Product & Customer Profiling for Direct Store Delivery (DSD)

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Abstract

This thesis is to analyze the suitability of different products, suppliers and customers for Direct Store Delivery (DSD) model with respect to the qualitative profile and the quantitative benefits. During the research, interviews with retailers, suppliers and industrial experts provide the basis and insight for the qualitative analysis of factors that make certain products, suppliers and customers best suitable for a DSD model. In order to quantify the benefits that DSD can bring to the entire supply chain, a generic model of the DSD system is built. Based on the quantitative analysis, the stock-out at store shelf is simulated in order to understand the effects of DSD operations to the minimization of stock-out costs at the store shelf, a major benefit that DSD is assumed to generate. With the conceptual framework and the quantitative model, this thesis is aimed at providing supply chain managers a comprehensive perspective to adopt DSD for their products and customers.

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Interviews with industry practitioners are critical in developing the models and acquiring insights in the process of this research project. I hereby would like to extend sincere thanks to our sponsor company that provided great help in every aspect during the course of this research. I would also like to thank many other industry leaders and researchers who helped to provide their insights on the topic, including Paula Rosenblum (Director, Retail System Research), Lora Cecere (Research Director, AMR Research), Alexi L. Sarnevitz (Senior Director, SAS Institute), Cheryl Schondek (Director, Product Management, Shaw's), Brett Frankenberg (Director, Supply Chain Planning, Coca Cola Consolidated), and Camelia Silva (Associate, Unilever). I hereby would like to express my sincere thanks to all of you.

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Thesis Question

According to the definition by American Marketing Association [AMA], Direct Store Delivery (DSD) is:

1. (physical distribution definition) A system whereby goods are delivered to the buyer's store instead of going through a warehouse or distribution center. This can result in less handling and faster deliveries, but does not necessarily result in lower costs.
2. (retailing definition) Delivery by a vendor directly to a retail store of a customer, as opposed to delivery to a distribution center operated by the customer.

DSD has been widely adopted in industries such as beverage, brewery, news and magazines and snacks and frozen foods by companies such as Coca-Cola, Pepsi Bottling and Frito-Lay. Grocery stores rely on a suppliers' DSD network to replenish store stock, assort the shelves and manage the category. Because in a DSD model, a route salesman checks the stock of the stores on his route as frequently as several times a week, a clean shelf, high stock fulfillment and high customer satisfaction are achieved in most cases. The Grocery Manufacturers Association (GMA) revealed in its 2005 research report "Unleash the Power of DSD" that a typical large-format store received 12,000 DSD deliveries a year and a typical small-format store received 1,100 deliveries a year. [GMA, 2005] Most merchandise replenished via the DSD mode are of fast rotation, high volume, high sensitivity to product features, short lead time and demanding operational requirements. The importance to store sales performance has driven some retailers (that have invested heavily in transportation and warehousing assets) to start looking to shift products from flowing via a suppliers' DSD channel to their own internal network.

Facing the pressure from retailers, supply chain managers of DSD suppliers feel an urgency to have answers to the questions: What values does the DSD model still have to suppliers and retailers over a retailer's internal network? If the shift is inevitable, to what extent or what products and customers would the DSD model still be the best solution? Finding the right answer is critical for suppliers and retailers to justify and leverage existing DSD networks and to determine future strategies for replenishment and network investment.

The most prominent advantages of DSD focus on micromarketing where employees are motivated to maximize sales and category management that can help improve the ability to restock the stores for new product changes and major shelf set changes. According to the same 2005 GMA research report, DSD suppliers devotes nearly 17,000 labor hours, delivering and merchandising product to a typical large-format store each year and nearly 700 labor hours to a typical small-format store each year. [GMA, 2005] Focusing on these two functions performed mainly at the store shelf, this thesis will try to find out which product and customer features have the most positive impact on minimizing lost sales and improving the shopping experience. Meanwhile, a detailed analysis of the stock-out costs at store shelf via both the DSD and the DC model will be conducted in order to quantify the benefits and determine the key variables impacting the costs and service levels. In order to make the research scope workable, this thesis investigates the traditional DC model and two variances of a generic DSD model: Through-the-Backroom Model and Direct-to-Shelf Model.

In addition to the distribution model, the thesis addresses the suitability of DSD model from the two perspectives: who and what products. In another words, who and what products can generate the most benefits from the DSD model? In this thesis, the benefits are defined to include both strategic competitive advantage and costs. Strategic competitive advantage refers to how a company grows and competes in the market by obtaining advantages over its competitors through the right distribution strategy. Strategic competitive advantage is always a part of the operations strategies, takes effect in a long term and is seldom quantifiable. Costs are a quantitative measure for the productivity of the whole model, often resulting in financial gains. For the question who is best suitable for a DSD model, the thesis addresses the question from the perspectives of a company's overall strategy, economy of scale and geographic location. To address the question of what products are best suitable for DSD model, the thesis looks at such aspects as product sales volume, velocity, shelf life, demand pattern, substitutability, specialty and new product.

1.2 Methodology

Based on the extensive interviews with industrial experts and the on-site observation of a DSD supply chain in a frozen food company, a generic DSD model is built to compare the total supply chain costs with that of the DC model. Further, a model simulating the stock-out costs at store shelf is built. Sample data from one single item from each of the A, B, C categories from that frozen food company's depot to a retailer store are input to the model to compare the results and do a sensitivity analysis.

2 Literature Review and Interviews

2.1 Literature Review

DSD system is widely used in consumer packaged goods (CPG) industries and plays a critical role in achieving sales volume. Many of America's best-known consumer packaged goods reach final consumers through the DSD supply chain. According to GMA, eight out of the top ten brands in US supermarkets are direct store delivery. DSD dominates six of the top ten large-format retail sales categories, boasts a 92.4% household penetration for those same categories and turns inventory three times faster than warehouse-delivered brands. These categories produce up to 30 percent of total retail sales volume and contribute more than 80 percent of retail dollar growth for the top 20 CPG categories. [GMA, Unleash the Power of DSD, 2005]

2.1.1 The suitability of DSD Model

A lot of discussion centers on the dominance of DSD in the top CPG categories, trying to find reasons in terms of product features and service competition.

According to a study by Ernst & Young to develop a working analysis of the DSD value chain, the results indicated that the DSD value chain distribution channel was most suitable for high-velocity, high-bulk, perishable and specialty products from the manufacturer or the manufacturer's agent directly to the retail shelf. [Anonymous, 1995]

In the May issue of Beverage Industry [2006], Daniels, VP of retail shelf merchandising, national retail sales at Anheuser-Busch highlighted the advantages in the three-tier distribution system. DSD is the best system for brewers, wholesalers, retailers and especially consumers. Beer's shorter shelf life and environmentally controlled storage requirements make it particularly well-suited to DSD, and out-of-stock concerns require the frequent attention provided by DSD personnel.

In the same article [2006], Krigline, VP of supply chain optimization at Sara Lee Corp.'s food and beverage division stated that the bakery business requires DSD to get a high level of service, with daily or even more frequent merchandising efforts and a high rate of returned product. Beverage distribution, on the other hand, offers a shorter order lead time and longer shelf time. Both systems are dealing with SKU proliferation and the challenge of mining vast amounts of data for usable store level information.

Huppertz [1999] argued that DSD could be an effective model for frequent small orders. Inventory reduction and E-Commerce are driving shipment sizes ever smaller and increasing the frequency of shipments. These factors drive higher order management and distribution costs due to more transactions, increased handling, and smaller freight moves. DSD or drop shipping allows trading partners to avoid the cost of handling smaller orders in a retailer's or a distributor's distribution center. Also a DSD supplier can consolidate freight on routes to effectively offset some of the rising transportation costs associated with smaller shipment sizes.

Huppertz [1999] also indicates that DSD might be a valid approach to gain service advantages for products competing on services such as shipping accuracy and punctuality. Sometimes suppliers might not handle small pick-pack types of orders and cannot do so as efficiently as retailers. However DSD suppliers may offer the most reliable shipping window to gain a service advantage over retailers. Whether or not DSD actually could provide a cost or service advantage in a given situation requires careful assessment. Since transportation costs, delivery costs and store receiving costs typically would increase, the benefits could easily be offset.

Besides the order size related discussion, Huppertz [1999] suggests that DSD or drop shipping could be suitable for products with short shelf life. Very short shelf life items require the least length of time flowing from suppliers' plants to store shelves. By eliminating a handling step, DSD may reduce the total time a product is delivered to the end consumers and the product damages for some sensitive products.

Some other articles added that those products requiring special storage and handling could be good candidates for DSD, such as frozen food. Deborah Scarpace, Edy's logistics director asserted that DSD offers greater control at more supply points. Through their Direct Store Service program (DSS), Edy's employees were involved in dispensing product at the store level and spent a good deal of time doing micro-merchandising. [Graham, 2001]

2.1.2 The benefits of DSD Model

A DSD supply chain serving CPG categories potentially provide great benefits to all players in this chain, including suppliers, retailers and consumers.

GMA [2005] argues that successful direct store delivery (DSD) practices offer CPG manufacturers and retailers unique opportunities to maximize sales and minimize inefficiencies in the supply chain

McEvoy [1997] argues that despite its complexities, DSD still provides great benefits to both suppliers and retailers in most product categories. Through covering the distribution cost up to retail stores and controlling the supply chain, suppliers gain the ability to manage their portfolios of authorized SKUs. Meantime, retailers are relieved from handling costs, inventory level and quality control, and benefit from a guaranteed-sale format.

In the article "How DSD fits into category management" in the August issue of Progressive Grocer [1995], Adams stated that a DSD model can maximize sales by providing much more micromarketing of products through highly motivated route drivers or merchandisers. Also DSD can enable stores to quickly adapt to a new product launch and major shelf set changes.

The Boston Consulting Group (BCG) analyzed the top 100 food categories in supermarkets, using activity-based costing with a focus on contribution margin to measure DSD's effectiveness. The study measured the direct and incremental costs incurred by both manufacturers and retailers along the supply chain, and, by adding in such items as warehousing, delivery, merchandising and administrative costs, concluded that contribution margin was the best calculation. The result underscored the fact that DSD categories accounted for 52% of store profit and 25% of store sales. In-store labor provided by DSD representatives could translate into $1 billion to $2 billion annual cost avoidance for supermarkets, according to the study. [Lewis, 1998]

The Boston Consulting Group concluded that the 3 S's - sales, service and satisfaction were the essence of DSD. These factors including such elements as efficient assortment, efficient replenishment, effective promotions and product introductions and merchandising, were the key drivers for sales growth within the DSD distribution system. Overall, DSD was a complete the ECR (Efficient Consumer Response) movement - a system that puts category experts in a store every day and does not just substitute manufacturer labor for retailer labor. The consultancy argued that efficient assortment and replenishment, as well as effective promotions, product introductions and merchandising were driving DSD growth. DSD supplier representatives provided highly focused views of particular categories. [Lewis, 1998]

In the same study, the Boston Consulting Group concluded that, in general, DSD systems had obvious advantages over the systems employing traditional models in such measures as return on working capital, sales turns, cash flow and return on assets and space. The study found that annual shelf turns for DSD salty snacks, soft drinks, and bread/baked goods was 2.7 times higher than for comparable warehouse-delivered products. The leading DSD cookie SKUs sold more than four times as many units per store per week than the comparable warehouse product. [Lewis, 1998]

2.1.3 Issues and Challenges of DSD Model

On the other hand, issues and challenges were quoted frequently by opposite views about current DSD systems

Determining the optimal service methods and frequencies for each retail account is one of the biggest challenges for DSD companies. A handful variances such as sales, order placement, delivery and merchandising make the situation very complicated. Hjort [2000] suggests using account profitability, defined as gross profits per account less the direct costs of service as a guide for service decisions. The author also suggests applying sophisticated software tools to more precisely manage shelf-sets for product velocity, product profitability and distribution management. With such tools, distributors have the ability to use depletion rates - at a package and account level - to achieve a better balance of sales and distribution cost optimization.

