individual warehouse. For example, a 4-pack of regular size rolls of Bounty paper towels at warehouse A has a different item code from the same product at Warehouse B. Also, an 8-pack of regular size Bounty rolls will have a different item code than a 4-pack, even at the same warehouse. In addition to the item code, two fields, 8-week Average Movement (which includes promotional items) and 8-week Turn Movement, were used in the volume modeling process. The database does not have any data about standard deviation of demand for any given product, but it can be used as a typical distribution of movement at C&S. Certainly some products are high in autumn, but this is true in any season, and what is important in this analysis is the distribution of products' movement, not the movement of individual products themselves.

*4.2 - Best Case Scenario - User Input*

One important aspect of modeling the volume to be outsourced is deciding how distributors would think about the question themselves and then tailoring the model to these expectations. Distributors order and ship turn (regular) volume and promotional volume differently, requiring different treatment in the model.

In order to keep use of the model simple, users are given three choices on how to estimate the volume that will be sourced from ES3:

1. *All items with a weekly turn volume below a certain level.* This option is likely to appeal to a distributor that defines "slow movers" based on their regular movement.
2. *A certain percentage of the slowest moving items.* This option is likely to appeal to a distributor with a large number of items due to serving multiple customers who wants to drastically reduce its item count.
3. *A certain percentage of all turn volume.* This is likely to appeal to a distributor that wants to outsource specific manufacturers because costs associated with those manufacturers are high.

Again, in order to keep the model simple, 50% of promotional volume is assumed to come through the manufacturer's distribution centers and 50% is assumed to be delivered directly from the plant. Therefore, in the volume calculation, 50% of the promotional volume for the products to be sourced from ES3 is assumed to be coming from ES3, and 50% directly from the plant. This rate was supplied by ES3 management and is easily changed by management at any time.

### *4.2.2 - Modeling Process*

Once the user has defined how to determine the volume to be outsourced, the model references the data from C&S to make an estimate. A direct approach was adopted to calculate volume to be outsourced. A database was compiled and placed in the model with the fields shown in Figure 4.2.1. The second column, Number of Items, lists the number of items which had an average turn movement from the first column. There were 2838 items that had an average turn movement of two per week. Movement was rounded to the nearest integer for each item. The third column, Total Turn Movement, is the total average movement for those items. It is the second column multiplied by the first. So, the 2838 items with an average movement of 2 had a total movement of 2838 x 2 = 5676.

The fourth column is the percentage of all movement from items with movement below the movement in the first column. 0.2% of total movement came from items with average movement of 2 or less. The fifth column is the total number of items with movement at or below the first column. 6023 items had movement of 2 or less. The final column is the percentage of items below the movement in the first column. So though only 0.2% of volume came from items at or below 2 cases per week, those items represented 7.2% of all items.

*Figure 4.2.1 - Database for Turn Volume*

| Average Turn Movement | Number of Items | Total Turn Movement | Percent Turn Movement Below | Number of Items below | Percent Items Below |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0.0% | 0 | 0.0% |
| 1 | 3185 | 3185 | 0.1% | 3185 | 3.8% |
| 2 | 2838 | 5676 | 0.2% | 6023 | 7.2% |
| ⫲ | ⫲ | ⫲ | ⫲ | ⫲ | ⫲ |
| 5698 | 1 | 5698 | 99.5% | 83388 | 100.0% |
| 8532 | 1 | 8532 | 99.7% | 83389 | 100.0% |
| 9114 | 1 | 9114 | 100.0% | 83390 | 100.0% |

Using this database, volume, maximum movement, and percentage of items can be estimated for all of the options users have for inputting data. If the user inputs a maximum volume, it is matched in column 1 and the value in column 4 is the volume outsourced. Column 6 has the percentage of items outsourced. If users input a percentage of items, the maximum average movement can be determined by using the chart in reverse.

As an example, assume the user chooses to outsource all items below 25 average turn cases per week. Approximately 54.4% of the items are below 25 turn cases per week, and 13.5% of the turn volume will be outsourced. Turn volume represents 58% of total volume at C&S, so this 13.5% of turn volume is 7.9% of total volume. These products are assumed to represent 13.5% of the 42% of total volume which is promotional volume, so promotional volume for these products represents 5.5% of all volume. Half of this promotional volume is sourced through ES3, so 10.7% of all volume is sourced through ES3.

This solution, while requiring the model to store much data, allows fairly accurate estimations of volume, movement, and items to be outsourced. It is likely to produce accurate estimates because of the large amount of data from which the database was created. There are over 85,000 items with a total of 1072 different average total movement (only integers are recorded.) Any reasonable value given by the user is certain to have a close match in the database.

*Chapter 5: Phase I Safety Stock Savings*

This chapter discusses the methods and results used to estimate safety stock savings for both the Best Case and Current Manufacturer's Scenario. The savings discussed here are only for Phase I. Phase II inventory savings are discussed in Chapter 7.

## 5.1 Reasons for Safety Stock Savings

Retailers will realize significant safety stock savings in both scenarios and in both ES3 phases. In Phase I, these savings will be due to significantly reduced lead time. Currently, distributors must accept lead times from MDCs of 5-10 days or longer. These long distribution times are mostly the result of manufacturers' waiting to have a full truckload of product to ship after an order from a distributor is placed. Because ES3 can consolidate orders from several manufacturers, it does not have to wait for a full truck from one manufacturer and expects to ship to distributors with a 24-48 hour lead time. This dramatic difference will allow distributors to carry less inventory because the standard deviation of demand during lead time will be much less. These savings are similar for both the Best Case scenario and the Current Manufacturer's scenario. In Phase II, when ES3 is operating with direct to store delivery, all inventory will be eliminated at the distributor's facility because the distributor's step in the supply chain is effectively eliminated.

## 5.2 General Approach to Calculating Phase I Best Case Safety Stock Savings.

One important tenet of the project assignment was to base the results on real data and not theory, but safety stock provided a challenge to accommodating this requirement. For some areas of savings, such as operations and transportation, C&S facilities themselves provided perspective on how outsourcing volume to ES3 would affect costs. For instance, C&S facilities of varying sizes provided an estimation for how many employees could be saved as volume was eliminated, and facilities in various locales provided perspective into savings for different trip lengths in transportation. However, with safety stock, no facility currently operating at one-day lead-time exists. There was no way to establish a real-life relationship between lead time and safety stock. However, to simply use safety stock theory based on a periodic replenishment model was prone to significant error, as in the real world stock help often varies significantly from theory.

To solve this problem, an approach was used that calculated the theoretical safety stock necessary and then adjusted it based on what was actually observed in C&S facilities. This method, while not perfect, was the best available to estimate the significant safety stock savings.

The process for determining safety stock savings is outlined below.

1 Determine average weekly demand of items to be outsourced.
2 Estimate standard deviation during lead time for that average demand.
3 Calculate theoretical safety stock required.
4 Adjust by a factor of actual at C&S/theoretical safety stock.
5 Calculate standard deviation at ES3 lead time (set at 24 hours).
6 Calculate theoretical safety stock at ES3 for ES3 service level.
7 Adjust to actual level based on ratio calculated in step 4.
8 Calculate difference between current and ES3 estimates of safety stock.
9 Multiply this savings by the number of items to be outsourced.
10 Multiply total cases savings by cost of capital, provided by the user, to estimate annual holding cost savings.

Each step is discussed in some detail below. This process describes the Phase I Best Case scenario only. The Phase I Current Manufacturers scenario is discussed in Section 5.9 and Phase II inventory savings are discussed in Chapter 7.

## 5.3 Step #1: Estimation of Average Movement Outsourced.

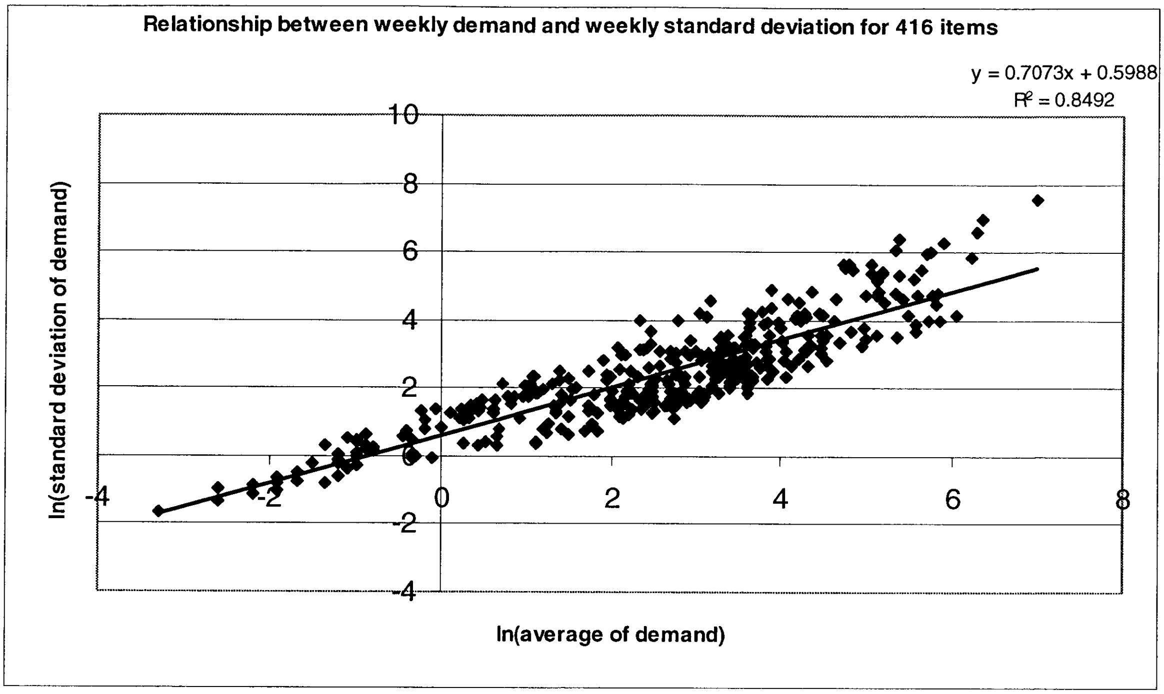
In the volume section of the model, the maximum average weekly movement of products to be outsourced was estimated. If this number is 100 cases, then all products that average 100 cases or fewer per week will be outsourced. Because safety stock required is dependent on demand and standard deviation, it is necessary to get a weighted average of movement of products to be outsourced. With the database for total volume generated for the volume calculation, this estimate is easy. The total volume for all items below the maximum average is determined. This value is divided by the total number of items to be outsourced. For example, in the case of a maximum movement to be outsourced of 100 cases per week, a total of 5,057,000 cases would be outsourced from 71,545 items at C&S, for an average movement of 70.7 cases.

## 5.4 Step #2: Estimation of Standard Deviation

Safety stock required is also driven by standard deviation of demand during lead time. Therefore, once the average movement of items to be outsourced is determined (70.7 cases per week in the example above) the standard deviation during lead time for these products must be estimated. To do so, a relationship was established between average demand and standard deviation for 416 items at C&S. These items were chosen to represent the entire range of average weekly movement of products available through C&S. To establish this relationship, a lead time at C&S for all 416 products was 7 days was assumed. Lead times for individual products were unavailable, but 7 days is accepted internally as an average lead time for all products.

First, a log-log relationship between standard deviation and weekly demand was established. At $r^2 = 0.85$ this relationship is highly significant. Chart 5.4.1 on the next page below shows this relationship.

*Figure 5.4.1 – Relationship between Standard Deviation and Average Demand.*

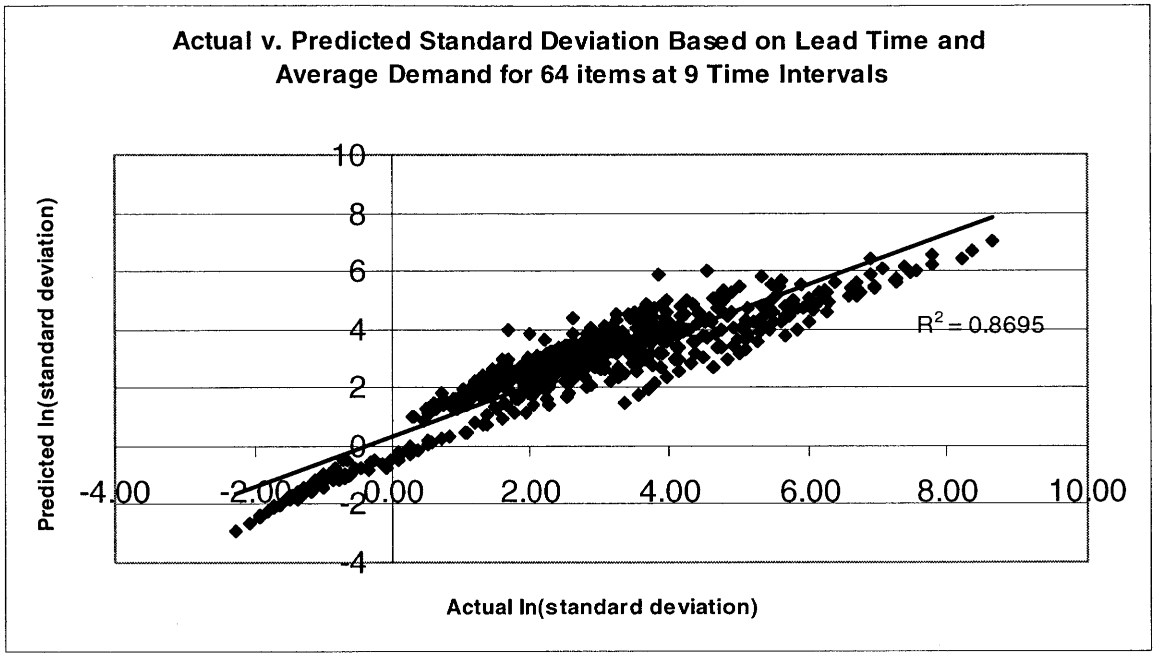



To be able to adjust for lead times other than 1 week, which may be encountered at other retailers, an additional term was added. To calculate the slope of this term, demand and standard deviation of 64 of these 416 items was calculated for periods of 2, 3, 4, 5, 7, 10, 14, 21, and 30 days. A multivariable regression model was then built to find ln(standard deviation) as a function of ln(daily demand) and ln(time period). The results from this model are shown in Figure 5.4.2.

Parameters for this model give the relationship between standard deviation, demand, and lead time as follows:

$\ln(\text{stdev}) = 0.78\ln(\text{daily demand}) + 0.69\ln(\text{lead time in days}) + 0.71.$

*Figure 5.4.2 – Multivariable Regression Results Predicting Standard Deviation from Lead Time and Average Daily demand*




The correlation coefficient for this relationship is $r^2 = 0.87$.

These two relationships reconcile reasonably well, but there is some discrepancy. For example, for an average weekly demand of 100 cases and a lead time of 7 days, the first relationship predicts a standard deviation of 47.2 cases per week. The second relationship predicts a standard deviation of 62.00 cases per week. The first relationship is considered more reliable because it contains 416 items versus only 64 for the second. The reason for this difference is that the time period for calculation of demand for several time periods for all 416 products was prohibitive. To get the most accurate estimate possible, the coefficient for demand and intercept from the first relationship was used and a correcting term was added for lead time with a coefficient of 0.69, taken from the second relationship. In this relationship, for consistency of units, lead time is in weeks. Therefore, for any given demand and lead time, the predicted standard deviation during lead time is estimate by the relationship:

ln(standard deviation during lead time) = 0.707*ln(weekly demand)+0.690*ln(lead time in weeks)+0.599. This relationship is used extensively in estimating the safety stock required in the system.

## 5.5 Step #3: Calculate theoretical safety stock required by user

Theoretical safety stock was calculated for a straight periodic review system. Safety stock is the level which triggers a new order. The time period it takes for that order to arrive is the lead time for the product. This model vastly oversimplifies the true state of the ordering system at C&S, which is complicated by promotions run by manufacturers, consolidated shipments of many products from one manufacturer, and varying lead times. However, for the scope of this project, and the data available, it is a good starting point to understand safety stock that needs to be held. Because the theory is adjusted further in the process based on actual data at C&S, the theory does not need to perfectly model the actual situation.