Although DSD is supposed to provide high service level, some retailers are complaining about DSD services. Clark [2005] quotes the remarks of Giant Eagle's Diane Roberts, director of merchandising systems. "Not bringing enough products in to meet demand, and bringing the wrong items in to meet demand" are two key problems that fall under DSD management related to the issue of out-of-stocks.

Because DSD is carrying important categories to the sales of retailers, the out-of-stocks may incur huge loss in sales to both suppliers and retailers. Recently retailers who have invested heavily in their distribution network are pushing to have these important categories flow through their own distribution network.

GMA [2002] estimated that when a DSD product is unavailable on the store shelf, the retailer can potentially lose $75,000 annually per supermarket, resulting in a 2.9 percent annual loss per average supermarket.

Chen, John, Narasimhan [2005] did a study of the sports drink market, which features competing producers (All Sport, Powerade, and Gatorade) and heterogeneous channels (direct-store-delivery and independent wholesalers). The authors estimated the demand and cost parameters for a number of alternative models of competitive interaction (horizontal as well as vertical), and then employed these estimates to study one possible channel switch, namely, switching Gatorade from its current (independent wholesaler) channel to a DSD channel belonging to Pepsi. The paper found out that the wholesaler channel was much more cost efficient than the DSD channel in the abovementioned context, and that this efficiency effect outweighs the strategic effects from oligopolistic price competition. The key finding is becoming the major theoretical support for the switch from DSD.

2.1.4 New Opportunities and Future of DSD

Recent changes in the DSD operating horizon and more competition in supply chain costs and service have brought forth new requirements to the current DSD system. Meanwhile, the industrial view on the functions of DSD has been evolving from a pure distribution model to an integrated approach for marketing products.

Still in the May issue of Beverage Industry [2006], Korchersperger, associate professor of the food marketing department at St. Joseph's University's Haub School of Business said that consumers change behavior faster than the DSD system can change. Efforts should be focused on anticipating and adapting to retail pressures rather than protecting today's DSD model.

In Food Logistics June issue [2007], Bornemann, managing partner of consumer products at Clarkston stated that product availability and effective merchandising have dramatically increased in importance compared to traditional marketing tools such as advertising. DSD is one of the most effective methods available – not only in terms of influencing product presence at the store shelf, but also in growing revenues when used as an extension of the marketing and sales execution model.

Kuai [2007], in his research "Who Stocks the Shelf? An Analysis of Retail Replenishment Strategies" cited Ryan who argues that DSD presents the food distribution industry with both challenges and opportunities. On the one hand, DSD offers a way to ensure that fresh products are always on the shelf and a significant step toward realizing the potential offered by micromarketing. On the other hand, DSD adds layers of complexity to backroom receiving and vendor/distributor relations and causes mountains of invoices and receiving documents.

Green, Richard, Wong, Angela [1995] suggest that DSD could benefit retailers as DSD offers a cost-effective approach for entrance into current industry movements to reengineer the supply chain. Computerized DSD systems can help reduce costs from the distribution process, and improve efficiency, automate operations, and provide a win-win relationship between suppliers and retailer by improving productivity.

Joseph [1992] indicates that DSD is regaining attention from supermarkets as a major strategic thrust. The key to giving DSD a new kick-start is the information technology to be applied to more efficiency in backdoor receiving. A pilot test of the Delivery Exchange (DEX) technology began at Ralphs Grocery in 1988. Based on the success, Ralphs implemented a fully automated receiving system in 16 stores in 1992. The real advantages of DEX would be digitalized invoices and other information. Opportunities for standard DSD policies and procedures exist at both the retail receiving and headquarters levels.

Some experts argue that in long run, service will still be of strategic importance. Again in the May issue of Beverage Industry [2006], Hampton, director of customer delivery systems at Frito-Lay argues that technology and infrastructure pressures will continue to force DSD to evolve. But in the long run, service will be what sustains DSD's competitive advantage, and DSD suppliers will need to keep improving the DSD service performance.

2.2 Expert Opinions

In order to collect comprehensive and practical opinions regarding the value of DSD and the product and customer suitability of DSD, extensive interviews were conducted with industrial veterans from suppliers and retailers that have been running the DSD model for decades. Researchers from independent research institutes were also interviewed to get opinions from a neutral perspective.

With regards to the value of DSD to suppliers and retailers, a veteran from a food company that has been using DSD to deliver its products since its foundation argued that the DSD system had greater elasticity to demand than the DC model, a feature that enables DSD model to be more responsive to demand variation than the DC model and capture sales opportunities. With such elasticity to demand change, twelve percent (12%) of DSD products generated 52% of the total profit in a retailer store. Such a level of elasticity is very difficult to replicate, so far, only Wal*Mart can come close to that level.

In the beverage industry, one director of supply chain planning in a bottler who made 3.4 million deliveries to its customers in 2007 explains why the DSD is the most widely adopted model in his industry. He suggests that the common practice of franchising makes the DSD model a predominant way of delivering products to the retailer's stores. Under a franchising agreement, each bottler serves all retailers within its franchised region through its DCs and fleet. According to the franchising agreement, the bottler is legally prohibited to sell and deliver products beyond its region. However, retailer's DCs are not deployed to match each franchised region. It's quite often for a retailer's DC to serve stores in two or more regions franchised to different bottlers. In such case, the DC model doesn't work. The bottler of the region without a retailer DC cannot sell and deliver products to the stores in its region just because the bottler cannot cross its region to deliver to a retailer's DC that is located in a region franchised to another bottler. Besides the legal restriction on selling and delivery across regions, the DSD model can enable bottlers to gain more control of the supply chain, decrease inventory by minimizing storage points in the supply chain, and increase sales and revenue by merchandising in the store.

While some suppliers consider DSD an effective approach for maximizing their own product lines, other suppliers still hold doubts about the value of the DSD model. An associate from a grocery supplier advises that her company currently only uses the DSD model for promotions to certain club stores for certain brands in its portfolio. Most of the DSD deliveries are in full truck load and requested by the club stores. When explaining the limited usage of the DSD model in her company, she cited three reasons. Firstly, the DSD model is viewed more costly than is the DC model. Secondly, no detailed analysis has been done to access the incremental sales and revenue by the DSD model so the tradeoff is not well understood and the application is not justified. Thirdly, the current ERP system of her company cannot accommodate the requirements of flexibility imposed by running the DSD model.

At stores, big retailers care more about the service level for the entire category and use the DSD model as a benchmark for their own distribution network. One product management director of a New England based food retailer noted that in her company, it is the store manager and category manager that are responsible for the service level for both DSD categories and DC categories. Both the DSD suppliers and the company's own DC are measured at the same standard: ordered vs shipped. With five to seven deliveries a week to a typical store, she argued that the retailer's own distribution network can have more control over the supply chain, gain better use of the very limited delivery window and provide uniform and expected service level. Also with in-house management of delivery scheduling and routing, the retailer can be more responsive to demand variation. In contract negotiations, the retailer will ask DSD suppliers to provide a cost breakdown for products and the DSD service. The retailer can always pick up the model with the lower total landed costs.

One senior director of a software company specializing in retail strategy noted that the DSD model would increase the complexity of store processes as each DSD supplier has their own schedule and route preference to a store, while it can offer more flexible delivery than the DC model. However under the DSD model, since some suppliers hold and manage the safety stock, they have the greatest incentive to make sure that the product is available at the store and shelf.

One research director of consumer products from AMR Research argued that DSD merchandisers usually have a better sense of customer preference than the store staff. Therefore they can perform merchandising to shoppers at stores more efficiently. Talking about speed to market, she explained it takes up to at least 14-15 days on average for a non-DSD product to go through all of the systems and nodes to finally reach store replenishment. Whereas, DSD, can deliver much, much more quickly and in a more timely manner as far as response time. Meanwhile, with frequent visits to the store, suppliers can monitor the store execution of the corporate supply chain planning with respect to their products. DSD fits in the middle and links the two together.

With regard to the suitability of DSD to products, suppliers and customers, volume and time are the two factors that were mentioned as the most relevance in choosing between the DSD and DC model. Products with high volume and velocity, and perishable products, were viewed as the best candidates for DSD in all interviews. The same senior director argues that due to the higher running cost of DSD, products with low volume cannot absorb the heavy investment of the network and the operations. He suggested that large stores were more suitable for a DC model, while smaller chain stores favor the DSD model due to volume and operations sophistication. He further suggested that products whose manufacturing is less centralized are suitable for DSD as the costs will be higher if products are consolidated at a regional DC.

The research director of AMR Research suggested new products, promotional products and products requiring regional assortment are also suitable for the DSD model. She mentioned that 50% of the new products are introduced through DSD. Products with category characteristics are also suitable for DSD. For frozen products, not every store has a freezer or sufficient space in the freezer to hold inventory in the backroom. In such a case, it is better for DSD suppliers to centralize the inventory in their own freezer warehouse.

Some experts also think retailers should use DSD for products that are cash-tied up like jewelry in order to free the cash the retailer ties up with holding the inventory. This opinion was supported by the product management director in the interview who noted that the company uses DSD for slow-moving products with a large range of SKUs.

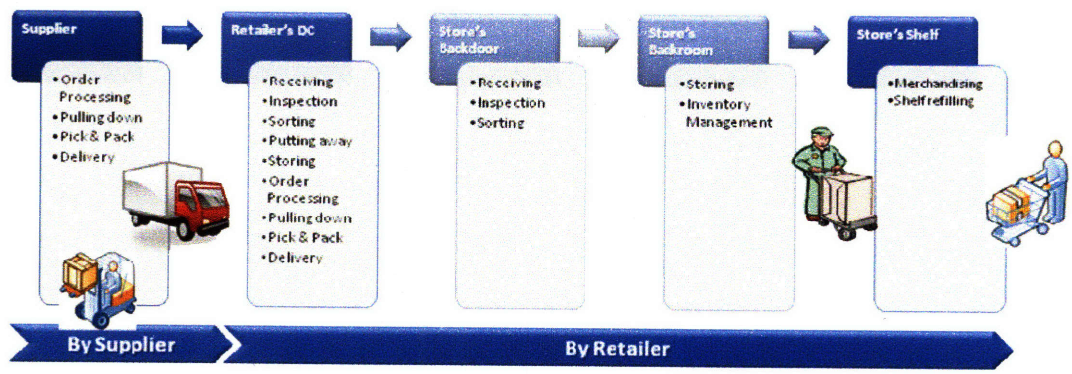
When talking about the challenges and opportunities for the DSD model, the research director of AMR Research suggests that the industry change the traditional view to see DSD as merely a distribution model. As a distribution model, due to the economy of scale from consolidation by large retailers, DSD has no advantage where cost is an important measure. However, when looking at the cost structure of a product, delivery accounts for only 3.8% of the total cost while the trade promotion accounts for nearly 40%. Considering the advantage of DSD and its merchandisers in store marketing and promotion, DSD should be viewed at a higher marketing strategic level in order to fully leverage its power in merchandising, responsiveness and improving shelf experience.