Theoretical safety stock in a periodic review system depends on demand during lead time, standard deviation during lead time, and target service level. For any given mean lead time demand and standard deviation service level was calculated assuming a normal distribution of demand. For example, if mean demand is 100 and standard deviation is 25 during lead time, the is some finite probability that actual demand during lead time will be 0,1,2,3.........all the way to infinity. For each potential demand, some or all of the demand will be met depending on safety stock held. If 20 cases is held as safety stock and the order size is assumed to be 100 (demand during lead time), as long as actual demand is less than 120, all demand will be met, if actual demand is 125, then 120/125 cases, or 96 % of demand will be met. The unit loss function was used to calculate theoretical safety stock. The unit loss function gives the inventory necessary, in terms of standard deviations of demand, based on the service level desired and the ratio of order size to standard deviation during lead time. In the model, the assumption is made that order size equals lead time demand. As an example, if demand during lead time is 100, standard deviation during lead time is 50, and the desired service level is 96%, 1.02 standard deviations, or 51 units, of safety stock must be held. For the model, users are given a choice of service levels in 0.5% increments from 95% to 99.5%. Figure 5.5.1 below shows the theoretical safety stock as a number of standard deviations required to meet the service level based on the unit loss function.

*Figure 5.5.1 – Theoretical Safety Stock, in Terms of Standard Deviations of Lead Time Demand, by Ratio of Lead Time Demand to Standard Deviation and Service Level*

| | Ratio of Demand to Standard Deviation | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Service Level | 7.00 | 6.50 | 6.00 | 5.50 | 5.00 | 4.50 | 4.00 | 3.50 | 3.00 | 2.50 | 2.00 | 1.50 | 1.00 | 0.75 | 0.50 | 0.25 | 0.10 |
| 95.0% | 0.10 | 0.16 | 0.22 | 0.28 | 0.33 | 0.42 | 0.49 | 0.58 | 0.67 | 0.78 | 0.90 | 1.05 | 1.26 | 1.39 | 1.57 | 1.86 | 2.16 |
| 95.5% | 0.18 | 0.23 | 0.29 | 0.34 | 0.42 | 0.49 | 0.56 | 0.64 | 0.73 | 0.84 | 0.96 | 1.14 | 1.31 | 1.44 | 1.61 | 1.90 | 2.20 |
| 96.0% | 0.27 | 0.31 | 0.35 | 0.43 | 0.49 | 0.56 | 0.63 | 0.71 | 0.80 | 0.90 | 1.02 | 1.17 | 1.36 | 1.49 | 1.66 | 1.92 | 2.24 |
| 96.5% | 0.34 | 0.41 | 0.46 | 0.52 | 0.58 | 0.64 | 0.71 | 0.79 | 0.88 | 0.97 | 1.14 | 1.24 | 1.43 | 1.56 | 1.71 | 1.97 | 2.28 |
| 97.0% | 0.46 | 0.51 | 0.56 | 0.61 | 0.67 | 0.73 | 0.80 | 0.88 | 0.96 | 1.05 | 1.17 | 1.31 | 1.49 | 1.61 | 1.78 | 2.04 | 2.32 |
| 97.5% | 0.58 | 0.62 | 0.67 | 0.72 | 0.78 | 0.84 | 0.90 | 0.97 | 1.05 | 1.16 | 1.26 | 1.39 | 1.57 | 1.69 | 1.86 | 2.11 | 2.38 |
| 98.0% | 0.71 | 0.76 | 0.80 | 0.85 | 0.90 | 0.96 | 1.02 | 1.14 | 1.17 | 1.26 | 1.36 | 1.49 | 1.66 | 1.78 | 1.92 | 2.16 | 2.44 |
| 98.5% | 0.88 | 0.92 | 0.96 | 1.00 | 1.05 | 1.14 | 1.17 | 1.24 | 1.31 | 1.39 | 1.49 | 1.61 | 1.78 | 1.90 | 2.04 | 2.26 | 2.52 |
| 99.0% | 1.14 | 1.15 | 1.17 | 1.21 | 1.26 | 1.31 | 1.36 | 1.43 | 1.49 | 1.57 | 1.66 | 1.78 | 1.92 | 2.04 | 2.16 | 2.38 | 2.60 |
| 99.5% | 1.43 | 1.46 | 1.49 | 1.53 | 1.57 | 1.61 | 1.66 | 1.71 | 1.78 | 1.86 | 1.92 | 2.04 | 2.16 | 2.26 | 2.38 | 2.56 | 2.92 |

The model uses this chart to estimate theoretical safety stock by taking the average demand and standard deviation for items to be sourced from ES3.

## 5.6 Step #4: Adjust theoretical results based on actual safety stock observed at C&S.

This step in estimating the safety stock savings actually involves two sub-steps. The first is defining safety stock based on C&S data, and the second is correlating actual safety stock to demand.

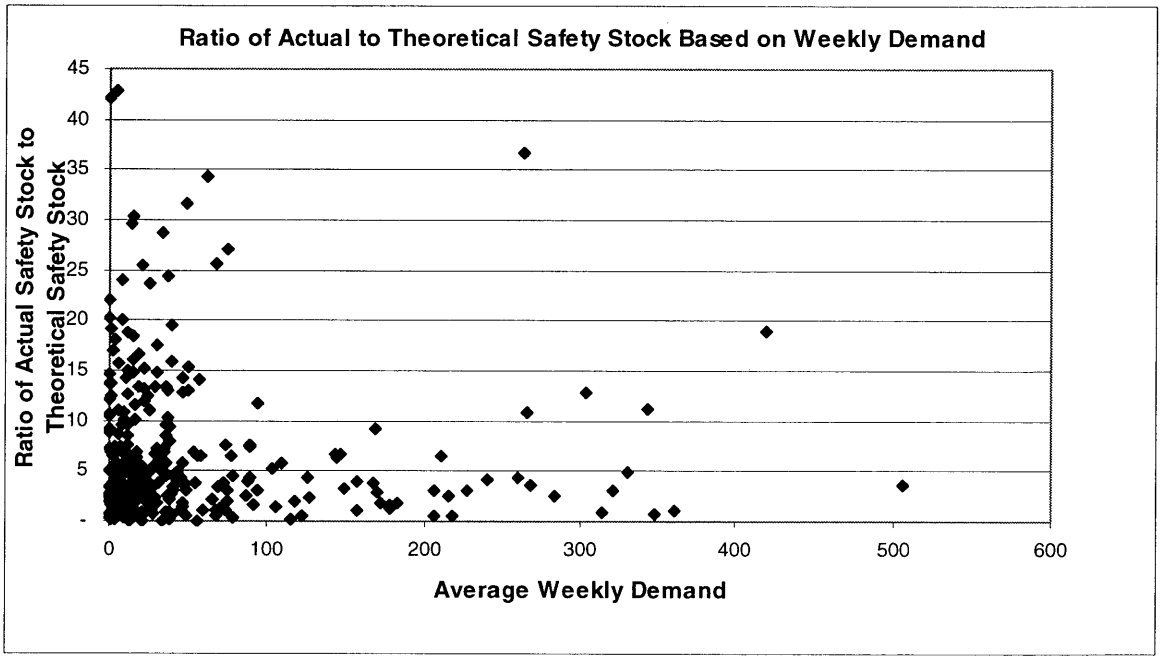
### *5.6.1 - Calculating Safety Stock at C&S*

Defining safety stock is somewhat arbitrary, because C&S does not directly set safety stock levels or differentiate safety stock from cycle stock. However, the simplest definition of safety stock gives the most defensible calculations. Safety stock for a single product is taken to be the average balance less ½ the average order size. For the 416 products in the database, average balance is calculated using inventory level taken every Saturday at noon for 26 weeks. Average order size is taken as the average of all incoming orders during the same 26 week period.

*5.6.2 – Relationship between Actual/Theoretical Ratio and Weekly Demand*

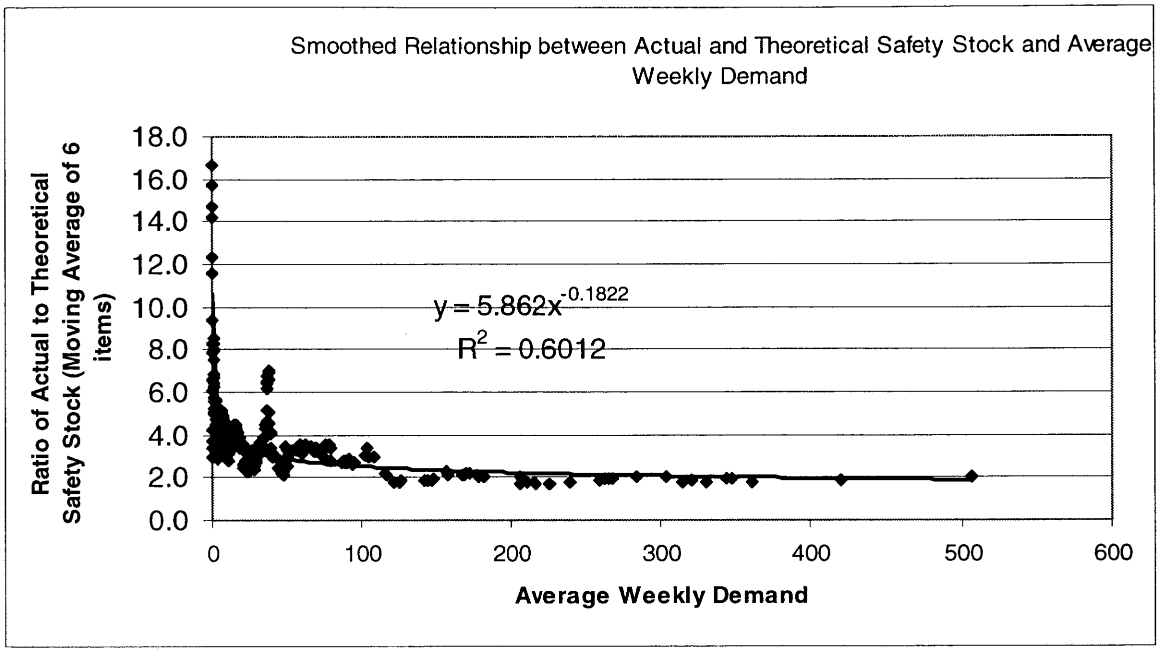
Once safety stock for each item is calculated, the ratio of actual to theoretical is calculated. Figure 5.6.1 shows the relationship between this ratio and weekly demand per item.

*Figure 5.6.1 – Ratio of Actual to Theoretical Safety Stock Based on Weekly Demand*




This relationship shows that there is a lot of variation from one product to the next, but that there is a general trend toward lower ratios based as demand increases. To better see the relationship between demand and ratio, the graph (Figure 5.6.3) below plots the ratio as a moving average of 6 items.

*Figure 5.6.2 – Smoothed Relationship between the Ratio of Actual and Theoretical Safety Stock and Average Weekly Demand.*




This smoothed relationship provides a much clearer picture of the ratio as a function on weekly demand. To estimate the ratio for products which will be sourced from ES3, a power regression line is fit to the smoothed curve.

With this relationship, Ratio = 5.86*weekly demand^-0.1822, the ratio for actual to theoretical safety stock can be estimated. So, if an item has an average demand of 100 and a standard deviation of 50, the theoretical safety stock for a 96% service level is 1.02*25 = 51 cases. The ratio between actual and theoretical is 6.56*100^-0.247 = 2.53, so the estimated actual safety stock is 129.0 cases.

This calculation is far from perfect, and simplifies reality considerably, but a simple method is needed to make the model easy to use and flexible, and the results are accurate enough to make the savings estimates meaningful.

## 5.7 Steps #5, #6, and #7 – Calculating actual safety stock at ES3

Steps #5, #6, and #7 repeat the process of steps #2,#3, and #4 but for the situation where these products are sourced from ES3 instead of from the RDC. Weekly demand is the same, but a new standard deviation is calculated, using the same relationship, with the ES3 lead time. This lead time is set at 24 hours, but can be changed by ES3 in the future. The shorter lead time will result in a lower standard deviation, and lower theoretical safety stock. The ratio between actual and theoretical is the same, because it is a function of weekly demand, which does not change with ES3.

## 5.8 Steps #8, #9, and #10 – Calculating Savings

The final three steps are the simplest and calculate the estimated dollar figure safety stock savings. Step #8 is simple subtraction of the estimated actual safety stock levels per item in both the C&S model and the ES3 model to get a per item case savings. Step #9 calculates total case savings by multiplying the per item savings by the total number of items, which is calculated in the Volume Input and Output sheet (section 4.2). Finally, in step #10, the dollar savings are determined by multiplying the total case savings by the average case value provided by the user and by the cost of capital to get annual holding cost savings. Holding cost is not actually exactly the same as cost of capital, but it will be close, and retailers are not likely to have an accurate holding cost figure. The one time cash flow (total case savings multiplied by average case value) is also of great interest to retailers and will be presented in summary of results.

## 5.9 Phase I Safety Stock Savings for the Current Manufacturers

Unlike the above scenario where the slowest moving items are considered to be sourced from ES3, the Current Manufacturers scenario requires products from across the distribution of average movement to be sourced from the 18 ES3 manufacturers. Therefore, the average movement of these products cannot be estimated using the volume distribution database. This scenario is a "market basket" approach where a variety of products, from very slow movers to very fast movers will be sourced from ES3. Products to be sourced from ES3 are determined by manufacturer and not movement. Fortunately, a more direct (and therefore likely more accurate) approach can be taken. Using the database which is a snapshot of all products from a day in the autumn of 2002, the average movement for all products from the ES3 manufacturers can be calculated. Likewise the number of items, average inventory for these items, and average incoming order size for these items can be determined. These estimates have some seasonal bias, because certain ES3 manufacturers are highly seasonal. This data from this day was the only data available and while seasonal effects are not trivial, fortunately fall is transitional for these manufacturers' sales, so the movement for the 8 weeks ending on this day in autumn 2002 is likely near the annual average.

### *5.9.1 - Calculation of Safety Stock at Retailer*

With the snapshot from autumn 2002, the average safety stock per item can be determined. The average inventory on hand for all items in the ES3 manufacturers chosen less ½ the average order size for these same manufacturers is the average safety stock per item at C&S, and at the retailer in question. For example, if all ES3 manufacturers are chosen by the user, the average inventory on hand per item is 202 cases and the average order size is 146 cases. Therefore, the average safety stock is 129 cases for items for these manufacturers at ES3.

### *5.9.2 - Calculation of Safety Stock at ES3*

To determine the safety stock per item that will be found when these items are sourced at ES3 a procedure very similar to steps 5-7 in the potential scenario is used. The only difference is that the actual to theoretical ratio must be calculated for the manufacturers that have been chosen by the user. This value is obtained by using the average movement to estimate standard deviation and the unit loss function as described in section 5.5. For all ES3 manufacturers, this ratio is 5.96, which is much higher than the ratio of 3.1 that would be predicted for an average movement of 34 cases (the average movement for all ES3 items at C&S.) This exact reason for this difference is not known, but there are three likely explanations. First, the largest (and therefore most influential on weighted averages) manufacturers at ES3 sell items which are important to profits at retailers, so C&S may hold more safety stock in these items in order to operate at a higher service level for them. Second, because the ES3 manufacturers are a market basket of goods across the spectrum of movement, the comparison to the ratio for the slow-movers scenario is not totally direct. A third possible explanation is inaccurate or incomplete data, always of concern in building this model, but whatever the reason for the difference, the ratio calculated using the market basket approach is used for this scenario.

Once this ratio is determined, the actual estimated safety stock at ES3 by multiplying the theoretical level at ES3 lead time by the theoretical to actual ratio. For example, if the user chooses to source all ES3 manufacturers and ES3 lead time is 24 hours, the estimated standard deviation during lead time is 5.7 cases, the theoretical safety stock at 98% service level is 8.6 cases, and the actual safety stock is 8.6* 5.96 = 51.1 cases per item.

*5.9.3 - Calculation of Savings*

Once the estimations of safety stock at the retailer and at ES3 are made, calculating the savings is easy. First, the difference in safety stock per item is calculated. Then, this difference is multiplied by number of items to be sourced from ES3. It is not exactly clear how to estimate this number of items. Unlike the slow movers scenario where the number of items is based on the percentage of all items needed to meet the volume to be outsourced, the number of items at ES3 for an given manufacturer is constant no matter how big or small the retailer might be. So, an argument could be made that the same number of items would be sourced to each and every retailer. The actual situation is more complicated, as some retailers may not stock every item from every manufacturer. A much more conservative approach is to use the same percentage of items regardless of the size of the retailer. In other words, if ES3 manufacturers represent 15% of the items at C&S, we will assume they represent 15% of items at any retailer using the model. The truth is likely between these two extremes, but to make the model more robust for smaller retailers, we will use the more conservative approach.