3 DSD Model and its suitability

3.1 Two Replenishment Models: DC Model and DSD Model

3.1.1 DC Model

Figure 1: DC Model - Product Flow



Source: Interviews

In a DC model, a supplier renders an order at a retailer's distribution center where the retailer receives, stores and distributes the product to the stores served by this distribution center. In such a model, the retailer issues an order to the supplier who then ships full truck load (FTL) to the distribution center. Upon receipt, the retailer will inspect the shipment against the order for integrity. Bar-coding is widely used in this stage for accuracy and productivity and the inventory system is updated accordingly. Once a shipment is inspected, the distribution center then sorts and puts the product away in the assigned area in the warehouse. Cargo receipts are then issued on paper or electronically to the supplier, authorizing the latter for invoicing.

At the distribution center, the retailer monitors the inventory level of the products and manages the replenishment according to its inventory management practices. Upon receipt of orders from individual stores, the retailer starts processing them and prepares the outbound shipment. The warehouse staff picks & packs orders, loads them onto a truck, plans the route and the order of deliveries, and transports the orders to each store according to the plan.

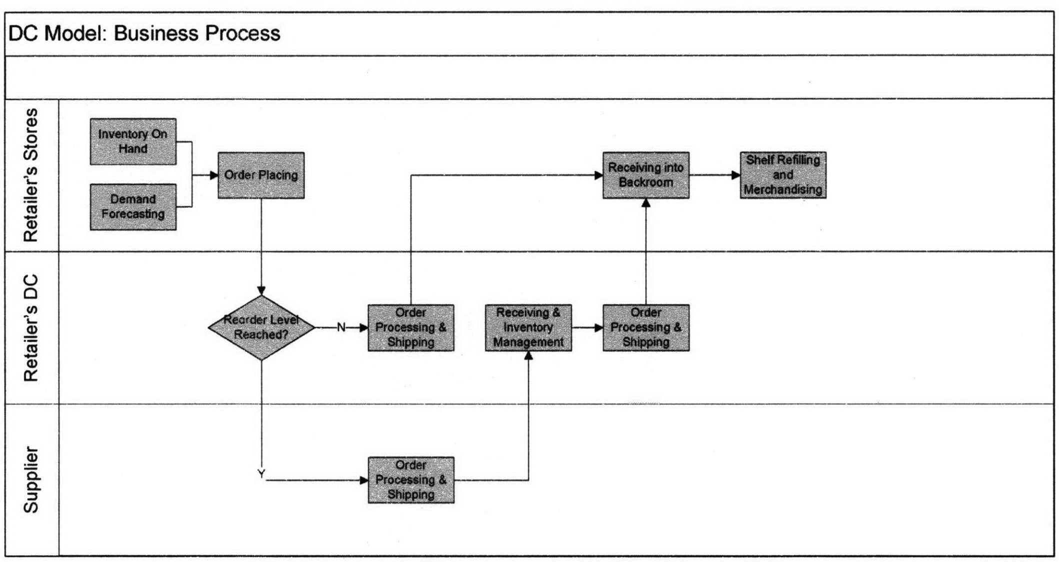
At the backdoor of a retailer store, store staff work with the truck driver to inspect the integrity of the shipment and update the order information to the store's inventory system. Then SKUs in the shipment are sorted and pulled into the store as needed at the shelf. The SKUs are either temporarily stored in the store's backroom or directly put on the shelf by the store staff.

Normally category managers in stores and their staff are responsible for the merchandising process, including controlling shelf life, refilling the shelf and improving shelf display for the products in the entire category.

Nowadays, some retailers are involved in VMI (vendor managed inventory) programs where the supplier determines when and what quantity a shipment should be to the retailer's distribution center, based on the information of inventory level and sales provided by the retailer, most of the time through a B2B website. In VMI, the supplier is responsible for the inventory level and the replenishment policy of its product. It is actually the supplier that triggers the issuance of an order to itself. The retailer's distribution center is still responsible for receiving, sorting, storing and shipping to stores.

In general, in a DC model, the supplier receives the order and replenishes the inventory at the retailer's distribution center. The retailer is responsible for the replenishment from its distribution center to each individual store that the distribution center serves. The retailer thus takes the responsibility of monitoring and managing the stock-out at the distribution center and each store. If VMI is adopted, the supplier takes the responsibility of stock-out at the distribution center and the retailer does so for each store. Figure 2. illustrates the business process of the DC Model.

Figure2: DC Model – Business Process

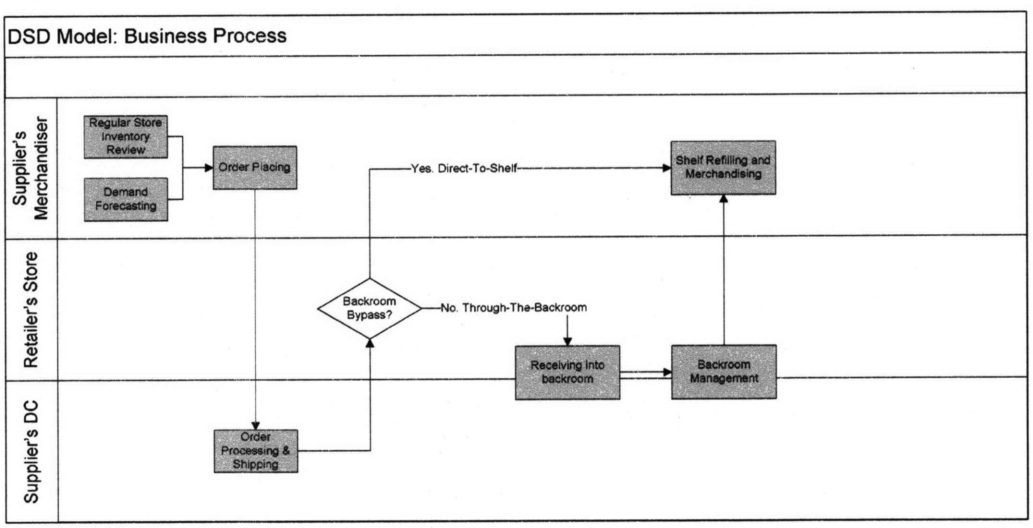


Source: Interviews

3.1.2 DSD Model

In a Direct Store Delivery (DSD) Model, the supplier is responsible for replenishing a retailer's store, a process including two major functions: merchandising and delivery. Merchandising includes such tasks as inventory control of the store backroom, ordering, replenishing the shelf, controlling the shelf life and improving the shelf display. Maintaining a good relationship with the category manager of a store is also an important part of merchandising. Delivery is where a supplier ships an order from a supplier's distribution center directly to either the backroom or the shelf at each individual store of the retailer on a route truck. In some cases, such as for promotional items, the backroom might be replenished from the retailer's DC directly rather than from delivery from the supplier's DC. Figure 3 illustrates the business process of the DSD Model:

Figure3: DSD Model – Business Process

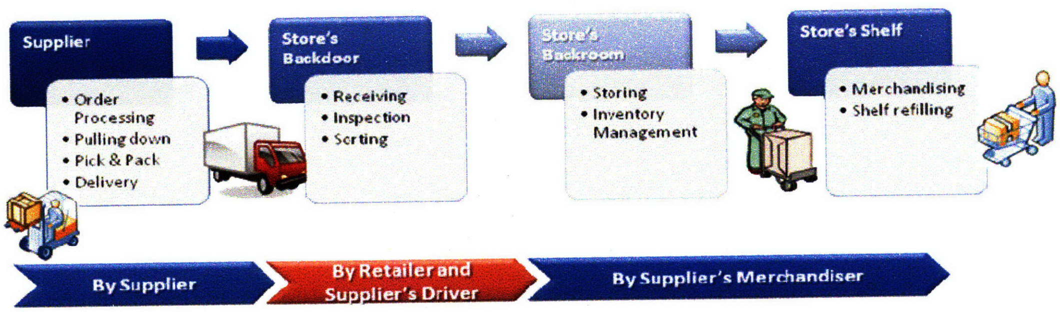


Source: Interviews

Based on the product's physical flow, there are two types of DSD model: through-the-backroom and direct-to-shelf.

3.1.2.1 Through-the-backroom Model

Figure 4: Through-the-backroom Model – Product Flow



Source: Interviews

In this model, orders are delivered to the backroom and held as inventory temporarily there before the products are put on the shelf. In this model, the functions of merchandising and delivery can be performed by a merchandiser and a driver, respectively, or by one individual, depending on the number of stores, the area of coverage and the complexity of tasks.

A merchandiser is a supplier's employee assigned to merchandise the product at the stores on his route. A merchandiser visits each store on a regular basis. At the store, the merchandiser reviews the sales in the past review cycle and all the inventory of the supplier's products on hand at the shelf and in the backroom. Based on the inventory level and the sales at each store, the merchandiser forecasts the demand of each product item for the next review cycle and determines the items and the quantities of each item in the next order that a store should place to the suppliers. Very often, the same merchandiser writes the order back to the supplier on behalf of the retailer store according to the agreement between the supplier and the retailer.

A merchandiser is also responsible for product merchandising and category management at a store. A merchandiser sorts the items stored in the backroom and moves them to the shelf for replenishment. Before putting products on the shelf, the merchandiser reviews the shelf life of each unit and removes the expired or damaged units off the shelf. Then the shelf is refilled to full with the items from the backroom. Lastly whenever seeing it necessary, the merchandiser will make sure that the display of the shelf is in good order and the product presentation is easy to see.

It is also very important for a merchandiser to maintain a good relationship with the category managers of the stores on the route. The good relationship with local stores can reward the supplier and the merchandiser with better cooperation and support at local store level, and smoother and timelier information exchange about the store plan, policy and competitors.

The work of delivery is performed by either a merchandiser or a route driver. The delivery routes are organized in two ways: Milk-runs and Pool points. In a milk run, the driver delivers orders to retailer stores, which are located close to each other, in a planned sequence. In Pool points, the supplier ships FTL of product from its DC to some regional dispatching points that are close to the retailer stores. At the dispatching point, orders are sorted and trans-loaded on smaller route trucks. Then, each smaller route truck delivers orders to stores on its route by milk run. Upon delivery, the driver works with the retailer's store to unload, inspect and sort the order from the truck at the backdoor. Very often, the driver also moves the received order into the backroom. Lastly, the driver collects the verified receipt from the store for invoicing.

The merchandising work is often compensated according to an incentive plan linked with the sales of products at the stores the merchandiser covers. The delivery work is paid per route trip or per working hour.

3.1.2.2 Direct-to-shelf Model

Figure5: Direct-to-shelf Model – Product Flow

Source: Interviews

This model is commonly used in delivery to convenient stores that don't have a backroom to store inventory or in delivery of products with extremely short shelf life or lead time such as newspapers, magazines, bakery, dairy and sodas. The only difference between Through-the-backroom Model and Direct-to-shelf Model is that in Direct-to-shelf model, upon receipt, the order is immediately put on the shelf either because there is no backroom or space assigned to it or because no time is allowed for the products to be stored temporarily in a backroom.

Because the products are put immediately on the shelf upon receipt, the functions of merchandising and delivery in the Through-the-backroom Model are performed by one route driver or merchandiser alone. Therefore, the route driver or merchandiser takes all responsibilities of ordering, delivering, controlling inventory and shelf life, replenishing the shelf, improving shelf display, removing returns and building relationship with store managers.

3.1.3 Comparison of DSD and DC Model

DSD and DC model bear big differences in transaction, material flow, inventory management and merchandising, therefore resulting in different pros and cons respectively, to suppliers and retailers. In the research "Who stocks the shelf? An analysis of retail replenishment strategies" in 2007, Philip Kuai did a comprehensive comparison of DSD and DC model. Table 3.1, Table 3.2, and Table 3.3 present a summary of the comparison:

Table 1: Comparison of responsibility and cost bearing of the two models

	DSD Model	DC Model
Product Transaction Point	Retail store or shelf	Retailer's DC
Re-ordering	Supplier's merchandiser or retailer	Retailer
Shipping to stores	Supplier's fleet	Retailer's fleet
Receiving into backroom	Supplier or retailer's store staff	Retailer's store staff
Inventory Management at backroom	Supplier's merchandiser together with store manager	Retail store manager
Merchandising	Mostly by supplier's merchandiser	Retail store manager and store staff

Source: Interviews

Table 2: Comparison of supply chain Pros and Cons of the two models

	Pros		Cons	
	DSD Model	DC Model	DSD Model	DC Model
General	Very high service level; High inventory turnovers; More flexible and responsive to demand fluctuation; More sales;	Low cost and high productivity from economy of scale; Uniform policy and processes to control; Advantage in service contract negotiation	High running cost; Free rider opportunity for small retailers (not fair to large ones); Less productivity due to less economy of scale	Less flexible and elastic to demand change; Heavy investment in building the distribution network;
Delivery	Feasible to make frequent delivery of small order quantity or urgent order; Flexible and elastic to demand change	Less unit transportation cost from freight consolidation	Higher delivery cost; Bearing extra risks and management in routing and transportation	Fixed frequency and schedule; Less responsive to small order quantity or urgent order;
Ordering	More frequent ordering to address unexpected demand change	Low ordering cost due to consolidation	High ordering costs due to additional labor and small order size	Large order size results in high inventory level and less responsive to demand change
Receiving	n/a	Uniform receiving policy and process;	Complex receiving policy and process; Time consuming;	If receiving large orders during store busy time, resource will be insufficient.
Inventory Management	Flexible and low store inventory; Quick response to unexpected stock-out	Easy to apply centralized inventory management system, policy and processes	More frequent review may erode the benefits from low inventory level.	Less flexible to demand change or new product launch
Merchandising	Better effect of merchandising by dedicated resource with product knowledge; Direct reach to shelf sales information; Better category management, especially for new product launch or promotion	n/a	High cost, requiring sufficient product margin or sales volume; Retailer may take advantage of the free resource for other store processes	n/a

Source: interviews

Table 3: Pros and Cons of the two models to suppliers and retailers

	Pros		Cons	
	DSD	DC	DSD	DC
Suppliers	Enable better in-store merchandising Provide special handling and storage capability and meet regulation compliance Make feasible frequent delivery of small order quantity Improve the ability to quickly restock stores for new product changes and major shelf set changes	Lower order processing and delivery costs	Provide free-rider opportunity for smaller players	Comparatively poor in-store merchandising due to limited labor resource Greater lost sales in reality
Retailers	Provide flexible distribution capacity Save significantly backroom spaces in retail stores Free labor hours contributed by suppliers	Enable consolidation for bigger retailers Mitigate the free-rider problem Standard receiving process	Difficult to manage receiving time windows	Costly to build and maintain infrastructure

Source: [Kuai, Jiaqi, Who Stocks the Shelf? An Analysis of Retail Replenishment Strategies, 2007]

3.2 Suitability of DSD model

According to the previous section, the DSD Model bears a big difference in responsibility and operation for suppliers than the DC Model. Such difference results in the respective strength and weakness of DSD model. The benefits from the strength of DSD model can be easily off-set by its weakness if the model is not applied properly. Therefore the question of who and what products are suitable for DSD model becomes essential to many companies. In general, the DSD model should be applied to companies and products that can benefit most from the model. The benefits include: Strategic Competitive Advantage and Costs

3.2.1 Who is suitable for DSD Model?

Company's Overall Strategy

Company's overall strategy determines the adoption of DSD model. Company strategy gives direction to any activity a company does. The selection of a DSD model should fit the company strategy in order to help the company to survive, compete or maintain an advantageous position in the fiercely competitive consumer product market. Companies whose corporate strategies center on competition over market share, sales, high service level and product availability can leverage the DSD model to achieve these strategic goals.

A very good example of this is Frito-Lay Inc., the largest manufacturer of salty snacks in the United States with annual sales of 10.98 billion in 2004 and 65% share in the market. (http://www.referenceforbusiness.com/history/En-Ge/Frito-Lay-North-America.html).

Frito-lay Inc. chooses to deliver its products directly to retail establishments. Ninety five percent (95%) of sales are through the DSD model. DSD is backed by its corporate culture that emphasized “service to sales” in order for the company to be able to keep the freshness and high quality of its products on the shelf and to the consumers. Under such a strategy, a 99.5% service level was achieved through DSD. [HBS, Frito-Lay: The Backhaul Decision, 9-688-104, 1992]

Economy of Scale

For both suppliers and retailers, economy of scale should be an important factor to consider using the DSD model. It is very costly to build and maintain such a DSD network. Small and median suppliers cannot afford the costs. Therefore it isn’t economical for them to use the DSD model. For suppliers with sufficiently large sales volume, they can gain economy of scale from freight consolidation when supplying small and medium retailers on route trucks by milk runs. Therefore, the DSD model can benefit both sides by delivering at lower unit costs from the supplier to these small and medium retailer stores.

When a supplier and a retailer both achieve a high level of economy of scale, besides the unit delivery cost, other factors such as company strategy, negotiation power or supply chain profit maximization should also be considered and the trade-off should be analyzed to maximize the benefit of the entire product supply chain.

Geographic Location

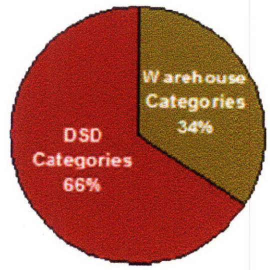
A DSD Model is cost effective for companies with less centralized and more local manufacturing. For newspaper, magazines, printings and beverage, a plant is usually built very close to the local market either because the short product life cannot afford the long transportation routes or because the high local demand can justify the costs of building a plant for that market. In such a scenario, a supplier can save more time and costs to deliver products directly from the local plant to the retailer stores in this local market rather than ship to each retailer's DC for distribution.

3.2.2 What products are suitable for DSD Model?

Products with high volume and high velocity

A DSD Model is suitable for products with high volume and high velocity. In general, products with such features are very important to the total retail sales for both suppliers and retailers. They are also important to boost the traffic in a store. Therefore, these products should receive the most attention and most reviews. According to GMA research "Unleashing the power of DSD in 2005", DSD categories accounts for 66% of the total volume of large-format top-20 categories, and contributes over 80% of retail dollar growth for the top 20 large-format CPG categories.

Figure 6: DSD categories account for 66% of volume in large-format top-20 categories



Source: Unleash The Power of DSD, 2005, GMA

By dedicating resources for on-site merchandising and frequent inventory review and replenishment at stores, DSD suppliers can provide the required level of review to their most important products and replenish the store backroom and shelf in a more flexible and frequent manner. A full and neat shelf at any time helps improve a customer's shopping experience and meet as much demand as possible.

Perishable Products

A DSD model is suitable to handle perishable products with very short shelf life. In order to compete with short perishing cycle of such products and ensure best product quality at the shelf, the speed to deliver these products from the end of the product line to the shelf becomes the most important consideration. For perishable products like dairy and bagged salads, the product life cycle lasts only 15 to 21 days. For products like newspaper, the product life is even only one day. As DSD suppliers deliver products directly from the supplier's premises to stores, bypassing a retailer's distribution center, time in transit is shorter. Also with frequent review at stores, DSD suppliers can better control the shelf life of their products by removing expired products and applying FIFO (first in, first out) and FEFO (first expire, first out) processes.

Products with high demand variations

Products with high demand variations are such products as pizza, snacks, soda or beers. The demand of these products is highly fluctuating, depending on the occurrence of regular or irregular events. Regular events can be sports events and planned promotions. Unexpected events can be parties, ceremonies or public celebrations. The fluctuation in demand is normally irregular and difficult to predict in forecasting. To tackle such variations requires holding extra safety stock, which is limited by the backroom capacity of each store, especially for small and medium stores and is also very expensive. More importantly, high variations with a finite shelf size means the product will experience high probability of stock-out if not replenished frequently on the shelf.

The DSD Model has the elasticity to respond to such fluctuations quickly and cost effectively. DSD suppliers can centrally keep the extra capacity as their inventory, saving a store's back room space. Once the store safety stock is exhausted by unexpected demand, replenishment can be delivered quickly to stores and put on the shelf.

In the United States, the demand for beers, snacks and frozen pizza always undergoes a sudden surge during big sports event such as NBA or MLB games. Retailers often face stock-out for these products and lose sales because of limited inventory in the small backroom. A DSD supplier of such a product, however, can mitigate the severity of the stock-out by quickly replenishing the inventory at stores and at the shelf by its route truck.

Substitutability

The DSD model enables products of high substitutability to compete on availability at the store shelf. In the grocery industry, the functions and features of different brands by different suppliers are becoming more and more similar to each other. In order to encourage competition, gain advantage in price negotiation, and offer better store setting and shopping experience, retailers put similar products side by side. A consumer who cannot find the preferred product at the shelf may easily switch to buy a similar product sitting next to it by another supplier. So availability becomes essential for products with high substitutability to win the competition at the shelf level. The DSD model helps a supplier of such products to compete in two ways. In one way, the more frequent shelf review and replenishment can reduce the lost sales in the store. In the other way, in-store merchandising by the DSD supplier enables the supplier to improve shelf layout and provide a better shopping experience to consumers.