Once the number of items is determined, the total case savings can be calculated, followed by the one time cash flow (number of cases by average case price) and the annual holding cost savings (cash flow by cost of capital.) For example, if all ES3 manufacturers are chosen, the average per item safety stock savings when ES3 lead time is 24 hours is 92.2 cases. ES3 manufacturers' items represent 15.4% of the items at C&S, so if a user indicated 100,000 total items, 15,400 items would be taken as sourced from ES3. The total case savings would be 15,400 items by 92.2 cases per item, or just over 1.4 million cases. The value of these cases and the holding cost savings can then be determined by the average case value and cost of capital.

*Chapter 6: Cycle Stock Savings*

This chapter discusses the methods used to estimate inventory savings due to reduced EOQ in Phase I. This chapter discusses both the Current Manufacturer's and Best Case scenarios for Phase I savings, but Phase II savings are discussed in Chapter 7.

## 6.1 General Approach to Cycle Stock Savings for Best Case Scenario

Currently, manufacturers generally set their prices to encourage distributors to order a full truckload of product from a single manufacturer. This policy causes distributors to hold significantly more product than desirable, especially for slow moving items. If a distributor is required to order 100 cases of a product that moves an average of 1 case per week, its weeks on hand of inventory, 100, is extremely high. The problem lessens for faster moving products, but in the absence of a pricing scheme to encourage high order sizes, the EOQ for a retailer approaches demand for the time between shipments, which for slow movers is often a single case.

Manufacturers set their policies in this manner because to do otherwise would significantly increase their shipping costs. Less than truckload shipments are very inefficient, as virtually none of the shipping costs are variable with size of load. While fuel costs may vary slightly, driver pay and equipment costs are dependent on miles driven and time required for the trip. Large, diverse manufacturers ease the burden on distributors somewhat by offering a variety of products from a single MDC, but distributors still generally order more product than they would like for slow moving items. By consolidating several manufacturers' products into one facility, ES3 eliminates the problem. Consolidated orders allow the EOQ to distributors to be as low as one case, and distributors can order exactly what they need to meet demand between shipments from ES3. This reduction in order size will lead to significant reduction in cycle stock and result in savings for the distributor.

To estimate these savings, cycle stock is assumed to be one half the average order size. The general steps taken to calculate cycle stock savings for the best case scenario are:

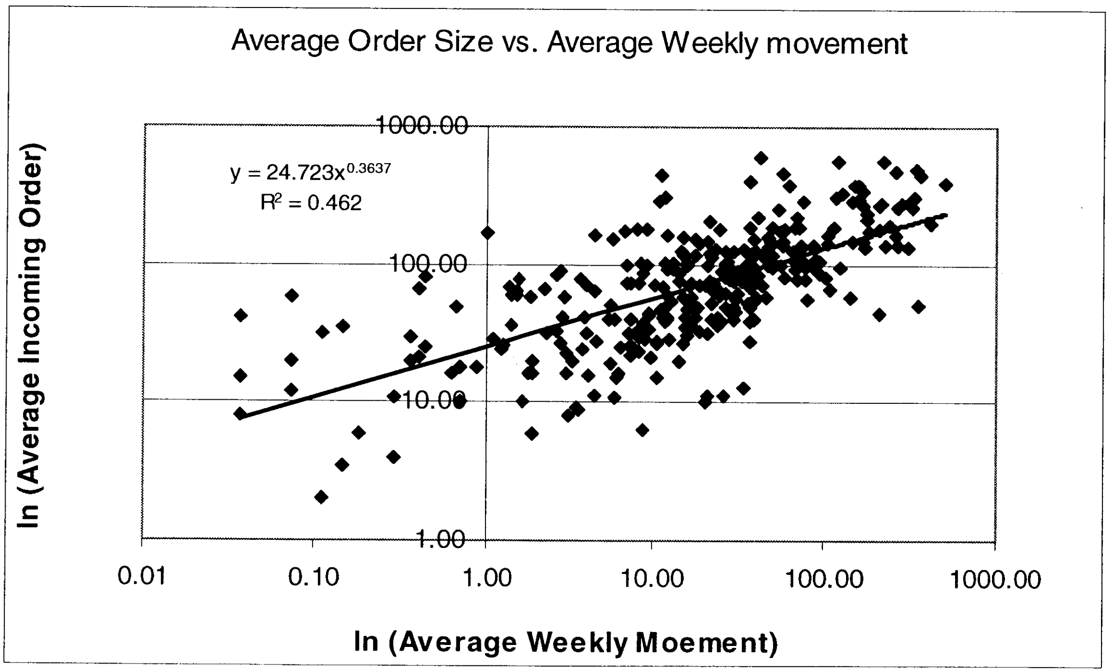
1) Estimate average movement of products to be sourced from ES3
2) Estimate average order size from manufacturers for these products
3) Estimate average order size for these products at ES3
4) Calculate holding cost savings

The first step is also needed to calculate safety stock savings and described in section 5.3

## 6.2 Step #2: Estimate Order Size for these Products

Despite manufacturers' policies to encourage full truck load shipments, average order size at C&S does increase with average weekly demand. Figure 6.2.1 below shows this relationship is on a log-log scale:

*Figure 6.2.1 - Relationship between Average Weekly Demand and Average Order Size*




Because there is a lot of variation from the trend line, the regression would not likely be very accurate for any single item, but since we are using it to estimate the average order size for many items, it will on average be accurate. To estimate the average order size for items to be sourced from ES3 in the slow movers scenario, the model simply uses the relationship based on the above regression, Order Size = 24.7*Average Weekly Movement^0.36. Use of this relationship is not completely accurate because the result of the function of the average value of a data set is not exactly the average of the function of that data set. However, the difference is small enough to ignore for the accuracy of the model and this same assumption is used elsewhere where averages are estimated. So, if all items to be sourced from ES3 have an average movement of 50 cases, the average order size for these items is taken as 102.6 cases, or just over two weeks of movement. ES3 will significantly reduce the cycle stock for these items.

## 6.3 ES3 Order Size

Because of consolidated orders at ES3, retailers can receive as little as one case of a single item without losing the efficiencies of full truck load shipments. If shipments are received every day, the average shipment size would be equal to the average daily demand. Currently, retailers typically receive shipments from ES3 5 times a week, so the average order size is 1/5 weekly demand. For example, if the average movement for items to be sourced from ES3 is 50 cases, the average order size at ES3 will be 10 cases.

## 6.4 Calculation of Savings

Once the average order sizes have been estimated, the calculating the savings is easy. One half the difference in the order size is the cycle stock savings per items. To get the total case savings, the per case savings are multiplied by the total items. Calculation of the total number of items was discussed in section 4.2. Finally, the one time cash value of the savings and the on going holding cost savings are calculated by multiplying the total case savings by the average case value and the cost of capital. For example, in the case where the average movement is 50 cases, the C&S order size was 102.6 cases while the ES3 order size was 10 cases, representing a cycle stock savings of 45 cases per item. The total number of cases, value of these cases, and value of the holding cost can then easily be determined based on user input.

## 6.5 Cycle Stock Savings in the Current Manufacturers Scenario

As in the case of calculating safety stock savings in the current manufacturers scenario, a more direct approach can be taken to estimate cycle stock savings under this scenario. The average order size is calculated using the snapshot of all movement from autumn 2002. The weighted average size of all incoming orders for all ES3 manufacturers chosen by the user is used as the average order size for this scenario. The ES3 order size is calculated in the same manner as described in section 6.3, and cycle stock savings are estimated in the same manner discussed in section 6.4. If all ES3 manufacturers are chosen, the average incoming order size is 137. The average movement is 34.9 cases per week. The ES3 order size is estimated at 7 cases, so the per item case savings are 65 cases.

*Chapter 7: Phase II Inventory Savings*

This chapter discusses inventory savings in Phase II for both the Best Case and Current Manufacturers scenarios. Inventory savings are achieved by eliminating all inventory from the distributor's facilities.

## 7.1 Phase II Inventory Savings

In phase II, direct to store delivery, the distinction between cycle stock and safety stock is no longer important because all inventory for any item sourced from ES3 will be eliminated. In other words, if a distributor chooses to have an item delivered directly from ES3 to the retail outlet, it has to hold no inventory for that item since the item never enters the distributor's facility. To maintain consistency in the model, the total inventory for the items to be outsourced is taken as the sum of the estimated cycle stock at the distributor and the estimated safety stock at the distributor.

For the current manufacturers scenario, simply adding the estimates for the cycle stock and safety stock provides estimates for total inventory as accurate as possible because all estimates are taken for specific items whose inventory levels are known at C&S. However, in the Best Case scenario, many estimates are made to calculate inventory. Theoretical safety stock, ratio between actual and theoretical safety stock, average order size, and average movement to be sourced from ES3 are all predicted from correlations with large variations, and the sum of these variations might distort the results.
A check for the accuracy of the inventory calculations can be done by comparing the total inventory predicted by adding the safety stock and cycle stock estimates with an estimate based on a regression between total inventory and weekly movement. Figure 7.1.1 plots the relationship between average weekly movement and average inventory on hand at C&S

.

*Figure 7.1.1 - Average Weekly Movement vs. Total Inventory*

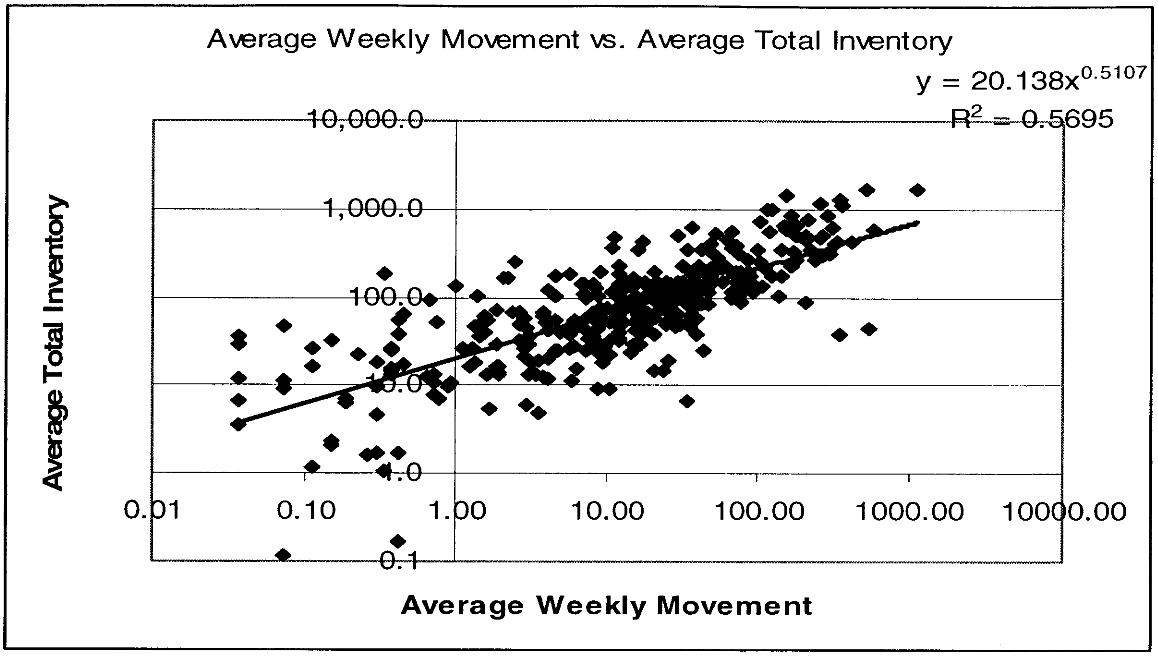
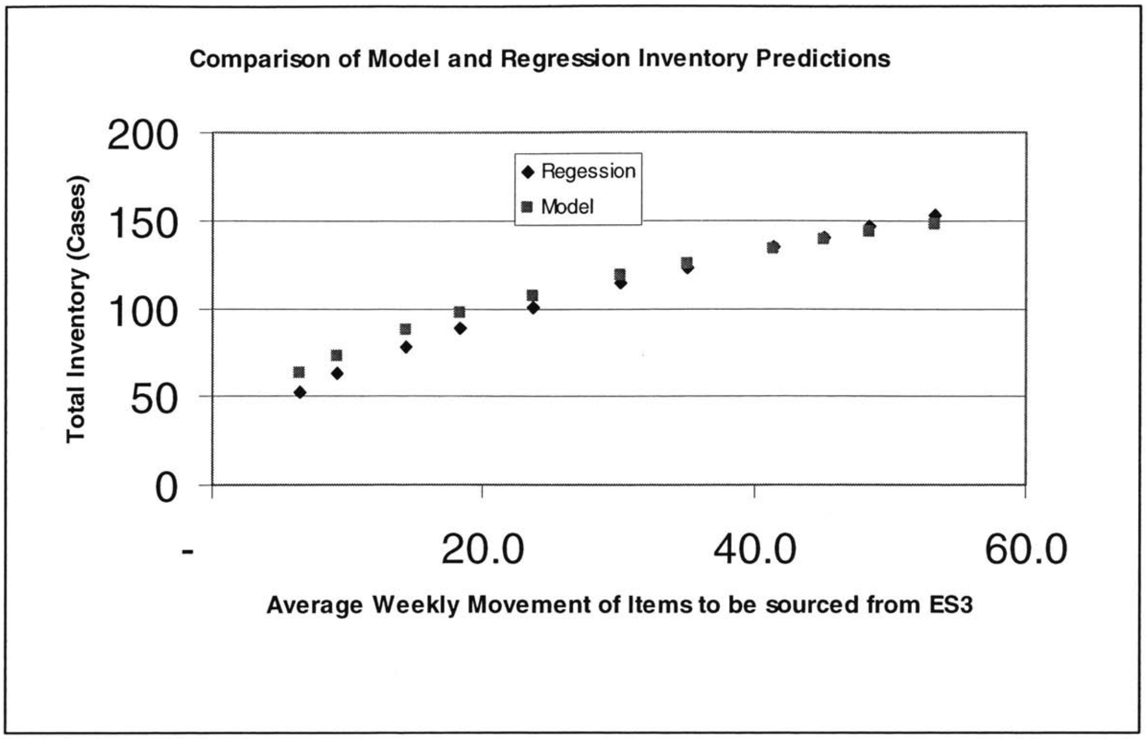



Figure 7.1.2 shows a comparison of the two methods of predicting total inventory as a function of average weekly movement. These average weekly movements correspond to maximum weekly movements of up to 1000 cases, which means this chart covers the range which any retailer would realistically enter into the model. While the two results from the two methods vary somewhat, the error between them is never greater than 17%, and much less than that for most of the range shown.

*Figure 7.1.2 – Comparison of Model and Regression Inventory Predictions*




This comparison serves as a top line check that the methods used to calculate inventory in the model are reasonably accurate on average.

*Chapter 8: Phase II Transportation Savings*

This chapter will discuss transportation savings distributors will realize by using ES3. These savings are recognized only in Phase II, when ES3 is operating using Direct to Store Delivery. The reasons for the transportation savings and methods used to calculate them are discussed in this chapter.

## 8.1 Reasons for Transportation Savings

When ES3 operates under the direct-to-store delivery model, significant amounts of transportation costs will be reduced from the entire supply chain because an entire shipping leg is eliminated. Two legs in the traditional model, the MDC to RDC leg and the RDC to first retail outlet, are replaced by a single leg, ES3 to first retail outlet, in the ES3 DSD model. (For a schematic overview of the traditional and Phase II ES3 supply chains, see figures 1.3.1 and 1.4.2). This reduction should lead to an overall reduction in transportation miles for virtually every retailer. ES3 was located in York, PA to best serve the Northeast and Mid-Atlantic, so regardless of where a distributor's facilities are located, the entire miles in the system will be reduced.

Miles on every trip will not be reduced, but on average they will be reduced regardless of where the RDC is located within the region served by ES3. To illustrate this point, imagine the extreme case of a product where the manufacturer's facilities are located in Augusta, ME and the distributor serves primarily Maine, with an RDC located near Portland, ME and the first retail outlet on a trip usually in Portland. For the sake of illustration, imagine the plant is 20 miles from the MDC, and the RDC is 20 miles from the first retail outlet. In the traditional model, this product is going to travel a short distance, from the plant in Augusta to the MDC in Augusta, then to the RDC in Portland before the retail outlet in Portland. In the DSD model, this product would travel much further, from Augusta to York to Portland. However, this is a very extreme case. The opposite extreme case (for the same retailer), would be a product made in Harrisburg, PA with an MDC in Cleveland, OH. In this case, the product currently travels from

Harrisburg to Cleveland to Portland and then to the outlet in Portland, while under the DSD model it would travel from Harrisburg to York to the outlet in Portland. Even though the distributor is far from York, there is still a significant mileage reduction for a product like this. Figure 8.1.1 shows the mileage for each leg for these two trips.