Specialty Product

DSD is suitable to handle specialty products. This kind of products has special requirements on distribution such as legal licensing, franchising, extreme care in handling, reverse flow handling or special equipment. It is not economical for retailers to invest to meet these special requirements for only a small group of such products. Instead, DSD suppliers of such products have the legal permission, expertise and economy of scale to handle such products at a lower cost. Therefore, DSD is widely applied in delivering fresh breads, frozen pizza and beers.

DSD is also used in delivering jewelry to stores. With the high value of jewelry, most retailers don't want to tie a large amount of cash in holding inventory. Also security and risk are also a concern. Therefore retailers prefer a DSD model where suppliers hold inventory and take on the risk.

New products

DSD has proven to be very effective for launching new products to the market. After well-planned marketing activities, the demand for the new product is generated. The speed of bringing new products to stores and changing the categories on the shelf becomes extremely important to meet the demand. The surging demand for the new product can be met through DSD's more frequent and faster replenishment than that of the DC model.

In summary, adoption of DSD model should be considered not only from a cost perspective but also from a company strategic perspective so that it can fit into the overall company strategy. Speed, elasticity to demand change and operational flexibility are also important factors in determining the suitability of DSD model. Lastly, retailers can leverage DSD supplier's expertise and existing capability in handling specialty products without extra investment and resources.

4 DSD Quantitative Analysis and Case Study

In this section of the thesis, a model simulating the stock-out situation at the store shelf is built to analyze the cost tradeoff between the reduction of lost sales due to more frequent reviews and the increased labor costs from greater review frequency. Then as the last mile in a supply chain, the stock-out costs are integrated into the generic DSD and DC model in order to calculate and compare the weekly profitability for the entire supply chains.

Actual sales and operations data from a frozen food company are used in the case study in order to test the model and get insights from the results.

4.1 Model Description

4.1.1 Stock-out at shelf

The objective of this model is to, first, simulate the stock-out situation at the store shelf, second, find out the key variables that determine the stock-out costs at the store shelf, and third, optimize the key variables to achieve minimal stock-out costs at the store shelf.

The following variables are used in the equations in the model:

D_d = average daily demand

δ_d = the standard deviation of average daily demand

R = review period in days

L_t = average replenishment lead time from store backroom to shelf in days

F_r = total frequency of shelf review in a week

F_0 = frequency of shelf review by the retailer in a week

F_1 = frequency of shelf review by the supplier's merchandiser in a week

F_2 = frequency of shelf review by extra resource assigned by the supplier in a week

S = shelf capacity

B_2 = Cost of unit lost sales

k = safety factor

The following assumptions are used to build the model:

1. An Order-Up-To (R, S) replenishment policy is used in this model. As in almost all situations, the store shelf size is pre-set and the inventory level at the shelf can never exceed the maximum capacity of the pre-set shelf size. Therefore, an (R, S) policy is appropriate in this model.

2. Customer demand is assumed to be normally distributed in the model. At each review, the stock at the shelf is replenished to the maximum capacity of the shelf size.

3. Each unit of stock-out results in immediately lost sales.

4. Each review is independent. There is no overlap between two consecutive reviews no matter who performs the review. Therefore, the total number of reviews in a week under the Through-the-Backroom model can be $F_r = F_0 + F_1 + F_2$

5. It's assumed that whenever a shelf review and replenishment occurs, the products are always in stock in the store backroom.

Based on the denotation of the variables and the assumptions, the Expected Shortage Per Replenishment Cycle (ESPRC) is used to calculate the number of units short in a review cycle. The ESPRC equals the standard deviation of the demand during the review period plus the replenishment lead time from the store backroom to the shelf times $G_u(k)$, a special function of the unit normal (mean 0, standard deviation 1) variable, as shown below:

$$ESPRC = \delta_{R+Lt} * G_u(k)$$ Eq. 1 [Silver, Pyke, Peterson, 1998]

With the daily average demand (δ_d), the review period (R), and the average replenishment lead time from store backroom to shelf in days (Lt), the standard deviation of the demand during the review period plus the replenishment lead time from the store backroom to the shelf can be calculated, using the following equation:

$$\delta_{R+Lt} = \delta_d * \sqrt{R + Lt}$$ Eq. 2 [Silver, Pyke, Peterson, 1998]

In order to calculate the value of $G_u(k)$, the safety factor k should be determined using the following equation:

$$D_L = x_L + k * \delta_L$$ Eq. 3 [Silver, Pyke, Peterson, 1998]

Where D_L is the Order-Up-To point and X_L is the expect demand over a replenishment lead time, Therefore, $k = (D_L - x_L)/\delta_L$

At the shelf, the maximum amount of demand that can be satisfied is the shelf's maximum capacity S. In one review period, the equation becomes:

$k = (S - D_{R+Lt}) / \delta_{R+Lt}$ Eq. 4

Where $D_{R+Lt} = D_d * (R + Lt)$ Eq. 5

With the value of k, the value of $G_u(k)$ can be calculated by inputting k into the following formula in an Excel spreadsheet:

$G_u(k)$ = NORMDIST(k,0,1,0)-k*(1-NORMDIST(k,0,1,1)) Eq. 6 [Silver, Pyke, Peterson, 1998]

Therefore, the actual cost of stock-outs, $C_{stock\text{-}out}$, at the shelf in a review period is B_2 times ESPRC:

$C_{stock\text{-}out} = B_2 * ESPRC$ Eq. 7

With the calculation of the amount of lost sales in a review period, there is another kind of cost incurred at the shelf, the labor costs for a store or a DSD supplier to replenish the shelf. With unit labor costs and the total labor hours, this calculation of the total labor costs for merchandising and replenishment is easy and is shown below:

Labor cost in a review period = Unit cost of labor hour * Total labor hour in a review period Eq. 8

By multiplying the number of reviews in a week, we estimate total labor costs in a week.

The total costs at the shelf are the sum of the cost of lost sales and the labor costs.

Figure 7 is the model showing the costs at the shelf.

Figure 7: The Stock-out Cost Model

Analysis of Stock-out cost and merchandising cost at shelf
- Single item, Single store

Daily demand	Average daily demand	Units	42
Daily δ	The standard deviation for daily demand	Units	33
S	Shelf Capacity	Units	40
F_0	# of Review of store category manager weekly	times	5
F_1	# of reviews by supplier's merchandiser weekly	times	2
F_2	# of reviews for Direct-to-Shelf Model	times	5
Lt	Replenishment Lead Time from backroom to shelf	Day	0.2
B_2	Cost of Unit Short	$	$ 2.00
Labor Costs	Retailer	$/labor hour	$ 15.00
	Supplier's Merchandiser	$/labor hour	$ 15.00
H_L	Labor hour per review	hours	0.50

			DC Model	Through-the-Backroom Model	Direct-to-Shelf Model
Review Period		Days	1.4	1.0	1.4
D_{R+Lt}	Cycle Demand during the period of review and lead time	Units	67	50	67
$\delta_{(R+Lt)}$	Daily δ*sqrt(R+Lt)	Units	42	36	42
k	Safety Factor = $(S-D_{R+Lt})/\delta_{(R+Lt)}$		-0.652	-0.288	-0.652
$G_u(k)$	Unit Normal Loss Function		0.807	0.559	0.807
Loss Sales	Unit short in a review period	Units	34	20	34
Weekly Loss Sales	Unit Short in a week	Units	168	142	168
		$	$ 336.68	$ 283.00	$ 336.68
Annual Loss Sales	Yearly Unit Short	Units	8754	7358	8754
		$	$ 17,555.53	$ 14,756.49	$ 17,555.53
Weekly Labor Costs	# of review per week * Labor hour per review * unit labor cost		$ 37.50	$ 52.50	$ 37.50
Yearly Labor Costs	Weekly labor cost * 52		$ 1,950.00	$ 2,730.00	$ 1,950.00
Total Weekly Cost			$ 374.18	$ 335.50	$ 374.18
Total Annual Cost			$ 19,505.53	$ 17,486.49	$ 19,505.53

The DC model and DSD model are listed adjacently for easy comparison. As in a DSD model, the DSD supplier sends its own merchandisers to replenish the store. Therefore the total number of inventory reviews at the shelf is the sum of the number of reviews by the store staff and that by the supplier.

4.1.2 Generic DSD Model

In order to compare the profitability of the DSD model and DC model from a supplier's perspective, two DSD models and the DC model are built to simulate their respective revenues and the supply chain costs for a single item to a store under different models.

Revenue wise, the sales revenue of a store equals the number of units sold in a week times the unit wholesale price to the retailer. In reality, the unit price of a product in the DSD model is a little bit higher than that of a product in the DC model because of the service for delivery and merchandising in stores.

Cost wise, the total supply chain costs include costs at the store shelf, warehouse costs and transportation costs. The costs at the store shelf can be calculated, using the model developed in the previous section to sum up the stock-out costs and the total labor costs for merchandising. So in this section, detailed models are built to calculate the warehouse costs and transportation costs for the respective DSD and DC model in order to have a full picture of the total supply chain costs.

The warehousing costs include three parts:

1. Receiving Costs are the costs for receiving a delivery, unloading the truck, checking it and putting it away. In the thesis, the unit cost per receipt is used as per the activity based cost.
2. Inventory holding costs are the costs to hold inventory in the warehouse.

The total inventory holding costs on average = (average order size/2+ safety stock)* product costs*holding costs

3. Order processing costs are the costs to receive an order, pull-down, pick and pack, and load the truck. In this model, the unit cost per order processed is used as per activity based cost.

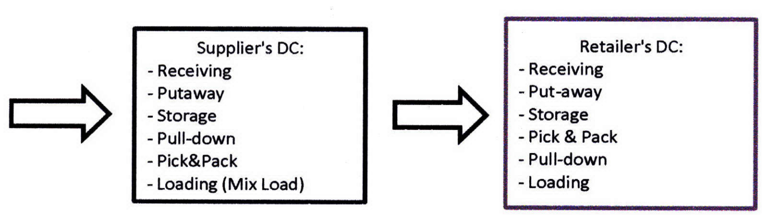
The transportation costs refer to the costs to deliver an order to the next warehousing facility or stores. The transportation costs equal the cost per unit per delivery times the number of units in a delivery and further times the number of deliveries in a week.