*Figure 8.1.1 Illustration of Cost and Benefit in Transportation Mileage for Extreme Cases*

**Extreme Retailer Disadvantage**

| | Traditional Model | ES3 DSD |
|---|---|---|
| Plant (Augusta, ME) to MDC (Augusta, ME) | 20 | N/A |
| Plant (Augusta, ME) to ES3 (York, PA) | N/A | 553 |
| MDC (Augusta, ME) to RDC (Portland, ME) | 55 | N/A |
| RDC (Portland, ME) to outlet (Portland, ME) | 20 | N/A |
| ES3 (York, PA) to outlet (Portland, ME) | N/A | 499 |
| **Total** | **95** | **1052** |

**Extreme Retailer Advantage**

| | Traditional Model | ES3 DSD |
|---|---|---|
| Plant (Harrisburg, PA) to MDC (Cleveland, OH) | 330 | N/A |
| Plant (Harrisburg, PA) to ES3 (York, PA) | N/A | 26 |
| MDC (Cleveland, OH) to RDC (Portland, ME) | 738 | N/A |
| RDC (Portland, ME) to outlet (Portland, ME) | 20 | N/A |
| ES3 (York, PA) to outlet (Portland, ME) | N/A | 499 |
| **Total** | **1088** | **525** |

In this particular (and fictional) situation, the retailer would lose more from the extreme where it is disadvantaged by DSD than it would gain by the beneficial extreme. This result, however, does not mean that a retailer in Maine would incur additional transportation costs be using DSD. The extreme disadvantage example is far more extreme than the extreme advantage example. York, PA was chosen carefully as the site for ES3. It is in a sense the "weighted average" of locations for MDCs. Though in a few extreme cases a retailer far from ES3 might increase its miles for some products, we will argue that on average the distance from the MDC to the RDC will be the same as the distance from ES3 to the first retail outlet. Therefore, the miles eliminated from the system will be, on average, the distance from the RDC to the first retail outlet.

Another way to think of the assumptions made to arrive at this conclusion is to think of ES3 as the center of the "cluster" of all MDC locations in the Northeast and Mid-Atlantic and that any RDC is the center of the "cluster" of retail outlets it serves. With this assumption, the ES3 to first retail outlet leg will be the same, on average, as the MDC to RDC leg. Since the trip after the first retail outlet (to the second, third, etc.) will not change with DSD, the reduction in miles is equal to the RDC to first stop. There are cases when the assumption that the RDC is in the geographic center of its customers is definitely not true, most notably when the RDC serves a large metropolitan area, especially New York City. The facility will be located on one side of the city and the actual average distance saved by DSD will be either greater or less than the average distance to first stop depending on which side of the city the RDC is located. However, to keep the model simple, this assumption will be made for all RDCs.

## 8.2 Definition of Savings to Distributor

As discussed in the previous section, the average system savings in terms of miles for any given retailer can be estimated as the average distance between the RDC and the first retail outlet. In the traditional model, the manufacturer is typically responsible for transportation costs to the RDC and the distributor is responsible for transportation costs after that point. There may be arrangements with third party carriers and distributors will frequently carry product from MDCs to and RDCs as the last leg of a trip, since a truck, empty after shipments to retail outlets, needs to head back to the RDC anyway for its next shipment. However, these arrangements are made with the understanding that the manufacturer ultimately pays for shipping to the RDC and the distributors pays afterwards. With DSD, this arrangement will change, since the product will never go to an RDC. Many scenarios are possible. A distributor may pick up shipments at ES3 and deliver them to all individual outlets with its own fleet. A manufacturer may ship from ES3 to each individual outlet. A truck from an ES3 fleet may do the shipping. Finally, a company maybe contracted to do the shipping. The payment arrangements will be worked on an individual basis in the future, but for the sake of the model, a very clear definition of what the savings to the retailer will be must be used. ES3 has decided separately that the retailer will be responsible for all shipping after the first retail outlet. (Regardless of who does the shipping, ES3 anticipates the retailer paying for the shipping on these legs.) These legs, from the second retail outlet to the last, will not change with DSD, so the retailer savings for each trip are the costs the distributor would have incurred for the fist leg from its RDC, even though the shipment now comes from ES3. For the purpose of the model, all costs are calculated as if they are coming from the RDC, and distributor savings are the per mile cost for the entire trip (if it came from the RDC) times the miles to the first stop plus the driver pay for a single stop.

## 8.3 Calculation of per Trip Costs

In order to estimate transportation savings in the model, the cost structure of trips must be known. The details of transportation costs are highly confidential, but a summary was provided by the C&S transportation department that breaks down the costs on a per mile basis based on number of stops in the entire trip. To protect confidentiality, all transportation costs (except for savings totals in Chapter 11) have been indexed so that the median of the 8 facilities average trip costs is 100. The entire chart used in the model is available in Appendix 5, but a small portion of this chart is shown below with indexed values.

*Figure 8.3.1 – Sample per Mile Transportation Costs, Indexed*

| | Number of Stops | | | |
|---|---|---|---|---|
| **Total Trip Distance (Miles)** | **2** | **5** | **10** | **15** |
| **0-25** | 0.85 | 0.70 | 0.53 | 0.41 |
| **26-50** | 0.70 | 0.58 | 0.43 | 0.34 |
| **51-75** | 0.60 | 0.50 | 0.38 | 0.29 |
| **76-100** | 0.53 | 0.44 | 0.34 | 0.26 |
| **101-150** | 0.43 | 0.36 | 0.27 | 0.21 |
| **150-200** | 0.35 | 0.30 | 0.23 | 0.17 |
| **201-300** | 0.28 | 0.24 | 0.18 | 0.14 |
| **300+** | 0.23 | 0.20 | 0.15 | 0.12 |

In addition to the per mile cost, an indexed driver stop pay cost of 6.47 is incurred for each stop. So, for a trip of 100 miles with 5 stops, the total cost would be 100 miles *0.44+6.47/stop*5 stops = 50.47.

To estimate transportation savings, the model takes user estimates of average miles per trip, average miles to the first stop, and average stops per trip and uses a regression that relates these factors to calculated trip savings from several C&S facilities. While the model itself uses only the user input and the parameters of these regressions to make the estimates, much up front work was necessary to establish the appropriate regressions. The procedure below outlines the total process of estimating transportation savings for a given retailer.

1. For each trip for an 8 month period in 2003 from seven C&S New England Division facilities, calculate the total trip cost and total trip savings using the cost structure in Appendix 5. Savings are the miles to the first stop multiplied by the cost per mile for the entire trip plus an indexed cost of 6.47 for the driver pay for the first stop.
2. Calculate the average total trip distance, average distance to first stop, and average number of stops for each facility.
3. Build linear relationships between average stops, trip distance, and distance to first mile and total trip cost and savings.
4. Estimate savings per trip for the user based on user input of average stops per trip, distance to first mile, and total trip distance.
5. Estimate reduction in number of trips at each of the user's facilities. This estimate is made by first calculating the cases to be outsourced from the total volume at the facility and the percentage of volume to be sourced from ES3. (Note that this step is done separately for the Current Manufacturers and Best Case scenario, but steps 1-4 are the same for both scenarios.) Next, the total volume is divided by the average number of cases per trip at C&S (1610 cases per trip) to estimate the number of trips eliminated by DSD.

6. Finally total transportation savings are estimated by multiplying the savings per trip from step number 4 by the total number of trips estimated in step number 5.

## 8.4 Transportation Savings Results

This section briefly presents the results from each of the steps outlined in the previous three sections.

Steps 1-2: The chart below summarizes the results from all of the trips for the eight months available from 8 New England facilities. The names of the facilities are hidden for confidentiality purposes. Also, the costs have been indexed for confidentiality. The median of the average trip costs for the 8 facilities has been assigned a value of 100. For example, the average trip from Facility #1 traveled 74 miles to the first stop and a total of 257.8 miles over 8.2 stops. Using the cost structure in Appendix 5, the average cost of these trips is 104.6 (or 1.046 times the median trip cost for these facilities) and the average savings under DSD would be indexed at 21.7.

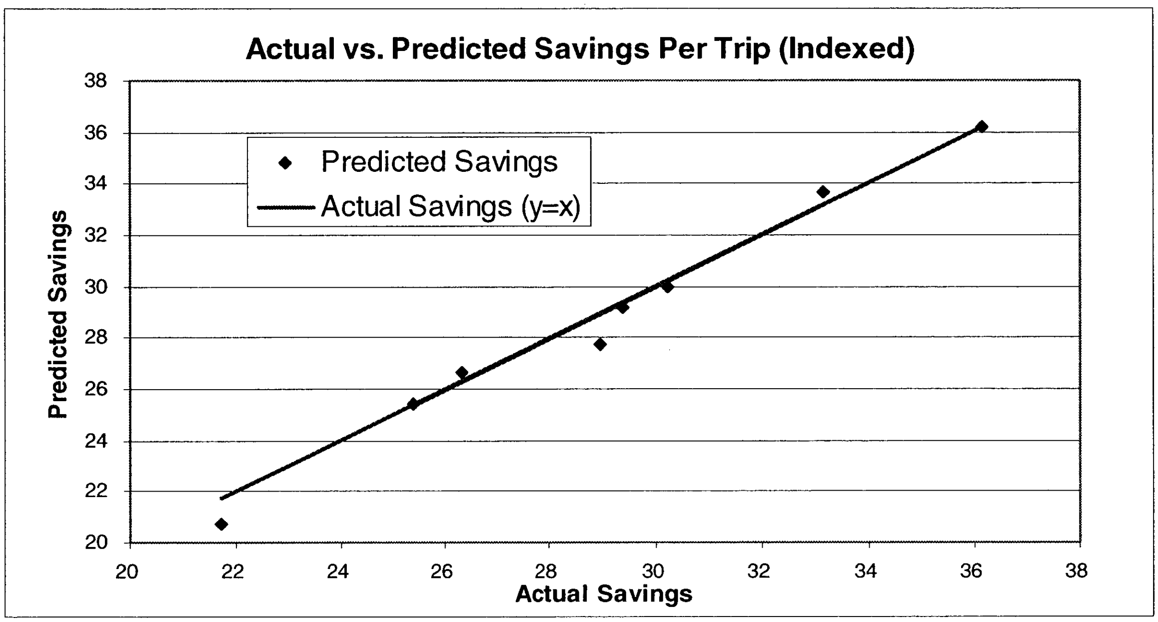
*Figure 8.4.1 Average Trip Costs and Savings for C&S Facilities, Indexed*

| | Weighted Average Miles to First Stop | Weighted Average Miles Per Trip | Average Number of Stops | Weighted Average Cost Per Trip (Indexed) | Weighted Average Savings Per Trip (Indexed) | Percentage Savings |
|---|---|---|---|---|---|---|
| Facility #1 | 74.0 | 257.8 | 8.2 | 104.6 | 21.7 | 20.7% |
| Facility #2 | 132.5 | 386.6 | 5.9 | 114.9 | 33.1 | 28.8% |
| Facility #3 | 98.7 | 257.0 | 4.8 | 92.1 | 30.2 | 32.8% |
| Facility #4 | 72.7 | 194.3 | 5.1 | 84.0 | 25.4 | 30.2% |
| Facility #5 | 148.9 | 373.5 | 5.9 | 112.7 | 36.2 | 32.1% |
| Facility #6 | 78.5 | 196.8 | 4.2 | 82.9 | 29.0 | 34.9% |
| Facility #7 | 106.1 | 319.7 | 7.6 | 109.3 | 26.3 | 24.1% |
| Facility #8 | 101.5 | 265.1 | 5.6 | 95.4 | 29.4 | 30.8% |

The average miles per trip, distance to first stop, and number of stops varies significantly from facility to facility because facilities serve different types of locales (urban vs. rural) and serve varying number of customers.

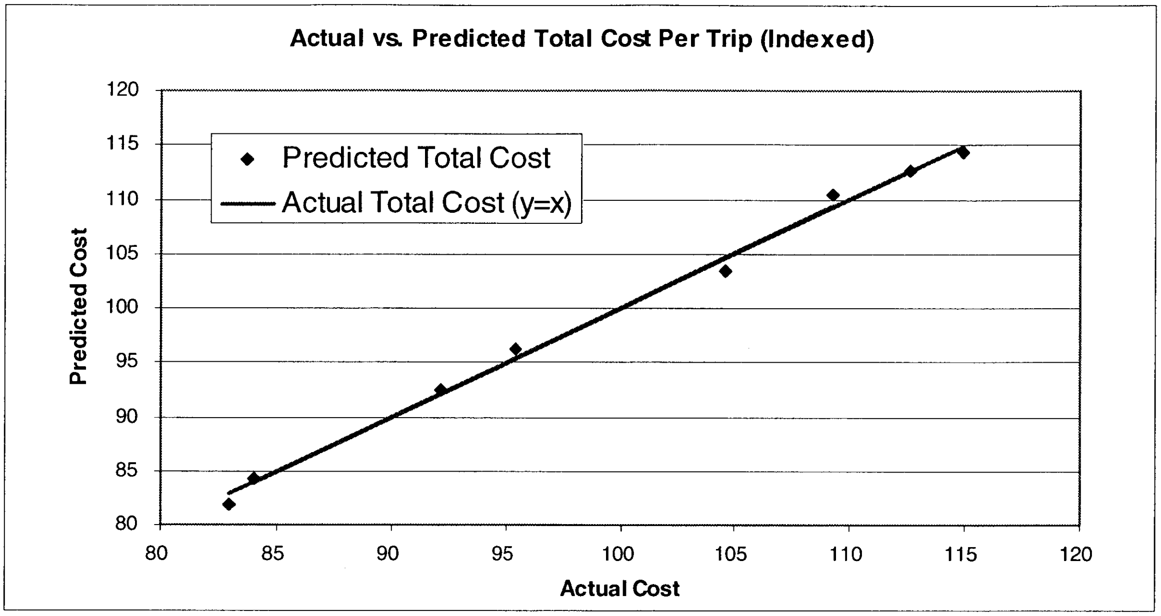
Steps Number 3-4: The next step is necessary to demonstrate that the three averages of distance per trip, distance to first stop, and number of stops can be used to reliably predict the average trip cost and savings. This prediction is not given because of the non linear cost structure. For example, one trip of 500 miles and one of 100 miles will not cost the same as two trips of 300 miles. However, the results show that there is a strong relationship between these three factors and trip cost and savings.

*Figure 8.4.2 – Average Savings as a Function of Average Distance to First Stop and Average Total Stops*




F ratios: Distance to First Stop: 222, Number of Stops: 37.3, MSE = 13.39, r^2 = 0.976

*Figure 8.4.3 – Average Total Cost as a Function of Average Total Trip Distance and Average Total Stops*




F Ratios: Total Miles = 854 Number of Stops = 136 MSE = 12.94 R^2 = 0.9959

The results in the above graphs are very intuitive, but such a strong linear relationship is not a given result from the price structure of transportation costs. With these strong linear relationships, the model can easily predict the per trip total costs and savings by asking the user to estimate the average total miles per trip, average miles to first stop per trip, and average stops per trip.

Steps Number 5-6: The average number of cases per trip at C&S facilities was taken from 8 weeks of C&S Volume Analysis Report for an 8 week stretch for several facilities. The average number of pieces, or cases, per load for each of these facilities is reported below.

*Figure 8.4.4 – Average Cases per Trip at C&S Facilities*

| Case per trip at | |
|---|---|
| Facility #1 | 1,668 |
| Facility #2 | 1,587 |
| Facility #3 | 1,671 |
| Facility #4 | 1,791 |
| Facility #5 | 1,573 |
| Facility #6 | 1,630 |
| Facility #7 | 1,709 |
| Facility #8 | 1,864 |
| Facility #9 | 1,542 |
| Average | 1,610 |

The average for the whole system is taken as 1610 cases. The total volume to be sourced from ES3 is calculated using the total movement at the user and the percentage of volume to be sourced from ES3. It is then easy to estimate the number of trips that will come from ES3 and the total transportation savings using the savings per trip calculated in step 4.

## 8.5 User Input

User input for transportation savings provided a very big challenge. The information that provides the most accurate estimate in the model – average distance to first stop, average miles per stop, and average number of stops per trip – is not likely to be readily available at any retailer that would be a user of the model. The components of these averages are likely tracked in trip records, but the averages are in many cases not likely to be readily available, and companies are unlikely to be willing to calculate them for the purposes of the model.