The DC Model:

In a DC model, the supplier's warehouse receives an order from the retailer and delivers the order to the retailer's distribution center. The costs occurring to the supplier are the warehousing costs at the supplier's warehouse and the delivery of each order. Therefore the DC model is as per Figure 8

Figure 8: The warehousing and delivery costs in the DC model

The DC Model



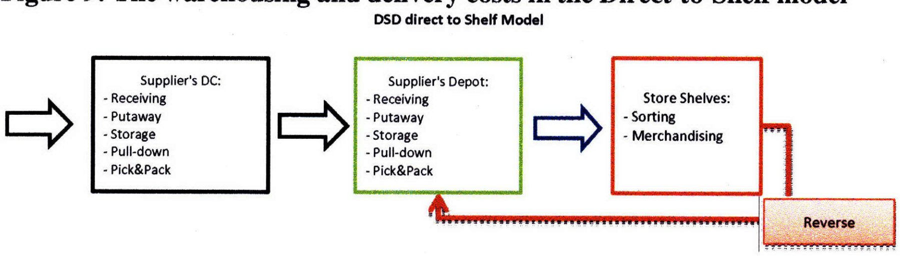
Commodity: All other categories than those using DSD models

Weekly Costs:			
Receiving	$	-	cost of receiving * # of truckload received weekly
Storage	$	-	average inventory level* product cost*inventory holding cost/52
Order Processing	$	-	cost of order processing * # of order processed weekly
Transportation	$	-	cost per unit per trip*# of units in a week
Weekly Total:	$	-	

The Direct-to-Shelf Model:

In the Direct-to-Shelf Model, the supplier's supply chain includes a supplier's warehouse and a supplier's depot which is close to stores. An order from a retailer is received at the supplier's depot, and then delivered to replenish the store shelf directly. In this model, there is no inventory held in a store backroom. The Direct-to-Shelf Model is as per Figure 9:

Figure 9: The warehousing and delivery costs in the Direct-to-Shelf model



Commodity: Newspaper, Magazines, Dairy, Soda

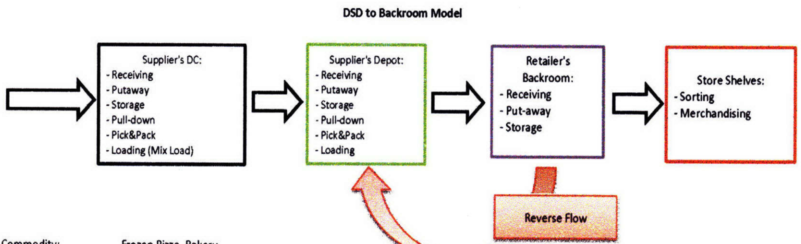
Weekly Costs:

	Supplier's DC	Supplier's Depot	
Receiving	$ -	$ -	cost of receiving * # of truckload received weekly
Storage	$ -	$ -	average inventory level* product cost*inventory holding cost/52
Order Processing	$ -	$ -	cost of order processing * # of order processed weekly
Transportation	$ -	$ -	cost per unit per trip*# of units in a week
Subtotal	$ -	$ -	
Weekly Total:	$ -		

The Through-the-Backroom Model:

In the Through-the-Backroom model, the supplier's supply chain includes a supplier's warehouse, a supplier's depot and a store backroom. An order from a retailer is received at the supplier's depot, and then delivered to the store backroom before the supplier or the store replenishes the shelf. The Through-the-Backroom model is as per Figure 10:

Figure 10: The warehousing and delivery costs in the Through-the-Backroom model



Commodity: Frozen Pizza, Bakery

Weekly Costs:

	Supplier's DC	Supplier's Depot	Retailer's Backroom	
Receiving	$ -	$ -	$ -	cost of receiving * # of truckload received weekly
Storage	$ -	$ -	$ -	average inventory level* product cost*inventory holding cost/52
Order Processing	$ -	$ -		cost of order processing * # of order processed weekly
Transportation	$ -	$ -		cost per unit per trip*# of units in a week
Subtotal	$ -	$ -	$ -	
Weekly Total:	$ -			

4.2 Case Study

4.2.1 Stock-out at store shelf

In this case, the Point of Sale (POS) data from the sponsor company are input to calculate the stock-out costs at the shelf of its traditional A, B and C categories of products in the DC and DSD models. The sponsor company categorizes all products into the A, B, and C category according to their sales volume. The annual sales data from one store of the sponsor company's customer are retrieved from the database for the case study.

Because the sponsor company has no Direct-to-Shelf operations, the operations data of the model are not available. Also, due to the same unit loss function, the stock-out costs of the Direct-to-Shelf model can be calculated by changing the frequency of review in the DC model. Therefore the Through-the-Backroom model is used to compare with the DC model.

Below lists the data that are used in the model to calculate the total costs at the shelf:

Table 4: Operational and financial data of a food company

The replenishment lead time from backroom to the shelf	0.2 Days
The cost of unit short	$2.00
The labor cost of store staff	$15/per labor hour
The labor cost of supplier merchandiser	$15/per labor hour
The average time spent on one shelf review	0.5 hour

Table 5: Demand pattern, shelf size and review frequency of A, B, C item

	The A item	**The B item**	**The C item**
D_d	**42 units**	**8 units**	**3 units**
δ_d	**33.46 units**	**7.82 units**	**2.44 units**
S	**40 units**	**20 units**	**10 units**
F_0	**5 times/week**	**2 times/week**	**2 times/week**
F_1	**2 times/week**	**1 time/week**	**1 time/week**

Table 6 indicates the results for the A item. With more reviews at the shelf, the DSD model has lower costs at the shelf than the DC model, saving around $2,019 in a year.

Table 6: Weekly and yearly stock-out costs comparison of the DC and DSD model for the A items

	DC Model	DSD Model
Weekly Loss Sales	168	142
Annual Loss Sales	8754	7358
$C_{loss\ sales}$	$ 17,555.53	$ 14,756.49
Weekly Labor Costs	$ 37.50	$ 52.50
Yearly Labor Costs	$ 1,950.00	$ 2,730.00
Total Costs	**$ 19,505.53**	**$ 17,486.49**

Table 7 indicates the results for the B item. The result indicates that with more reviews at the shelf, the DSD model saves around $513 in a year. However it's noted that, compared with the A items, both the store and the supplier reduced the frequency of shelf review to save labor costs because of less sales. Also, the shelf size is reduced to half the size of the A items.

Table 7: Weekly and yearly stock-out costs comparison of the DC and DSD model for the B items

	DC Model	DSD Model
Weekly Loss Sales	24	15
Annual Loss Sales	1246	796
$C_{loss\ sales}$	$ 2,499.35	$ 1,595.56
Weekly Labor Costs	$ 15.00	$ 22.50
Yearly Labor Costs	$ 780.00	$ 1,170.00
Total Costs	$ 3,279.35	$ 2,765.56

Table 8 indicates the results for the C item. Now it turns out that for the C items, the DSD model is more expensive than the DC model. It means that it isn't economical to send a merchandiser to review the shelf as the labor cost exceeds the savings from fewer lost sales. At the shelf level, it's better to let the store review and replenish the shelf.

Table 8: Weekly and yearly stock-out costs comparison of the DC and DSD model for the C items

	DC Model	DSD Model
Weekly Loss Sales	5	2
Annual Loss Sales	257	99
$C_{loss\ sales}$	$ 515.92	$ 199.01
Weekly Labor Costs	$ 15.00	$ 22.50
Yearly Labor Costs	$ 780.00	$ 1,170.00
Total Costs	$ 1,295.92	$ 1,369.01

4.2.2 Sensitivity Analysis of the stock-out costs at the shelf

As indicated in section 4.2.1, three variables play important roles in affecting the total costs at the shelf level: the demand pattern, the shelf size and the frequency of review. In this section, a detailed sensitivity analysis is conducted to see how these three variables affect the total costs. Due to its importance to the store's revenue, the A item is studied in detail with the actual data in Table 4 and Table 5.

4.2.2.1 The sensitivity to customer demand:

The customer demand pattern is determined by two variables: the mean of the daily demand and the standard deviation of the daily demand. In reality, the mean of the daily demand is mostly known to shelf planning, which means in most cases, the shelf size is big enough to hold the product quantity equivalent to the mean of the daily demand. The lost sales are mainly caused by the fluctuation of the daily demand. As an alternative way of expressing the standard deviation of the daily demand, the co-efficient of variation (*cov*) is introduced in this analysis to describe the daily demand fluctuation.

cov = the standard deviation of the daily demand/the mean of the daily demand.

Therefore:

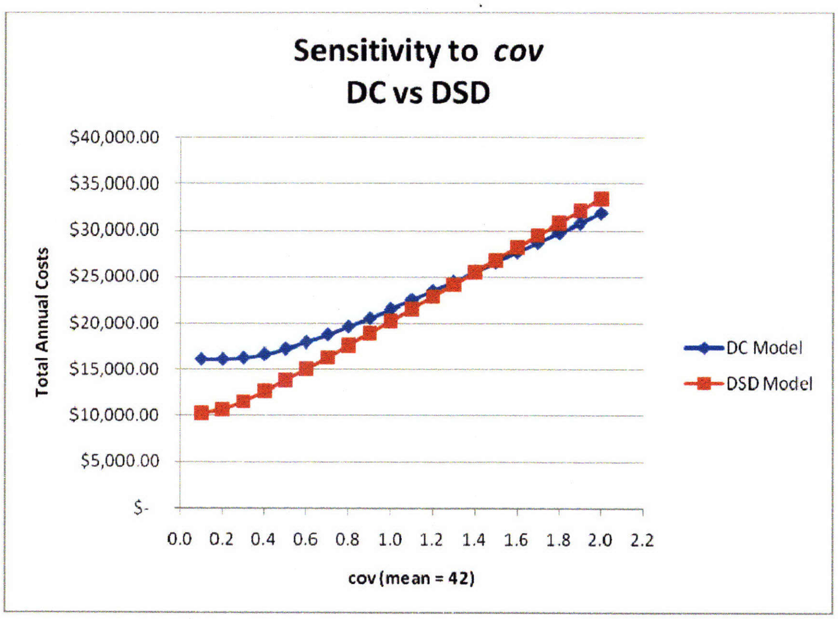
The standard deviation of the daily demand = *cov* * the mean of the daily demand

The results of the total costs at the shelf with different values of *cov* are listed in Table 9 and plotted in Figure 11:

Table 9: Sensitivity to co-efficient of variation

DC Model			DSD Model		
	Total Annual Cost			Total Annual Cost	
cov	$	19,189.54	cov	$	17,028.26
0.1	$	16,132.86	0.1	$	10,335.80
0.2	$	16,142.06	0.2	$	10,756.06
0.3	$	16,282.40	0.3	$	11,635.70
0.4	$	16,659.20	0.4	$	12,719.33
0.5	$	17,235.11	0.5	$	13,898.72
0.6	$	17,949.83	0.6	$	15,129.28
0.7	$	18,759.03	0.7	$	16,390.13
0.8	$	19,633.69	0.8	$	17,670.28
0.9	$	20,554.97	0.9	$	18,963.48
1.0	$	21,510.37	1.0	$	20,265.88
1.1	$	22,491.39	1.1	$	21,575.02
1.2	$	23,492.07	1.2	$	22,889.24
1.3	$	24,508.16	1.3	$	24,207.38
1.4	$	25,536.51	1.4	$	25,528.60
1.5	$	26,574.78	1.5	$	26,852.30
1.6	$	27,621.18	1.6	$	28,178.02
1.7	$	28,674.32	1.7	$	29,505.39
1.8	$	29,733.12	1.8	$	30,834.15
1.9	$	30,796.70	1.9	$	32,164.08
2.0	$	31,864.37	2.0	$	33,495.00

Figure 11: Sensitivity to co-efficient of variation



It turns out that for the A item, when cov is less than 1.4, the DSD model is less expensive than the DC model. When cov equals 1.4, both the DSD and DC model have almost the same cost at the shelf. When cov is greater than 1.4, the DC model is preferred from a cost perspective.

It indicates that with fixed shelf size and frequency of review, the greater the fluctuation of the demand, the more costs occur at the shelf in both the DSD and DC model. When cov reaches high enough, the difference in the total number of units short for both models become proportionally insignificant. As the DSD model has more review cycles in a year than the DC model, therefore the annual unit loss of the DSD model is bigger than that of the DC model. In such situation, the supplier and the store should consider expanding the shelf size in order to accommodate the fluctuation.

4.2.2.2 The sensitivity to shelf size:

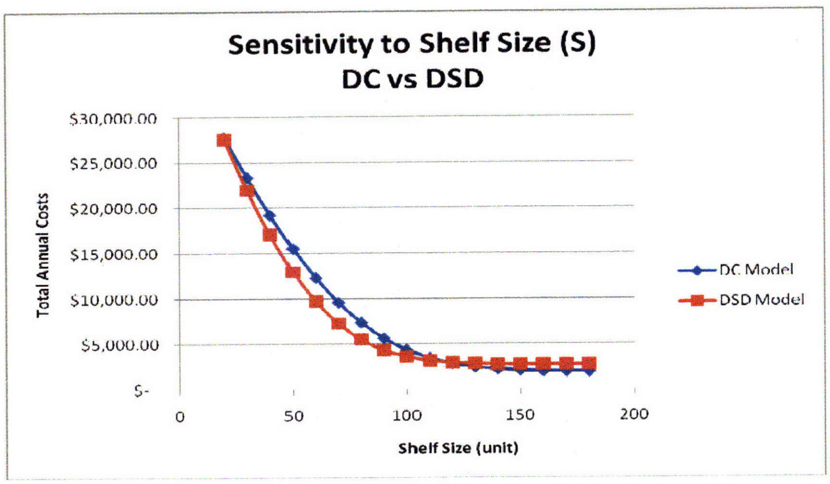
With given demand pattern and fixed review frequency, different shelf sizes have direct impact the total costs at the shelf.

With the same data for the A item in Table 4 and Table 5, the results of the total costs at the shelf to different *shelf size (S)* are listed in Table 8 and plotted in Figure 12:

Table 10: Sensitivity to the shelf size (S)

DC Model			DSD Model		
	Total Annual Cost			Total Annual Cost	
S	$	19,189.54	S	$	17,028.26
20	$	27,764.32	20	$	27,541.18
30	$	23,308.23	30	$	21,932.00
40	$	19,189.54	40	$	17,028.26
50	$	15,483.26	50	$	12,925.94
60	$	12,250.59	60	$	9,661.68
70	$	9,528.95	70	$	7,204.16
80	$	7,325.39	80	$	5,461.49
90	$	5,615.34	90	$	4,301.92
100	$	4,346.96	100	$	3,580.16
110	$	3,449.98	110	$	3,160.98
120	$	2,846.44	120	$	2,934.33
130	$	2,460.73	130	$	2,820.41
140	$	2,226.96	140	$	2,767.27
150	$	2,092.75	150	$	2,744.30
160	$	2,019.85	160	$	2,735.10
170	$	1,982.41	170	$	2,731.69
180	$	1,964.24	180	$	2,730.52

Figure 12: Sensitivity to the shelf size (S)



It turns out that in both models, the bigger the shelf size, the less total cost at the shelf. However, in reality, the shelf slot is very expensive and the allocation is very limited. Therefore, a further trade-off with the purchase cost of shelf size should be considered. Moreover, when the shelf size become big enough that there is no lost sales for either the

DSD model or the DC model, therefore the DSD supplier should not send any merchandiser to review the shelf because the labor costs exceed the cost of lost sales.

4.2.2.3 The sensitivity to review frequency:

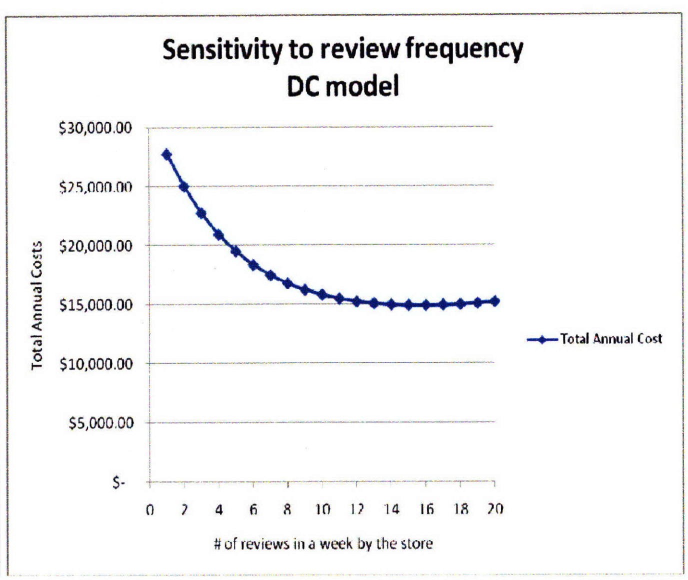
With given demand pattern and fixed shelf size, the level of frequency of review by either the retailer or the supplier has direct impact on the total costs at the shelf as well.

The DC model:

In the DC model, the store reviews the shelf and replenishes the stock on the shelf. Therefore, the sensitivity of the total cost at the shelf to *Review Frequency by the store* *(F_0)* is shown in the following table and chart:

Table 11: Sensitivity to the review frequency

	DC Model	
	Total Annual Cost	
F_0	$	14,909.83
1	$	27,758.59
2	$	25,029.75
3	$	22,750.67
4	$	20,936.35
5	$	19,505.53
6	$	18,377.07
7	$	17,486.49
8	$	16,784.93
9	$	16,235.42
10	$	15,809.77
11	$	15,486.22
12	$	15,247.70
13	$	15,080.68
14	$	14,974.30
15	$	14,919.76
16	$	14,909.83
17	$	14,938.56
18	$	15,000.96
19	$	15,092.86
20	$	15,210.73



It turns out to be a convex curve when plotting the data on the chart. When the store reviews the shelf for 16 times a week, the total costs at the shelf is the lowest. It means when the demand pattern is known and the shelf size is pre-set, there is an optimal review frequency by the store staff in the DC model. The store needs to reach the optimal review frequency in order to get the lowest total costs of lost sales and the labor hours.

The DSD model:

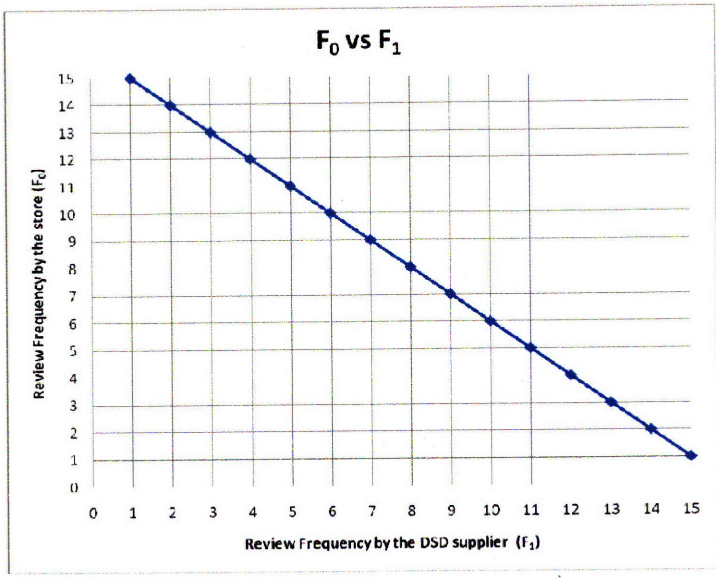
In the DSD model, the supplier sends merchandisers to review the shelf and replenish the stock. It's assumed that the review by the supplier's merchandiser is additional to the review by the store staff. So the cumulative frequency of review in a DSD model is the sum of the review frequency of the store and the DSD supplier. Therefore, the sensitivity of the total cost at the shelf to *Review Frequency by the store* (F_0) and *the DSD supplier* (F_1) is as per Table 12

Table 12: The sensitivity to review frequency by the store and the DSD supplier

DSD Model															
Total Annual Cost		F_1													
	$ 15,000.96	1	2	3	4	5	6	7	8	9	10	11	12	13	14
F_0	1	$ 25,029.75	$ 22,750.67	$ 20,936.35	$ 19,505.53	$ 18,377.07	$ 17,486.49	$ 16,784.93	$ 16,235.42	$ 15,809.77	$ 15,486.22	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76
	2	$ 22,750.67	$ 20,936.35	$ 19,505.53	$ 18,377.07	$ 17,486.49	$ 16,784.93	$ 16,235.42	$ 15,809.77	$ 15,486.22	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83
	3	$ 20,936.35	$ 19,505.53	$ 18,377.07	$ 17,486.49	$ 16,784.93	$ 16,235.42	$ 15,809.77	$ 15,486.22	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56
	4	$ 19,505.53	$ 18,377.07	$ 17,486.49	$ 16,784.93	$ 16,235.42	$ 15,809.77	$ 15,486.22	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96
	5	$ 18,377.07	$ 17,486.49	$ 16,784.93	$ 16,235.42	$ 15,809.77	$ 15,486.22	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86
	6	$ 17,486.49	$ 16,784.93	$ 16,235.42	$ 15,809.77	$ 15,486.22	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73
	7	$ 16,784.93	$ 16,235.42	$ 15,809.77	$ 15,486.22	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57
	8	$ 16,235.42	$ 15,809.77	$ 15,486.22	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81
	9	$ 15,809.77	$ 15,486.22	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25
	10	$ 15,486.22	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96
	11	$ 15,247.70	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96	$ 16,098.29
	12	$ 15,080.68	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96	$ 16,098.29	$ 16,321.80
	13	$ 14,974.30	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96	$ 16,098.29	$ 16,321.80	$ 16,557.21
	14	$ 14,919.76	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96	$ 16,098.29	$ 16,321.80	$ 16,557.21	$ 16,803.41
	15	$ 14,909.83	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96	$ 16,098.29	$ 16,321.80	$ 16,557.21	$ 16,803.41	$ 17,059.42
	16	$ 14,938.56	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96	$ 16,098.29	$ 16,321.80	$ 16,557.21	$ 16,803.41	$ 17,059.42	$ 17,324.36
	17	$ 15,000.96	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96	$ 16,098.29	$ 16,321.80	$ 16,557.21	$ 16,803.41	$ 17,059.42	$ 17,324.36	$ 17,597.46
	18	$ 15,092.86	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96	$ 16,098.29	$ 16,321.80	$ 16,557.21	$ 16,803.41	$ 17,059.42	$ 17,324.36	$ 17,597.46	$ 17,878.04
	19	$ 15,210.73	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96	$ 16,098.29	$ 16,321.80	$ 16,557.21	$ 16,803.41	$ 17,059.42	$ 17,324.36	$ 17,597.46	$ 17,878.04	$ 18,165.46
	20	$ 15,351.57	$ 15,512.81	$ 15,692.25	$ 15,887.96	$ 16,098.29	$ 16,321.80	$ 16,557.21	$ 16,803.41	$ 17,059.42	$ 17,324.36	$ 17,597.46	$ 17,878.04	$ 18,165.46	$ 18,459.19

It turns out that a series of combinations of F_0 and F_1 can generate the lowest costs at the shelf in the DSD model. By plotting the respective combination of F_0 and F_1 that generate the lowest costs, Figure 13 is established:

Figure 13: Substitution of F_0 and F_1



Now it's much clearer. As long as the cumulative frequency of F_0 and F_1 equals 16, the total costs at the shelf can reach the lowest point. Comparing the lowest total costs and the total number of reviews in a week with those of the DC model, it suggests that the DC and DSD model can reach the same level of the total costs at the shelf as long as the frequency of review can reach 16 times a week. This finding gives guidelines on how to split the workload of merchandising between the DSD supplier and the store during contract negotiation. The split should follow the curve in order to get the lowest total costs at the shelf.