Much effort was spent trying to find factors that would predict average distance to first stop, average number of stops, and average total miles. The idea was to build a relationship between factors easier for the user to provide accurately and the factors that could predict trip cost and trip savings. John McGonigle, Vice President of Transportation, provided guidance on factors that might correlate to these three pieces of information. He speculated that factors that would effect the average number of stops, average distance to first mile, and total trip distance are number of customers served by the facility, number of individual retail stops served by the facility, number of items stocked at the facility, volume per retail outlet, and type of area served. The justification for each is as follows. McGonigle speculated that the all else being equal, as number of customers increased, total trip distance could either increase or decrease. Increases would result from customers covering a wider geographical base, but decreases could result if competitors are served in the same area, decreasing the geographical base. All else being equal, as the number of retail stops increases or the volume per retail stop decreases the number of stops per trip would likely increase since it would imply less product would be left at a stop. Number of items stocked would probably be a result of more customers, meaning more private label items, and an increase in number of items stocked could imply either a higher or lower average trip distance for the same reasons that number of customers could reflect a change.

Though McGonigle's intuition is likely correct, the limited number (8) of facilities at C&S for which detailed trip data was available, no relationships could reliably be built. Therefore, I made the decision to ask the user to estimate the averages for each facility for each of the three important criteria (distance to first stop, total trip distance, and number of stops per trip). Users are prompted for normal ranges based on observations at C&S. While users are unlikely to be able to accurately make very accurate predictions, they will have a very good understanding of the business they are managing, and having them make estimates is likely more accurate than using a non-statistically significant model to predict total transportation savings.

*Chapter 9: Operations Savings*

This chapter discusses the reasons and methods for estimating savings that a distributor will realize using direct-to-store delivery. These savings are the same for both the current manufacturers and best case scenario, but exist only in Phase II, direct to story delivery.

## 9.1 Introduction to Operations Savings

A significant portion of the savings in Phase II, when ES3 operates in a direct to store delivery model, will be operations savings through reduction of activity in the warehouse. There are two general reasons why these savings will be realized. The first reason is obvious. As volume is sourced directly from ES3 to the retail outlet, the distributor's warehouses will move less volume, resulting in lower demand for labor and equipment. The second reason is less obvious but more important. Because ES3 will initially remove primarily slow movers from the distributor's facilities, the labor efficiency of the facility will improve. In other words, a 20% reduction in volume should result in more than a 20% reduction in labor. The reasons for this belief will be discussed in more detail in section 9.3, but in general, removing an item from a facility reduces the average distance selectors must travel to pick an item.

The reason that savings which result from efficiency increases are more important from savings from volume decreases is that efficiency increases represent true system savings, or savings that are not simply shifted in the system, while some of the volume savings are simply moved from the distributor's facility to ES3. An example will better illustrate the difference. At a distributor's facility in the traditional model, a pallet of a single item is received from the MDC. It is unloaded by forklift and placed in an open storage slot. This slot number, along with necessary billing and receiving paperwork, is recorded in the receiving office. The storage slot is typically behind a pick slot, which is so called because it is accessible to employees picking cases to fill orders and contains an open pallet of product. Selectors fill orders by traveling on jacks to the appropriate pick slot, picking the correct number of cases, and moving to the pick slot for the next item on the list. When the pick slot is empty, the forklift driver moves a pallet of the product from a storage slot to the pick slot so that the selector will be able to access the item when it is next needed. The systems employed to store product, replenish empty pick slots, and direct selectors to the appropriate pick slot vary from facility to facility, but the basic work is the same.

Under DSD, the distributor no longer has to pick each case to go to the retail outlet. However, the case will have to be picked at ES3. In the traditional system, an entire pallet is picked at the MDC and then individual cases are picked at the RDC. (There are exceptions in both locations, but the majority of product is picked in this manner.) In the ES3 DSD model, there is no pallet pick at the MDC, but the case pick is now done at ES3 rather than at the RDC. So, while the distributor eliminates a case pick at its facility, this case pick must be done at ES3. A pallet pick is eliminated, which is must less costly than a case pick on a per-case basis, because pallets contain several cases. ES3 has technology that helps it to pick cases more efficiently than most RDCs, but the picking must still be done. Case picking is a large portion of the labor cost at a facility, and therefore, some, but certainly not all, of the labor savings from volume elimination at the RDC are pushed to ES3. The distributor would have to pay for some of the case picking labor indirectly, in the form of its fee to ES3. For the purposes of the model, all labor savings are reported. No ES3 fees are subtracted from the savings. A 20% reduction in labor costs is all reflected as savings in the model though the distributor will pay some of this to ES3 through its fee.

In contrast, savings from efficiency increases are not pushed to ES3. If a 20% decrease in volume through a facility represents a 20% reduction in labor due to volume decreases, (as argued in section 8.2) and an additional 5% decrease in labor due to efficiency increases, the 5% savings are total system savings. The labor costs are not being pushed to ES3. It is simply a more efficient use of the labor. For the purpose of the model, labor savings due to volume reduction and labor savings due to efficiency increases are treated separately.

## 9.2 Labor Savings from Volume Reduction

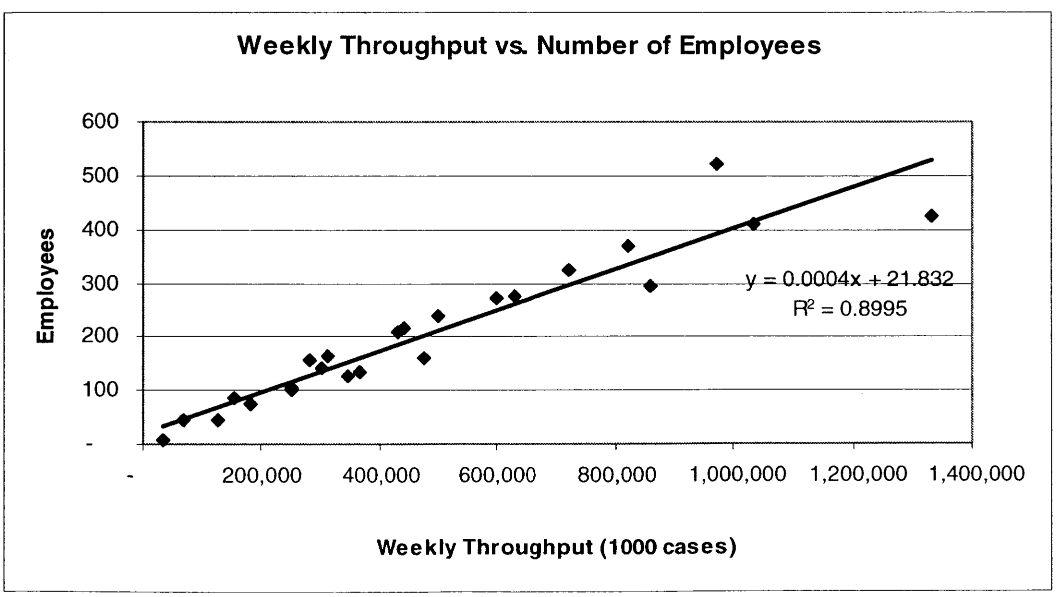
When a facility sources volume to ES3 due to direct to store delivery, the distributor will realize savings in labor costs and equipment uses. For the purpose of the model, the following questions must be answered.

1. For any given facility with a certain average weekly movement and number of employees, how many employees can be eliminated through any given percentage of volume reduction (not accounting for efficiency increases mentioned in section 8.1)?
2. What are the savings for this employee reduction in terms of dollars?
3. What equipment costs can be eliminated by the reduction in volume?

*9.2.1 - Linear Relationship between number of Employees and Weekly Throughput*

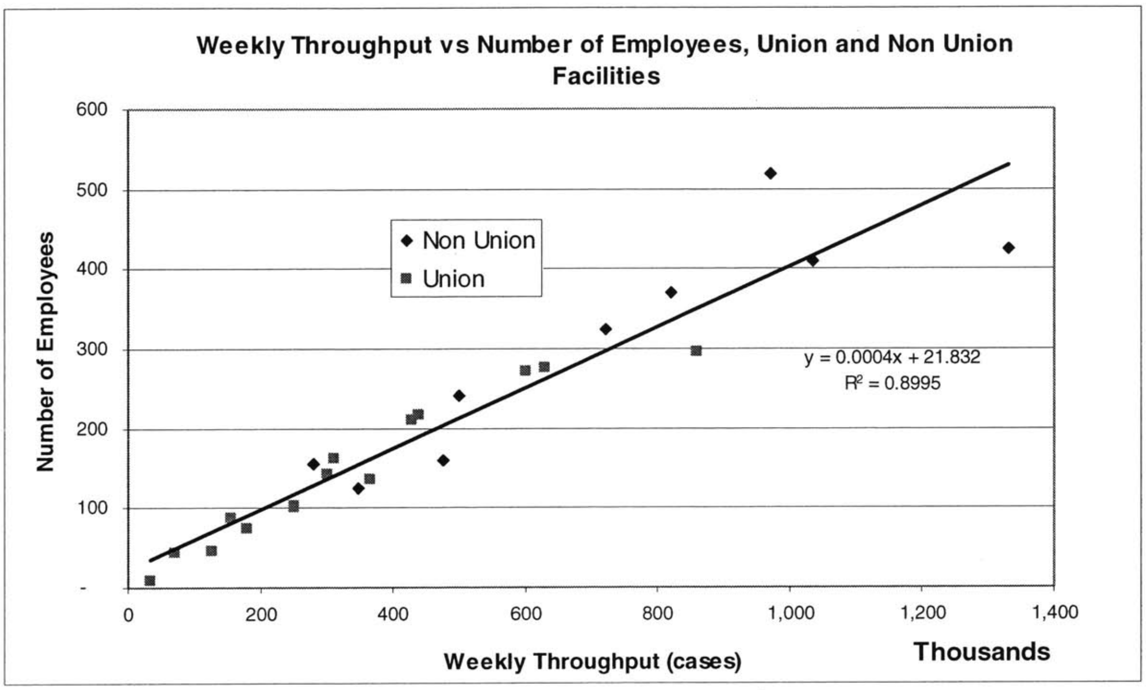
The first question is surprisingly easy to answer. There is a direct, strong linear relationship between the weekly throughput at a facility and the number of employees employed. This relationship was developed by graphing the number of employees against the weekly throughput for 24 C&S facilities and is shown in Figure 8.2.1

*Figure 9.2.1 - Relationship between Number of Employees and Weekly Throughput*



C&S has union and non-union facilities. Both represented as points on the graph and the single relationship shown in figure 9.2.1 holds for both. Figure 8.2.2 below shows the same relationship but differentiates between union and on union facilities. Though the non-union facilities tend to have higher average throughput, both the union and non union facilities are equally distributed above and below the trend line. (5 non union above, 4 non union below, 7 union above, 8 union below).

*Figure 9.2.2 - Volume vs. Throughput for Union and Non-Union Facilities.*




That the same relationship holds for union and non-union facilities is important because it means it can be applied to distributors who use the model and may have both types of facilities. Also, it refutes the idea that the relationship is strongly linear because of union policy or C&S policy. C&S's labor practices in its non-union facilities employ incentive pay and are aimed at reducing the number of employees in the facility. In these facilities, C&S would make every effort to operate with fewer employees if possible.

This relationship came as a surprise to Sam Garland, the Director of Warehouse Operations at C&S. Garland expected non-union facilities would have fewer employees per case of output. He hypothesized that the reason non-union facilities appear not to employ fewer employees per unit throughout is because though incentive pay makes the non union selectors, those actually picking the product, more efficient, they spend all of their time selecting, and more employees must be hired to do other tasks. In a union facility, employees spend some time selecting, but once their quotas are met, they spend time cleaning the facility, helping unload trucks, or performing other important tasks at the warehouse.

The strong linear relationship makes it easy to model the reduction in employees. A base number of employees as set at 21. (The intercept of employee versus throughput ratio is 21.) If a facility had no throughput, it would still need 21 employees to operate. The remaining employees are variable with volume. So, if a user indicates a particular facility has 100 employees, and if from the volume input section 20% of the volume will be sourced from ES3, the reduction in employees would be 15.

100 total employees – 21 base employees = 79 variable employees

(20% of volume)*79 variable employees = 15.8 employee reduction, rounded down to 15.

*9.2.2 - Calculating Financial Savings*

Once the total employee reduction is known, the model uses a straightforward approach to calculate the financial savings. As input, the user chooses to either give the average wage for each facility or to use the average for the area where the facility is located. If the user chooses average, the zip code of the facility is matched to a metropolitan area where salary in formation is available. All salary information comes from www.salary.com. Wage data for the job title Material Handler II is used. Material Handler II is described as follows[1]:

> Loads and unloads material within a warehouse or storage facility. Utilizes hand trucks, forklifts, hoists, conveyors, or other handling equipment to move material to and from aircraft, trucks or trains and within the storage facility. Requires a high school diploma with 2-5 years of experience in the field or in a related area. Has knowledge of standard practices and procedures within a particular field. Relies on limited experience and judgment to plan and accomplish goals. Performs a variety of tasks. Works under general supervision; typically reports to a supervisor or manager. A certain degree of creativity and latitude is required.

[1] From www.salary.com

This description is broad and fits the general average description of warehouse employees. Some certainly are more or less educated and experienced, but on average, Material Handler II was identified as a good fit by ES3 employees. While in many warehouses, especially incentive pay warehouses like some C&S facilities, there are specific job titles for employees, the model does not distinguish and treats everyone the same. The full table of wage data is available in appendix 6. The average for the region where ES3 operates is $27,399 annually. The range is $24,447 to $29,352. Benefits, which include bonuses, retirement contributions, payroll taxes, health care, and vacation costs, average just less than 50% of pay, bringing total compensation per employee to $40,959.
In addition to direct wages, benefits are a costly portion of compensation to employees. The model is set to use the same benefits rate (50%) for all facilities, but is designed with the flexibility for ES3 to set separate benefit rates for union and non union facilities. No data was found to confirm this difference, but ES3 employees believe that union facilities incur higher benefit costs.

Calculating labor savings is then simply a matter of multiplying the total compensation estimate per employee by the number of employees reduced. For example, a facility that eliminated 16 employees and had average compensation would save $655,344.

## 9.3 Equipment Savings from Volume Reduction

### *9.3.1 – Equipment Reduction*

In addition to labor savings from direct to store delivery, facilities will realize a reduction in equipment costs. Facilities use forklifts to move pallets of product, and jacks to pick cases of products from shelves. Other equipment is also used by warehousing facilities, but only jacks and forklifts are were found to vary with volume.
The process to estimate reduction in jacks and forklifts is also simple and straightforward. The average number of employees per jack and per lift was calculated for all C&S facilities, broken down by number of shifts. Figure 9.3.1 below shows these averages.

*Figure 9.3.1 – Employees per piece of equipment*

Employees per Piece of Equipment

| | Fork Lifts | Jacks |
|---|---|---|
| 1 shift | 7.0 | 1.4 |
| 2 shifts | 11.9 | 1.7 |
| 3 shifts | 15.4 | 2.0 |

To calculate the savings, first the reduction in employees allowed by the direct-to-store delivery is calculated as described in section 9.2. Then, the equipment reduction is calculated by dividing the number of employees by the employees per piece of equipment and rounding down. For example, a facility that reduced the number of employees by 16 and operated on one shift would save 16/7 = 2.3 lifts, rounded down to 2 lifts, and 16/1.4 = 11.4 jacks, rounded down to 11 jacks.

### *9.3.2 – Economic Benefit of Equipment Reduction*

In terms of dollar amounts, equipment savings are small compared to labor savings, but they are included in the model so the user will realize they exist. The calculation of savings is easy. Purchase costs, resale values, depreciation methods, and maintenance costs were obtained from the C&S warehousing department. Figure 9.3.2 shows how the savings for a single piece of both types of equipment was calculated. Calculating annual savings is then simply a matter of multiplying the number of pieces by the per piece savings.

*Figure 9.3.2 - Savings per Piece of Equipment Eliminated.*

Savings per piece of equipment

| | Fork Lifts | Jacks |
|---|---|---|
| Purchase Price | $ 25,000.0 | $ 5,000.0 |
| Resale Value | $ - | $ - |
| Deprciation | 7 year straight line | |
| Annual Depreciation Costs | $ 3,571 | $ 714 |
| Maintenance | 15% of purchase price | |
| Total Annual Costs | $ 7,321 | $ 1,464 |

To give an order of magnitude comparison, a typical facility with 100 employees eliminating 20% of volume would save $665,344 on labor and only $30,750 on equipment.

## 9.4 Savings from Efficiency Increases

*9.4.1 – Logic behind Efficiency Increases*

It is a common belief at ES3 that Direct to Store Delivery would result in operations savings due to efficiency increases in addition to the savings from volume reduction. This belief is held because ES3's model is to handle a facility's slow-moving items and there are two logical reasons that when slow movers are removed, the selection efficiency in the facility should increase. The basic rationale behind these reasons is described below.

1. **Increase in Roller Pick Slot Percentage.** There are different types of slots from which product can be picked. The most efficient of these slots are roller pick slots, where the next case rolls forward to be ready for selection. By outsourcing items to ES3, a greater percentage of items can be stored in roller pick slots, increasing the efficiency per selector. It must be noted, however, that slow-moving items are less likely to be stored in roller pick slots, outsourced items will come disproportionally from non-roller pick slots.
2. **Decrease in average distance traveled per order.** To pick an item, a selector in a warehouse must read the item and location from an order list (or receive this information via headset), travel to that location, locate the item, and place it with the rest of the order. If slow movers are removed from a facility, the decrease in storage footprint will be disproportional to decrease in volume. (i.e. 10% volume ~50% of items if the slowest moving items are removed, decreasing storage footprint ~50%) This disproportional decrease would mean less distance traveled, on average, per order.

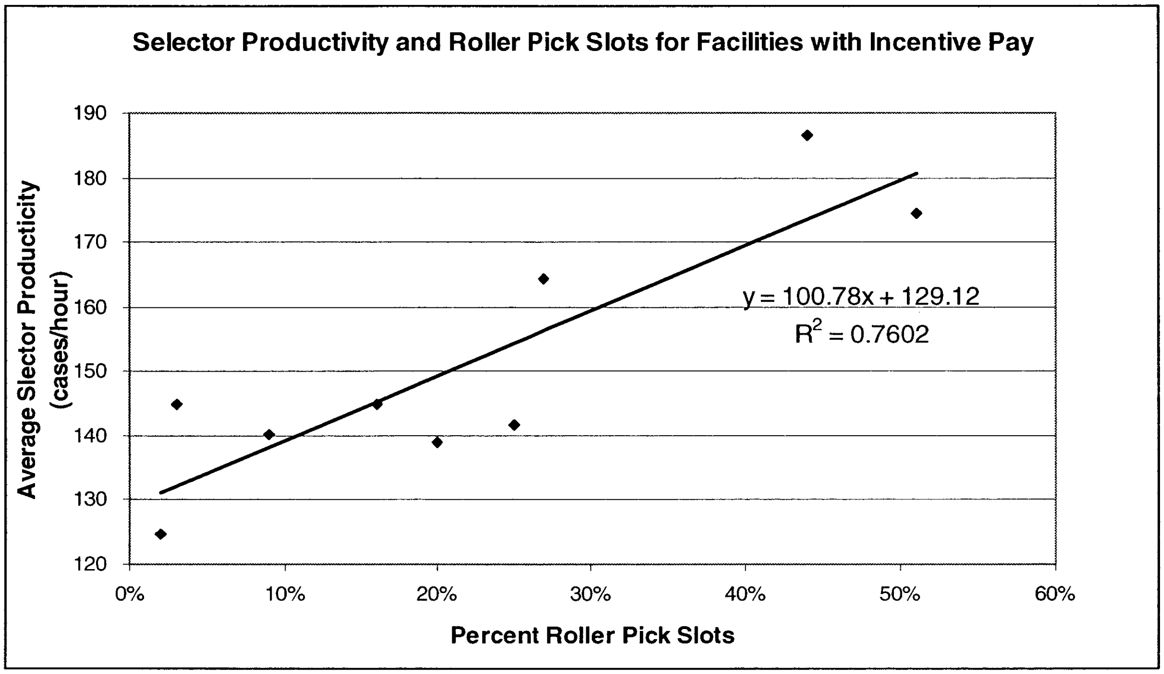
*9.4.2 - Attempts at modeling efficiency increases*

Unfortunately, data available to test these hypotheses was limited. Though ES3 has many facilities, selector efficiency is only tracked at facilities in the New England division, where incentive pay schemes pay selectors by the case, necessitating good record keeping. However, with only 8 data points, establishing meaningful relationships proved difficult.

*9.4.3 - Percent Roller Pick Slots and Efficiency*

Figure 9.4.1 shows the relationship between roller pick slot and selector productivity for the New England facilities with incentive pay for selectors. The data is taken from a 75 week period spanning 2002 and 2003.

*Figure 9.4.1 - Relationship between Selector Productivity and Roller Pick Slots for Facilities with Incentive Pay*




This relationship has a t-value of 4.36, meaning it is significant beyond 95% and indicating roller pick slots do have an effect on selector productivity. Figure 9.4.1 suggests increasing the percentage of items in pick slots will increase selector efficiency, but using it to predict efficiency increases from outsourcing is challenging because no good data was obtained that shows which products (slow movers versus fast movers) are typically held in roller pick slots. Therefore, it was impossible to get an estimate of the increase in items in roller pick slots from outsourcing slow movers. The necessary data is tracked in C&S, but limitations in IT support made it impossible to obtain.

*9.4.4 – Reduced travel times*

Selector efficiency increases due to reduced travel times did not prove possible to estimate from the available data. Part of the reduction in travel time is due to the increase in roller pick slot percentage. Roller pick slots allow more "facings", or exposed products, per square foot, reducing the footprint of the warehouse and reducing the average travel time for the selector. So, eliminating slow movers will reduce the footprint of storage simply because there fewer items to stock and also because those items will be stock more efficiently. It is impossible to separate this effect of roller pick slots from any effect from ease of selection due to the nature of the slot. Not enough data points exist to isolate one variable or the other.

## 9.5 Modeling Efficiency Increases

Because of the difficulties in estimating the savings due to efficiency increases, ES3 management made the decision not to include them in the model. However, estimates of what the savings might be, due to increased roller pick slot percentage only, are possible to make.

To illustrate the savings, we will estimate the efficiency savings at a sample grocery facility. We will assume that all items under 25 turn cases per week are outsourced to ES3, which we represent to be 10.7% of volume and 54.4% of items. We will make the assumption that slow movers and fast movers are equally distributed in the pick slots. This assumption is likely not true, but is used simply for the sake of ease in this illustration. The procedure to estimate selector reduction due to efficiency increases is outline below:

1 The necessary data for the grocery facility is:

| Sample Grocery Facility | |
|---|---|
| % Roller Pick Slots | 50% |
| Items | 20,000 |
| Employees | 160 |

2 The estimated efficiency, from the relationship in figure 9.4.1, based on 50% roller pick slots, is 180 cases per hour per selector.

3 The estimated percent roller pick slot after outsourcing is 100%. (50% of 20,000 items are currently in pick slots, meaning there are 10,000 roller pick slots. After 54.4% of the items are removed, fewer than 10,000 items will remain, leaving enough roller pick slots for all items.) Note that this is the step where the assumption slow movers are in roller pick slots at equal rates as fast-movers is used.

4 The estimated productivity, after sourcing from ES3, at 100% roller pick slot, is 229 cases per selector per hour. This estimate assumes linear behavior in figure 9.4.1 beyond the range for which data exists, which is a tenuous assumption, but will be used for the sake of illustration. This represents a 27% increase in estimated efficiency, or a 22% decrease in necessary selectors.

5 Since there are 160 employees and 21 base employees, there are 139 variable employees. Therefore, a 10.7% reduction in volume means a reduction of 14 variable employees simply due to volume. This reduction leaves 124 variable employees.

6 A 21% reduction in selectors due to efficiency means that an additional 27 selectors are eliminated due to efficiency increases.

Again, these numbers are for illustration only. In reality, the efficiency gains from increase in roller pick slot is probably significantly less. Despite the necessary assumptions and unknowns, these numbers demonstrate that productivity increases for selectors could mean significant savings for retailers in a direct-to-store delivery model. Chart 9.4.3 below makes the estimate for all a variety of typical fictional facilities using the same assumptions as the example above.

*9.4.3 – Example Reduction in Selectors due to Efficiency Increases (for Fictional Facilities)*

**Assumes equal distribution of fast/slow movers in roller pick slots*

| | % Roller Pick Slots | Items | Number of Employees | Actual Selector Productivity | Predicted Current Productivity | Roller Pick Slots W/ES3 | Predicted Productivity W/ES3 | Percentage Reduction in Selectors due to Effieciency | Reduction in Employees Due to Efficiency Increases |
|---|---|---|---|---|---|---|---|---|---|
| Sample Facility #1 | 50% | 20,000 | 160 | 174 | 180 | 100% | 230 | 22% | 27 |
| Sample Facility #2 | 45% | 7,200 | 58 | 187 | 174 | 99% | 229 | 24% | 8 |
| Sample Facility #3 | 27% | 9,500 | 169 | 164 | 156 | 59% | 189 | 17% | 22 |
| Sample Facility #4 | 3% | 5,500 | 180 | 125 | 132 | 7% | 136 | 3% | 3 |
| Sample Facility #5 | 25% | 11,000 | 175 | 142 | 154 | 55% | 184 | 16% | 22 |
| Sample Facility #6 | 3% | 16,000 | 165 | 145 | 132 | 7% | 136 | 3% | 3 |
| Sample Facility #7 | 9% | 4,000 | 102 | 140 | 138 | 20% | 149 | 7% | 5 |
| Sample Facility #8 | 20% | 14,000 | 202 | 139 | 149 | 44% | 173 | 14% | 22 |
| Sample Facility #9 | 16% | 2,275 | 41 | 145 | 145 | 35% | 164 | 12% | 2 |

*Chapter 10: Increased Sales due to Service Level Increase*

An additional benefit in under the ES3 model for Phase I and Phase II is that ES3 will operate at a higher service level that the current distributors RDC. Theoretically, every facility can increase its service level by increasing inventory held. In Phase I ES3, the reduction in lead time will allow a distributor to both decrease inventory and increase service level because the gains due to lead time and EOQ reduction are so great. In phase II, ES3 will be able to operate at a higher service level than the RDCs currently because the streamlined supply chain removes so much inventory from the system. Operating at a higher service level increases profits by increasing sales, but increases inventory.

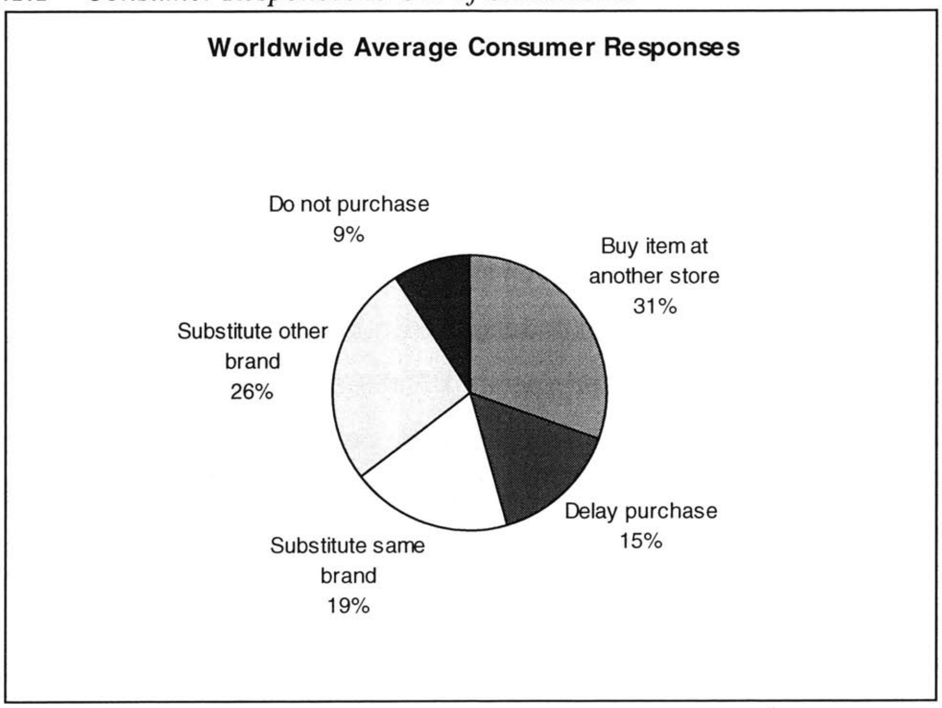
ES3 management requested that the model be built to show the effects of the distributor operating at an increased service level for Phase II and ES3 operating at a higher level than the RDC for Phase II. The benefits of reduced lead time and EOQ are so great to allow significant inventory savings even at a higher service level. A typical distributor service level to its individual retail outlets is 96%. ES3 requested the model be built assuming that the distributor would operate 1% above the user's current service level, but at a minimum of 98% and a maximum of 99.5%. So, if the user indicates a service level of 97% or below, the model assumes a service level of 98% when using ES3. From a user level above 97% to below 98.5% the model adds one percent to the user's current level. From a user level of 98.5% or higher, the model assumes a distributor's service level of 99.5% when using ES3. In reality, ES3 and the distributor could work together to determine the service level at which the distributor would operate, but for the model, the purpose is illustration of the benefit of higher service level.

To quantify this benefit, a very simple approach was used. When a distributor must cut product from a retail order, a consumer, as the retailer's customer, will often find the product missing at the point of purchase. According to an Emory University study funded by Procter & Gamble, there are 5 actions this consumer can take. [1] She can delay

[1] Gruen and Corsten, "Retail Out of Stocks: A Worldwide Examination of Extent, Causes, and Consumer Responses", 2002.

her purchase and eventually buy the intended item, avoid a purchase all together, buy the same item at another store, substitute a similar item from the same brand, or substitute a similar item from another brand. From the perspective of the distributor, neither a delayed purchase nor a substitution of a similar item of either the same or a different brand is not a problem. The distributor still gets a sale. However, avoiding purchase costs the distributor a sale. Going to another store may or may not cost the distributor a sale, depending on if this store is also served by the distributor. Figure 10.1 shows the relative proportions of these actions based on the findings of Gruen and Corsten.

*Figure 10.1.1 – Consumer Responses to Out of Stock Items*[2]




For the sake of the model, a fairly arbitrary assumption was made that the distributor would lose a sale about 2/3 of the time when the item is purchased at another store. For self-distributing retailers, this proportion is probably higher, because consumers are likely to go a close store from a different retailer. However, for wholesalers this proportion might be lower, as a large wholesaler can serve many chains in a single location.

[2] Gruen and Corsten, "Retail Out of Stocks: A Worldwide Examination of Extent, Causes, and Consumer Responses", 2002, page 5

Under this assumption, an out-of-stock item will cost the distributor a sale 29% of the time. ES3 indicated an average gross margin for a distributor is 25%. Using these values, it is easy to calculate the profit increase from operating at the higher service level. For example, a typical facility might move 1,000,000 cases a week, source 10% of its volume from ES3, operate currently at a 96% service level, and have an average case value of \$16.50. A 96% service level on the 10% of 1,000,000 cases moved means 4167 cuts. If 1,000,000 cases were moved, 1,004,167 must have been ordered to achieve a 96% service level. To operate at a 98% service level 102,833 cases must be moved, or 2083 fewer cuts. If 29% of these eliminated cuts go to the bottom line for the distributor, at a 25% gross margin and \$16.50 average case value, an extra \$2454 per week is made, and profits increase \$128,000 per year. These gains are obviously significant.

*Chapter 11: Results and Conclusions*

## 11.1 Typical results

Though no results are truly typical, using ES3 to source all products under 25 turn cases per week from the eight C&S New England facilities was used as a sample case as an example to develop the best case scenario. Sourcing all ES3 manufacturers from these same facilities was used to develop the current manufacturers scenario. These results are useful to get an understanding of the magnitude of savings distributors can expect in both phases. In the Best Case scenario, 10.7% of the volume and 54.5 % of the items will be sourced from ES3 using this input. For the Current Manufacturers, 14.3% of the volume and 15.3% of the items will be sourced from ES3. Figure 11.1.1 shows the dollar figure results for both phases in each of the key areas.

*Figure 11.1.1 – Sample Savings at 8 C&S New England Facilities Using all Products below 25 Cases per Week and all Current ES3 Manufacturers*

| | Total Gains | | | |
|---|---|---|---|---|
| | Phase I - | | Phase II | |
| | Best Case Scenario | Current Manufacturers | Best Case Scenario | Current Manufacturers |
| Total Inventory Savings | $ 2,525,586 | $ 1,707,914 | $ 3,328,833 | $ 2,323,804 |
| Total Transporation Savings | $ - | $ - | $ 2,524,515 | $ 3,376,837 |
| Total Operations Savings | | | $ 3,437,563 | $ 4,644,511 |
| Profit From Additional Sales | $ 1,942,232 | $ 2,597,795 | $ 1,942,232 | $ 2,597,795 |
| Total Annual Gains | $ 4,467,818 | $ 4,305,709 | $ 11,233,144 | $ 10,345,152 |
| One Time Cash Flow from Inventory Reduction | $ 50,511,713 | $ 34,158,283 | $ 66,576,670 | $ 46,476,078 |

These results are not very illustrative without context. In Phase II, the inventory savings represent a 75% reduction from the inventory costs C&S is incurring on these items without the use of ES3. In Phase II, all inventory costs for these items are eliminated. Using the calculations in the model, transportation savings for Phase II are approximately 32% of transportation costs to ship these items without the use of ES3. Note that both of these percentages are for items to be sourced from ES3 only and not for total costs at C&S. Because the model takes into account only labor savings from volume reduction, the operations savings for Phase II are just below the percentage of volume to be sourced from ES3. For the Best Case scenario, 10.4% of all operating costs will be eliminated.

For the Current Manufacturers scenario, 14.1% of all operating costs will be eliminated. Note that these are percent of all operating costs, not just on the items to be moved, but that a distributor would have to pay a large portion of these costs in the form of a fee to ES3.

## 11.2 Accuracy of Results

Testing the accuracy of the results is very difficult, because very little real information about the impact at distributors is available to ES3. To this date, ES3 has focused solely on manufacturers as customers, and worked little with distributors. There was one piece of data that did serve as a check for the results. C&S was an ES3 customer for a small set of ES3 products, giving one glimpse into how a distributor would see savings during Phase I. Phase I has no operations or transportation savings, and C&S was not operating at a higher service level on these products, making results for increase sales unavailable, but inventory on these products was tracked. The most meaningful statistic to managers at distributors is weeks of inventory on hand. This statistic is used by managers as a simple but effective measure of facilities' operations. For the scenario outlined in section 11.1, the model predicts weeks on hand for items to be sourced from ES3 as shown in figure 11.2.1.

*Figure 11.2.1 Weeks of Inventory on Hand for Example Scenario*

| | Best Case Scenario | Current Manufacturers |
|---|---|---|
| **Inventory Weeks on Hand Before** | **5.7** | **5.8** |
| **Inventory Weeks on Hand, After** | **1.4** | **1.5** |

In Figure 11.2.1, the numbers for after are Phase I results. ES3 managers familiar with operations at C&S felt the before numbers were accurate for the products analyzed. These managers also said that the average number of weeks on hand for ES3 products at C&S is currently about 3. The after numbers are lower than 3, but ES3 managers felt that the inventory at C&S could be reduced to a level of about 1.5-2.0 with more efficient ordering policies. In short, these managers felt that the results from the model painted a reasonably accurate picture of the savings from ES3 in an ideal situation, but that savings of the levels reported require behavior changes on the part of distributors to low inventory levels, and that these behaviors would have to be promoted by ES3.

The research for the model shows that there are significant savings distributors will realize by using ES3. These savings result primarily from the consolidation of several manufacturers into a single facility, which allows for shorter lead times and smaller order sizes. Consolidated ordering can benefit not only ES3 and its customers but all manufacturers and distributors willing to find way to pool inventory into fewer facilities.

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*Appendix 1: Glossary*

**Distributor** – A company which buys product from manufacturers and delivers it to retail outlets. Distributors for this thesis can be self – distributing retailers or wholesalers.

**ES3 Manufacturers** – Manufacturers who currently store product at ES3. They are listed in Appendix 3

**Item** – an individual product produced and sold by a manufacturer stored in a single distributor facility. A 4 roll pack of Bounty in Warehouse A is different that a 8 Roll pack of Bounty in Warehouse A, but it's also different than a 4 roll pack of Bounty in Warehouse B.

**Promotional volume** – Volume increases resulting directly from manufacturer or retailer promotions. Promotion volume is the difference between what is actually sold during a promotion and the turn volume for that year.

**Retailer** – Any company whose ultimate customer is an individual consumer. Stop & Shop and Kroger are examples. For this thesis, retailer refers to the entire company. Retail outlet – An individual store, owned and operated by a retailer, where consumers purchase goods

**SKU** – an individual product produced and sold by a manufacturer. SKU numbers are the same in all facilities within a distributor. A 4 roll pack of Bounty is different than an 8 roll pack of Bounty, but a 4 roll pack is the same SKU in all facilities.

**Turn volume** – Regular volume which a distributor moves in the absence of special promotions. Turn volume can vary seasonally, but does not changes with promotions

**Wholesaler** – A company which purchases products from manufacturers, sells it to retailers, and distributes it to those retailers' retail outlets.

*Appendix 2: Data Collected*

The 4 key databases used for all of the calculations necessary to build the model are discussed here.

## A2.1 Shipping, Receiving, and Inventory Database

One important database was all movement by shipment from all New England C&S facilities. The items used are listed on the next several pages. The time frame was 26 weeks in 2003. This database was used to calculate average order size for different movements and average inventory held. Appendix 4 summarizes some inventory results from these products. For each item, the following information was collected:

- Date and mount ordered, and amount received for *each incoming order* of each incoming order.
- Date, amount ordered, and amount shipped for *each outgoing order.*
- Inventory on hand for each item every Saturday at noon.
- Location where each shipment was sent

## A2.2 Transportation Database

The primary database used to calculate transportation savings contained travel information for each shipment leaving any of C&S's New England for an 8 month period in 2003. There were approximately 127,000 trips from 22 separate facilities included on in this database for a total of over 750,000 stops. About 37,000 were from the 7 New England facilities studied, were conclusively identified as dry grocery shipments, and had all necessary fields filled. These 37,000 trips were used in calculations in the mode. For each shipment, the following information was collected:

- Departure location (C&S facility)
- Date and time of departure
- Location of Each Stop
- Miles from previous stop
- Type of trailer (used to identify dry grocery loads only)

Figure A2.1 shows high level results from the transportation analysis from these facilities. Data given are averages.

*Figure A2.2.1 – Transportation Analysis Results*

| Facility | Outlets Served | Cases Per Load | Customers Served | Cases Per Stop | Number of Stops | Total Miles | Miles to First Stop |
|---|---|---|---|---|---|---|---|
| Facility #1 | 3,325 | 1,587.1 | 15 | 416.0 | 3.92 | 345.1 | 166.5 |
| Facility #2 | 1,076 | 1,573.0 | 4 | 939.1 | 4.26 | 198.2 | 78.1 |
| Facility #3 | 1,635 | 1,668.0 | 10 | 576.2 | 5.12 | 342.2 | 117.0 |
| Facility #4 | 1,865 | 1,791.3 | 2 | 1,202.9 | 6.00 | 231.2 | 69.8 |
| Facility #5 | 1,306 | 1,863.7 | 5 | 1,041.7 | 5.16 | 194.2 | 72.7 |
| Facility #6 | 304 | 1,670.8 | 15 | 743.3 | 5.50 | 207.3 | 56.7 |

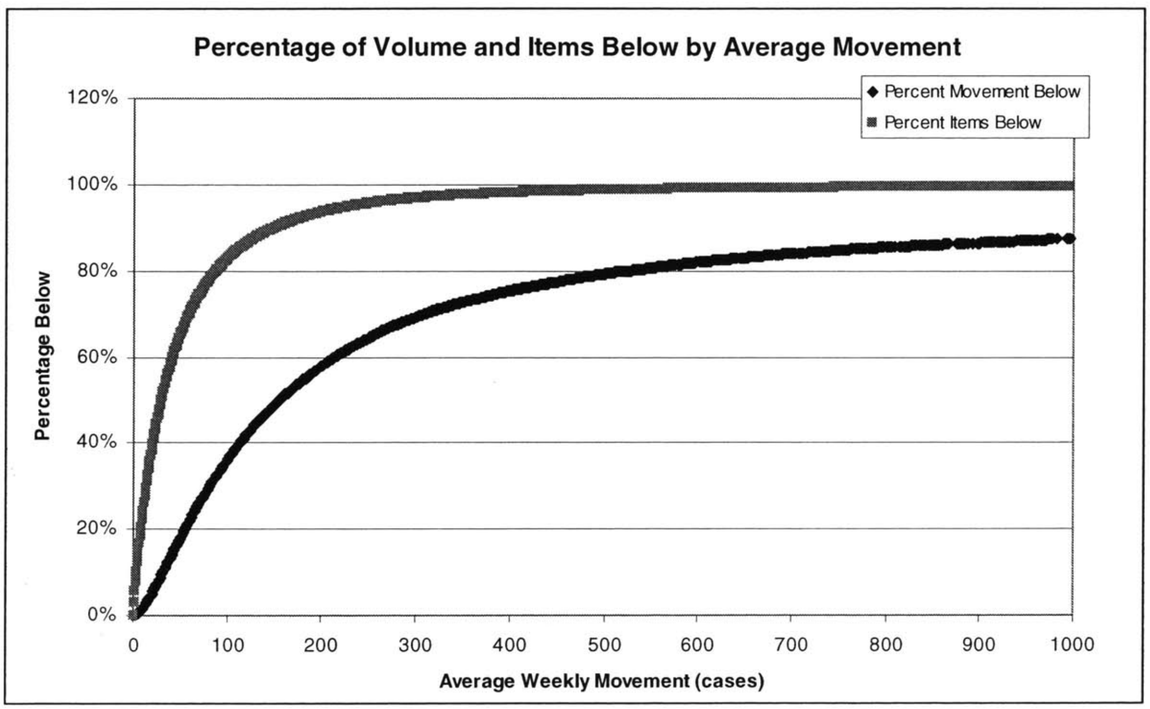
## A2.3 Snapshot of all movement.

An important database in determining volume to be outsourced was a snapshot of movement for all products in the C&S system from an unknown day in autumn 2002. This database was prepared for a different ES3 project, and though it was a year dated, little in terms of distribution of movements had changed in the previous year. Limited IT resources made it impossible to get a more recent snapshot, but this snapshot was effectively used. Data was available for over 94,000 different items. Much data was available in this database, but the only fields used were for each item:

- Manufacturer
- Average Turn movement for the previous 8 weeks
- Average total movement for the previous 8 weeks
- Inventory on hand on the day the snapshot was taken

Figure A2.3.1 shows the relationship between average turn movement and percentage of volume and percentage of items for total movement (turn plus promotions.) The graph is truncated at an average movement of 1000 cases, though there are a handful of products with average movement up to more than 15,000 cases per week.

*Figure A2.3.1 – Distribution of Items and Volume*




## A2.4 Operating Information Database

To calculate operations savings, C&S provided detailed data about employee productivity at several warehouses. This information is proprietary and no results will be presented here, but for each warehouse, the following information was provided for a 75 week period spanning 2002 and 2003. This information was provided for 9 facilities. All information is weekly averages, where applicable:

- Selection hours
- Cases selected
- Forklift hours
- Forklift pieces moved
- Backhaul hours
- Backhaul pieces
- Support hours
- Inventory Capacity
- Square footage
- Number of employees
- Number of items
- Number and identity of customers
- Number of retail outlets
- Percent Roller Pick Slots

## *Appendix 3: Current Manufacturers at ES3 as of 12/9/03*

Figure A3.1 has a list of current ES3 manufacturers and key data used to calculate savings for the current manufacturers scenario.

*Figure A3.1 – Current ES3 Manufacturers*

| Customer Name | Total Items | Average Total 8 Week Movement | Average 8 Week Turn Movement | Total Inventory | Average Movement | Average Inventory |
|---|---|---|---|---|---|---|
| Manufacturer #1 | 66 | 5,172 | 2,777 | 13,572 | 78.4 | 205.6 |
| Manufacturer #2 | 16 | 369 | 203 | 2,203 | 23.1 | 137.7 |
| Manufacturer #3 | 5 | 83 | 67 | 1,443 | 16.6 | 288.6 |
| Manufacturer #4 | 2,453 | 202,929 | 135,377 | 602,500 | 82.7 | 245.6 |
| Manufacturer #5 | 3,071 | 158,881 | 95,438 | 510,762 | 51.7 | 166.3 |
| Manufacturer #6 | 131 | 6,245 | 3,397 | 27,215 | 47.7 | 207.7 |
| Manufacturer #7 | 61 | 4,419 | 3,880 | 9,932 | 72.4 | 162.8 |
| Manufacturer #8 | 1,180 | 99,903 | 59,892 | 279,269 | 84.7 | 236.7 |
| Manufacturer #9 | 160 | 22,938 | 8,903 | 68,288 | 143.4 | 426.8 |
| Manufacturer #10 | 879 | 59,297 | 30,604 | 216,455 | 67.5 | 246.3 |
| Manufacturer #11 | 16 | 593 | 566 | 3,229 | 37.1 | 201.8 |
| Manufacturer #12 | 5,603 | 284,978 | 180,755 | 1,033,544 | 50.9 | 184.5 |
| Manufacturer #13 | 21 | 838 | 223 | 5,133 | 39.9 | 244.4 |
| Manufacturer #14 | 47 | 1,936 | 1,212 | 8,490 | 41.2 | 180.6 |
| Manufacturer #15 | 73 | 5,530 | 4,393 | 16,318 | 75.8 | 223.5 |
| Manufacturer #16 | 92 | 5,550 | 4,096 | 15,441 | 60.3 | 167.8 |
| Manufacturer #17 | 10 | 697 | 513 | 1,527 | 69.7 | 152.7 |
| Manufacturer #18 | 58 | 1,252 | 279 | 1,411 | 21.6 | 24.3 |

*Appendix 4: Safety Stock Levels Observed at C&S*

Due to confidentiality concerns, data for individual products cannot be displayed. However, the graphs below represent general trends between total inventory and average movement for the 416 products studied. Just fewer than 100 of the products had either no movement or had incomplete data and were not included in the analysis.

Figure A4.1 Plots the relationship between average inventory on hand and average weekly movement. Inventory on hand is taken every Saturday at noon, and data is available for 26 weeks in 2003.

*Figure A4.1 – Relationship between Average Movement and Average Inventory on Hand*

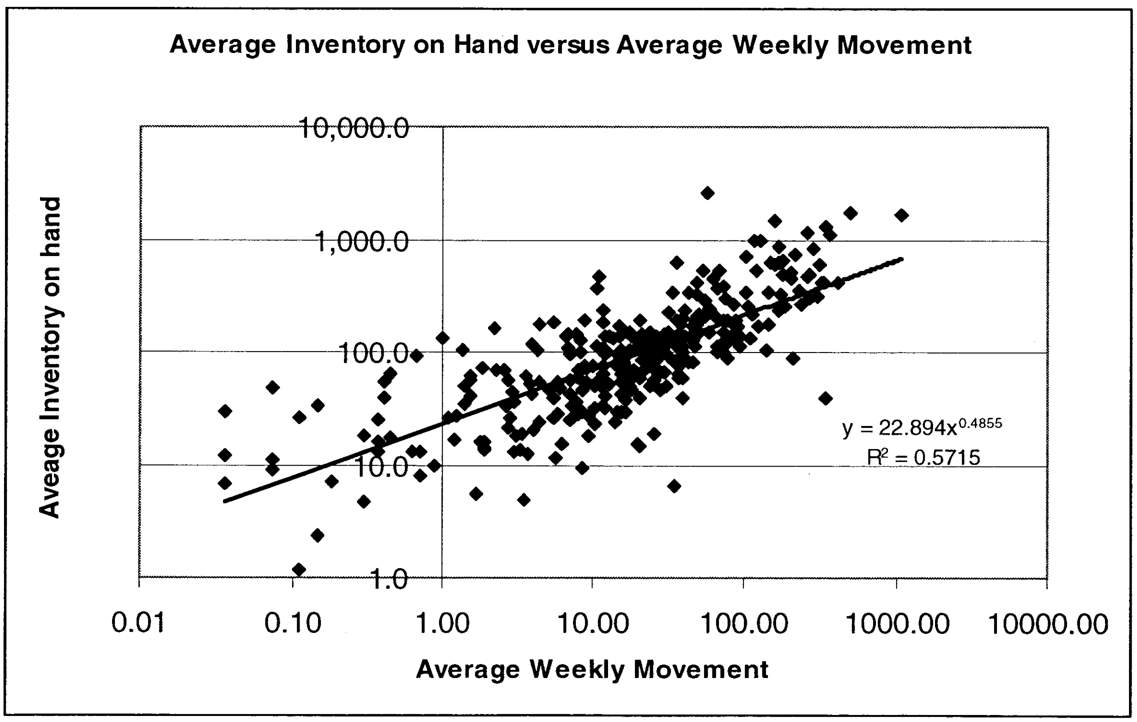



Figure A4.2 plots the relationship between average order size and average weekly movement. Average order size is the average incoming order size for C&S.

*Figure A4.2 – Average Weekly Movement vs. Average Order Size*

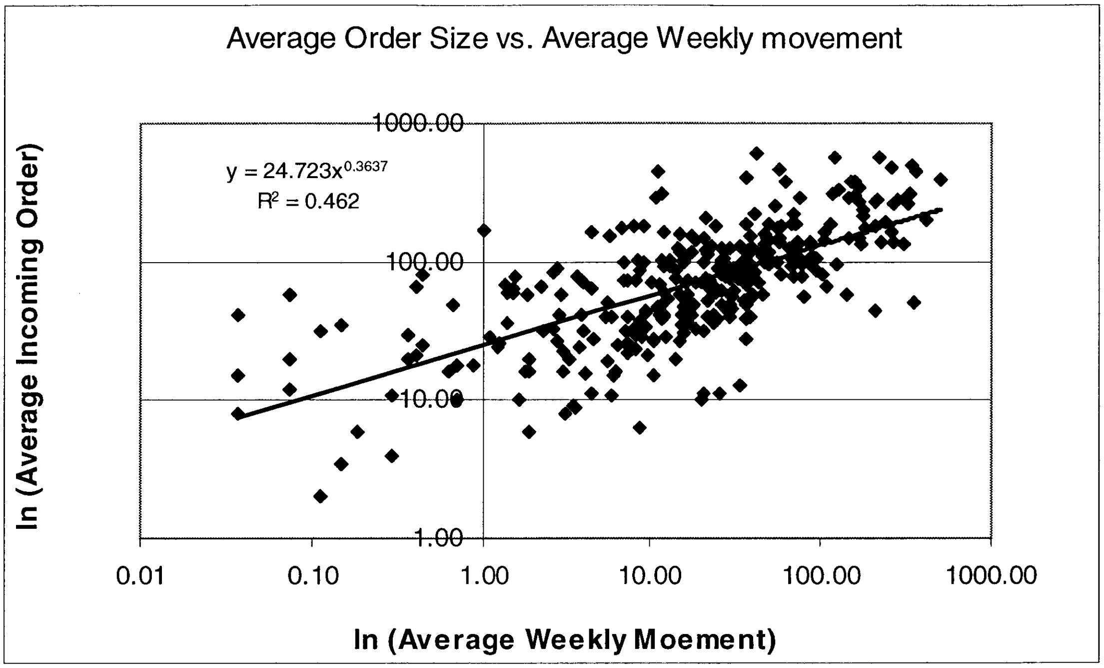
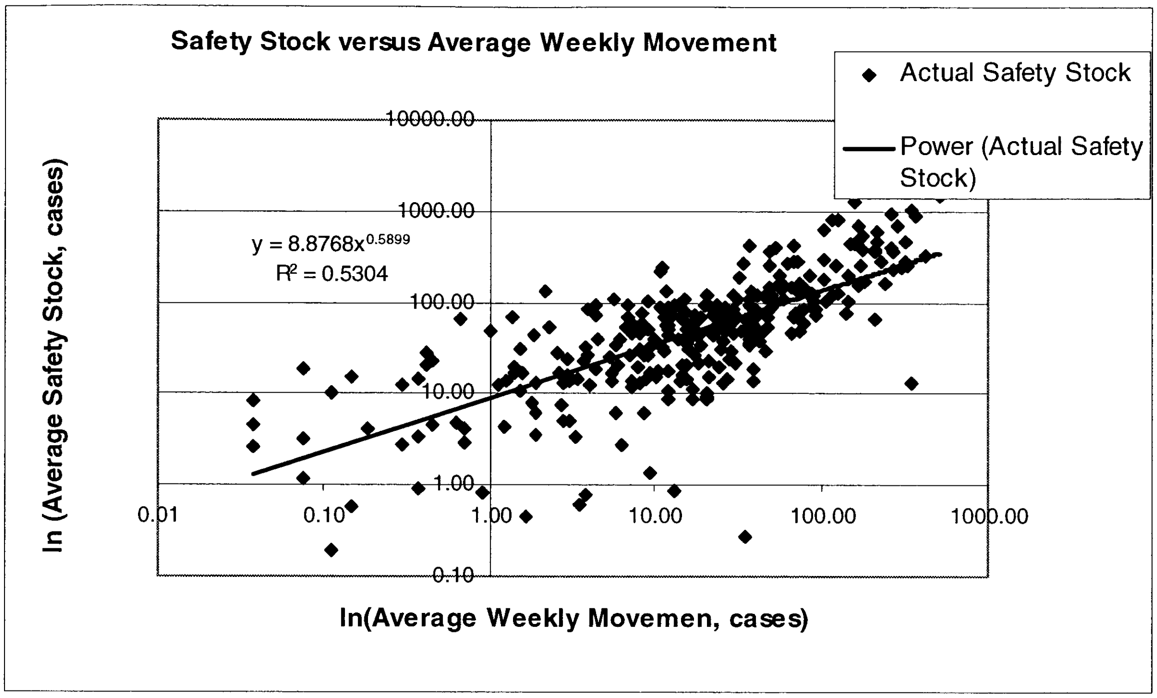



Figure A4.3 plots the average safety stock versus the average movement. Safety stock is calculated as balance on hand less ½ of the average incoming order size.

*Figure A4.3 – Average Safety Stock versus Average Weekly Movement*



## *Appendix 5: Cost per Mile Based on Stops per Trip*

To calculate trip cost and savings in Phase II, per mile costs are needed. The following chart shows the *indexed* cost per mile used to calculate these costs. Costs are indexed to the such that the median of the 8 available average trip costs by facility is 100. In addition to the per mile costs, there is an indexed cost of 6.47 for driver pay per stop.

*Figure A5.1 - Indexed per Mile Cost Based on Total Trip Distance and Number of Stops*

| | Number of Stops | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Total Trip Distance (Miles)** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| **0-25** | 0.85 | 0.81 | 0.75 | 0.70 | 0.65 | 0.62 | 0.59 | 0.56 | 0.53 | 0.50 |
| **26-50** | 0.70 | 0.66 | 0.62 | 0.58 | 0.53 | 0.51 | 0.48 | 0.46 | 0.43 | 0.41 |
| **51-75** | 0.60 | 0.57 | 0.54 | 0.50 | 0.47 | 0.44 | 0.42 | 0.40 | 0.38 | 0.36 |
| **76-100** | 0.53 | 0.50 | 0.47 | 0.44 | 0.41 | 0.39 | 0.37 | 0.35 | 0.34 | 0.32 |
| **101-150** | 0.43 | 0.40 | 0.38 | 0.36 | 0.34 | 0.32 | 0.30 | 0.29 | 0.27 | 0.26 |
| **150-200** | 0.35 | 0.33 | 0.31 | 0.30 | 0.28 | 0.26 | 0.25 | 0.24 | 0.23 | 0.21 |
| **201-300** | 0.28 | 0.27 | 0.25 | 0.24 | 0.23 | 0.22 | 0.20 | 0.19 | 0.18 | 0.18 |
| **300+** | 0.23 | 0.22 | 0.21 | 0.20 | 0.19 | 0.18 | 0.17 | 0.16 | 0.15 | 0.14 |

| | Number of Stops | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Total Trip Distance (Miles)** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** |
| **0-25** | 0.48 | 0.45 | 0.43 | 0.41 | 0.39 | 0.37 | 0.35 | 0.33 | 0.32 | 0.30 |
| **26-50** | 0.39 | 0.37 | 0.35 | 0.34 | 0.32 | 0.30 | 0.29 | 0.27 | 0.26 | 0.25 |
| **51-75** | 0.34 | 0.33 | 0.31 | 0.29 | 0.28 | 0.27 | 0.25 | 0.24 | 0.23 | 0.22 |
| **76-100** | 0.30 | 0.29 | 0.27 | 0.26 | 0.25 | 0.23 | 0.22 | 0.21 | 0.20 | 0.19 |
| **101-150** | 0.25 | 0.24 | 0.22 | 0.21 | 0.20 | 0.19 | 0.18 | 0.17 | 0.16 | 0.16 |
| **150-200** | 0.20 | 0.19 | 0.18 | 0.17 | 0.17 | 0.16 | 0.15 | 0.14 | 0.13 | 0.13 |
| **201-300** | 0.17 | 0.16 | 0.15 | 0.14 | 0.14 | 0.13 | 0.12 | 0.12 | 0.11 | 0.11 |
| **300+** | 0.14 | 0.13 | 0.12 | 0.12 | 0.11 | 0.11 | 0.10 | 0.10 | 0.09 | 0.09 |

| | Number of Stops | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Total Trip Distance (Miles)** | **22** | **23** | **24** | **25** | **26** | **27** | **28** | **29** | **30** | **31** |
| **0-25** | 0.29 | 0.27 | 0.26 | 0.24 | 0.23 | 0.22 | 0.21 | 0.20 | 0.19 | 0.18 |
| **26-50** | 0.23 | 0.22 | 0.21 | 0.20 | 0.19 | 0.18 | 0.17 | 0.16 | 0.16 | 0.15 |
| **51-75** | 0.21 | 0.20 | 0.19 | 0.18 | 0.17 | 0.16 | 0.15 | 0.14 | 0.14 | 0.13 |
| **76-100** | 0.18 | 0.17 | 0.16 | 0.16 | 0.15 | 0.14 | 0.13 | 0.13 | 0.12 | 0.11 |
| **101-150** | 0.15 | 0.14 | 0.13 | 0.13 | 0.12 | 0.11 | 0.11 | 0.10 | 0.10 | 0.09 |
| **150-200** | 0.12 | 0.12 | 0.11 | 0.10 | 0.10 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 |
| **201-300** | 0.10 | 0.09 | 0.09 | 0.09 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.06 |
| **300+** | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 |

| | Number of Stops | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Total Trip Distance (Miles)** | **32** | **33** | **34** | **35** | **36** | **37** | **38** | **39** |
| **0-25** | 0.17 | 0.16 | 0.15 | 0.15 | 0.14 | 0.13 | 0.13 | 0.12 |
| **26-50** | 0.14 | 0.13 | 0.13 | 0.12 | 0.11 | 0.11 | 0.10 | 0.10 |
| **51-75** | 0.12 | 0.12 | 0.11 | 0.11 | 0.10 | 0.10 | 0.09 | 0.09 |
| **76-100** | 0.11 | 0.10 | 0.10 | 0.09 | 0.09 | 0.08 | 0.08 | 0.08 |
| **101-150** | 0.09 | 0.08 | 0.08 | 0.08 | 0.07 | 0.07 | 0.07 | 0.06 |
| **150-200** | 0.07 | 0.07 | 0.07 | 0.06 | 0.06 | 0.06 | 0.05 | 0.05 |
| **201-300** | 0.06 | 0.06 | 0.05 | 0.05 | 0.05 | 0.05 | 0.04 | 0.04 |
| **300+** | 0.05 | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 | 0.03 |

## *Appendix 6: Wage data from salary.com*

**Warehouse Worker Salaries**

*(All salary information from Salary.com using Material Handler #2)*

| | Average Annual Salary | Average With Benefits | Benefits as a Percentage of Salary | Average Hourly Rate |
|---|---|---|---|---|
| | | **New Hampshire** | | |
| Concord | $ 26,341 | $ 39,661 | 50.6% | $ 12.66 |
| Manchester | $ 26,549 | $ 39,931 | 50.4% | $ 12.76 |
| Portsmouth | $ 26,575 | $ 39,965 | 50.4% | $ 12.78 |
| | | **Vermont** | | |
| Burlington | $ 24,884 | $ 37,770 | 51.8% | $ 11.96 |
| | | **Maine** | | |
| Portland | $ 24,940 | $ 37,838 | 51.7% | $ 11.99 |
| Bangor | $ 24,447 | $ 37,196 | 52.1% | $ 11.75 |
| | | **Connecticut** | | |
| Hartford | $ 28,132 | $ 41,991 | 49.3% | $ 13.53 |
| Stamford | $ 29,118 | $ 43,274 | 48.6% | $ 14.00 |
| Bridgeport | $ 28,962 | $ 43,071 | 48.7% | $ 13.92 |
| Norwich | $ 27,405 | $ 41,045 | 49.8% | $ 13.18 |
| | | **Massachusetts** | | |
| Boston | $ 28,236 | $ 42,126 | 49.2% | $ 13.58 |
| Worcester | $ 26,731 | $ 40,167 | 50.3% | $ 12.85 |
| Springfield | $ 26,808 | $ 40,269 | 50.2% | $ 12.89 |
| Lowell | $ 26,705 | $ 40,134 | 50.3% | $ 12.84 |
| Pittsfeld | $ 25,744 | $ 38,884 | 51.0% | $ 12.38 |
| | | **Rhode Island** | | |
| Providence | $ 26,237 | $ 39,526 | 50.6% | $ 12.61 |
| | | **New York** | | |
| New York - Queens | $ 29,352 | $ 43,578 | 48.5% | $ 14.11 |
| Nassua | $ 28,262 | $ 42,159 | 49.2% | $ 13.59 |
| Huntington | $ 29,014 | $ 43,139 | 48.7% | $ 13.95 |
| Poughkeepsie | $ 27,302 | $ 40,910 | 49.8% | $ 13.13 |
| Syracuse | $ 26,212 | $ 39,492 | 50.7% | $ 12.60 |
| | | **New Jersey** | | |
| Newark | $ 28,883 | $ 42,902 | 48.5% | $ 13.89 |
| Trenton | $ 28,236 | $ 42,126 | 49.2% | $ 13.58 |
| Vineland | $ 27,847 | $ 41,619 | 49.5% | $ 13.39 |
| Atlantic City | $ 28,054 | $ 41,889 | 49.3% | $ 13.49 |
| | | **Delaware** | | |
| Wilmginton | $ 27,198 | $ 40,775 | 49.9% | $ 13.08 |
| | | **Maryland** | | |
| Baltimore | $ 26,497 | $ 39,863 | 50.4% | $ 12.74 |
| | | **Virginia** | | |
| Virginia Beach | $ 24,654 | $ 37,466 | 52.0% | $ 11.85 |
| Lynchburg | $ 24,577 | $ 37,365 | 52.0% | $ 11.82 |
| Richmond | $ 25,693 | $ 38,817 | 51.1% | $ 12.35 |
| DC | $ 27,535 | $ 41,214 | 49.7% | $ 13.24 |
| | | **Pennsylvania** | | |
| Philadelphia | $ 27,463 | $ 41,146 | 49.8% | $ 13.20 |
| Pittsburgh | $ 26,030 | $ 39,256 | 50.8% | $ 12.51 |
| Harrisburg | $ 26,056 | $ 39,289 | 50.8% | $ 12.53 |
| Erie | $ 26,186 | $ 39,458 | 50.7% | $ 12.59 |
| York | $ 25,667 | $ 38,783 | 51.1% | $ 12.34 |
| Lancaster | $ 25,589 | $ 38,682 | 51.2% | $ 12.30 |
| | | **Ohio** | | |
| Cincinnati | $ 26,004 | $ 39,322 | 51.2% | $ 12.50 |
| Cleveland | $ 26,341 | $ 39,661 | 50.6% | $ 12.66 |
| Columbus | $ 26,134 | $ 39,391 | 50.7% | $ 12.56 |
| Toledo | $ 25,882 | $ 38,986 | 50.6% | $ 12.44 |
| Lima | $ 25,882 | $ 38,986 | 50.6% | $ 12.44 |

**State Averages**

*If a Zip Code Cannot be matched with a city, the average for that state is used.*

| State | Minimum Zip Code | Maximum Zip Code | Average Hourly Rate | Benefits as a Percentage of Salary |
|---|---|---|---|---|
| Massachusetts | 1001 | 2719 | $ 12.91 | 50% |
| Rhode Island | 2801 | 2940 | $ 12.61 | 51% |
| New Hampshire | 3031 | 3987 | $ 12.73 | 50% |
| Maine | 3901 | 4990 | $ 11.87 | 52% |
| Vermont | 5001 | 5907 | $ 11.96 | 52% |
| Connecticut | 6001 | 6928 | $ 13.55 | 49% |
| New Jersey | 7001 | 8989 | $ 13.63 | 49% |
| New York | 10001 | 1495 | $ 13.48 | 49% |
| Pennsylvania | 15001 | 19640 | $ 12.58 | 51% |
| Delaware | 19701 | 19980 | $ 13.08 | 50% |
| Virginia | 20101 | 24658 | $ 12.31 | 51% |
| Maryland | 20601 | 21930 | $ 12.74 | 50% |
| Ohio | 43001 | 45999 | $ 12.52 | 51% |