4.2.3 Generic Model

To calculate the total profitability of each model for a supplier to supply a product to a store, this thesis uses the data of one A item product from the sponsor company. As the sponsor company is using the Through-the-Backroom model to supply the A item to the store, the real supply chain costs and profitability are calculated. In order to compare the costs with those of the DC model and the Direct-to-Shelf model, the virtual situations adopting these two models are assumed and the costs in these two models are calculated for comparison

Besides the data from Table 4 and Table 5 to calculate the total costs at the shelf, Table 13 lists all the operational and financial information for the A item to one store under the DSD and DC models.

Table 13: Costs and Operations in the DC and DSD model

Product Cost	$1.50/unit
The wholesale price under the DC model	$3.00/unit
The wholesale price under both DSD models	$3.20/unit
The weekly sales in the store	294 units
# of replenishment received at the supplier's DC	Once a week
Safety stock at the supplier's DC	56,000 units
Receiving costs per receipt	$10/receipt
Inventory holding cost	40% of product cost per year
Order processing cost	$10/order from the store $100/order from the DC and the depot

Also:

In the DC model, the number of shelf reviews by the store in a week = 5 times

In the Direct-to-Shelf model, the number of shelf reviews by the supplier's merchandiser in a week = 5 times

In the Through-the-Backroom model, the number of shelf reviews by the store in a week = 5 times and the number of shelf reviews by the supplier's merchandiser in a week = 2 times

Through-the-Backroom

In this model, the depot places 12 orders to the supplier's DC in a year or 0.25 times in a week with each order of 17,500 units, a FTL quantity. The transportation cost from the supplier's DC to the depot is $0.0625 per unit per delivery. The depot holds an average inventory of 4,000 units all the time in order to serve 8 stores in its region. The supplier's merchandiser visits the store and places orders twice a week to the depot. The average order size is 150 units. The depot processes the orders, picks and packs the products, loads the pallets and sends them to the store on a route truck. The transportation cost from the supplier's depot to the store is $0.0625 per unit per delivery. At the store, the delivered products are moved to the backroom, where an average of 350 units of the A items is stored all the time.

So the weekly costs of warehousing and transportation to the suppliers are as per Table 14:

Table 14: Weekly costs of warehousing and transportation of the Through-the-Backroom model

Weekly Costs:	Supplier's DC		Supplier's Depot		Retailer's Backroom	
Receiving	$	10.00	$	2.50	$	20.00
Storage	$	646.15	$	147.12	$	4.90
Order Processing	$	25.00	$	20.00		
Transportation	$	273.44	$	18.75		
Subtotal	$	954.59	$	188.37	$	24.90
Weekly Total:	$	1,167.86				

To calculate the costs to serve one store, the total costs at the supplier's DC, the receiving and storage costs at the supplier's depot is divided by the eight stores. So the cost to serve one store is $201.68. Adding the stock-out costs and labor costs at the store, the total costs to supply the A item to the store in a week are $537.18. The weekly profit for the supplier at this store under the current Through-the-Backroom model is $403.62.

DC model:

In the DC model, the retailer orders 3 times a week. Each order is 17,500 units, a FTL quantity. Upon receipt of orders, the supplier sends FTL to the retailer's DC. The transportation cost from the supplier's DC to the retailer's DC is $0.0625/unit per delivery. Therefore the weekly costs of warehousing and transportation to the suppliers are as per Table 15

Table 15: Weekly costs of warehousing and transportation of the DC model

Weekly Costs:		
Receiving	$	10.00
Storage	$	646.15
Order Processing	$	300.00
Transportation	$	3,281.25
Weekly Total:	$	4,237.40

As the retailer's DC serves 35 stores in the region, the supplier's cost to serve a store under the DC model is $121.07. As the stock-out costs and the labor costs are $374.18, thus the weekly profit for the supplier at this store under the DC model is $386.75.

Direct-to-Shelf Model:

Now let's assume in the Direct-to-Shelf model, the operations and the costs between the supplier's DC and the depot remain same. The supplier's merchandiser visits the store and replenishes the shelf directly 5 times a week. The transportation cost remains the same as that in the Through-the-Backroom model. Therefore the weekly costs of warehousing and transportation to the suppliers are as per Table 16:

Table 16: weekly costs of warehousing and transportation of the Direct-to-Shelf model

Weekly Costs:				
	Supplier's DC		Supplier's Depot	
Receiving	$	10.00	$	2.50
Storage	$	646.15	$	147.12
Order Processing	$	25.00	$	50.00
Transportation	$	273.44	$	46.88
Subtotal	$	954.59	$	246.49
Weekly Total:	$	1,201.08		

Using the same approach as in the Through-the-Backroom model, the cost to serve one store is $234.9. The stock-out costs and the labor costs in this model total $374.18. Therefore the weekly profit for the supplier at this store under the direct-to-shelf model is $331.72.

Table 17 indicates the summary of the revenue, cost breakdown and the profits of the three models:

Table 17: Financial Summary of the DC and DSD models

Per Week	Revenue	Delivery Costs		Costs at shelf		Weekly Profit	
DC Model	$ 882.00	$	121.07	$	374.18	$	386.75
Direct to Shelf	$ 940.80	$	234.90	$	374.18	$	331.72
Through Backroom	$ 940.80	$	201.68	$	335.50	$	403.62

It's indicated that the Through-the-Backroom model generates the highest weekly profits with the lowest costs at the shelf. With the same sales volume, the Through-the-Backroom model can generate more revenue because of the higher product price. With the lower costs at the shelf and moderate delivery costs, this DSD model drives more profit for the supplier. However, the direct-to-shelf model generates the lowest weekly profits with the highest delivery costs and the same costs at the shelf as the DC model. Therefore, it should not be a preferred model except for certain products such as newspapers.

5 Conclusions

This thesis conducted extensive literature reviews and interviews with industrial practitioners and researchers about the DSD practices in various industries. Based on the information collected, two models are built to simulate: first, the cost of stock-out at the shelf and second, the generic DSD model, in order to conduct the quantitative comparison between the DC model and two DSD models. Combining the expert opinions and practices, and the results of the models by inputting real operations and financial data, the following conclusions were gleaned.

The DSD models are widely used in such industries as beverage, brewery, bakery, dairy products, salty snacks, newspaper and magazines, and frozen food. These industries are characterized by features like high demand, high velocity, significant importance in revenue and profit generation, great variations, short shelf life or special handling requirements such as freezing equipment and high security. These product features favor the selection of the DSD model because the products with such features require more frequent and flexible level of management. The DSD models can achieve such level of management by contributing free and flexible labor hours to each retail store.

Company strategy and economy of scale are also important factors to consider when using the DSD model. The frontiers in research are promoting the shift of focus from cost to delivery to cost to serve. This new idea puts the DSD model beyond a merely distribution model and escalates it to be an integral part of corporate strategy. It's believed that by positioning the DSD model at a higher level in company decision making, DSD can attract more attention and resources, therefore be better integrated with marketing and sales strategy.

The DSD model can drive more sales at the store by minimizing the stock-outs and improving category management. While the DC model has a cost advantage over the DSD model in logistic handling, such as warehousing and transportation due to economy of scale, the fewer stock-outs resulting from the DSD model brings more revenue to cover the increased logistics costs and generates more profits than using the DC model. The result is much clearer when applying the A items in the model.

The DSD model is still evolving in order to keep its volatility and unleash its power of boosting sales at a higher strategic level. Two areas could be the next directions following this research: first, to study the category management with pre-set shelf size in order to achieve optimal shelf allocation and maximize the profit from a given shelf space; second, to develop better collaborative strategy between the supplier and the retailer to achieve the lowest and optimal labor contribution to shelf merchandising.

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Appendix I: Questionnaire for expert opinions

Name:

Title:

Company:

Date:

1. According to your knowledge and experience, in what industry and product is DSD model still the most widely-used logistics model?

2. Do you think DSD model is better in generating value to suppliers and retailers than is DC model in the industries mentioned in the answer to Q1

   If yes:

   - What benefits does DSD model generate to both suppliers and retailers? And how?
   - What issues or challenges prevent DC model to deliver same value as DSD model does?

   If no:

   - What issues or challenges do you think will jeopardize the delivery of expected value by DSD model? Why?
   - What are the advantages of DC model in this scenario?

3. What features of products and customers do you think most relevant in choosing between DSD model and DC model? Why?

4. What key performance indicators are commonly used to evaluate the value that DSD delivers? What's the logic behind these KPIs?

5. What do you think the future of DSD model will be like?

Appendix II: Costs of Stock-out at the shelf model

Analysis of Stock-out cost and merchandising cost at shelf
- Single item, Single store

Daily demand	Average daily demand	Units	42
Daily δ	The standard deviation for daily demand	Units	33
S	Shelf Capacity	Units	40
F_0	# of Review of store category manager weekly	times	5
F_1	# of reviews by supplier's merchandiser weekly	times	2
F_2	# of reviews for Direct-to-Shelf Model	times	5
Lt	Replenishment Lead Time from backroom to shelf	Day	0.2
B_2	Cost of Unit Short	$	$ 2.00
Labor Costs	Retailer	$/labor hour	$ 15.00
	Supplier's Merchandiser	$/labor hour	$ 15.00
H_L	Labor hour per review	hours	0.50

			DC Model	Through-the-Backroom Model	Direct-to-Shelf Model
Review Period		Days	1.4	1.0	1.4
D_{R+Lt}	Cycle Demand during the period of review and lead time	Units	67	50	67
$\delta_{(R+Lt)}$	Daily δ*sqrt(R+Lt)	Units	42	36	42
k	Safety Factor = $(S-D_{R+Lt})/\delta_{(R+Lt)}$		-0.652	-0.288	-0.652
$G_u(k)$	Unit Normal Loss Function		0.807	0.559	0.807
Loss Sales	Unit short in a review period	Units	34	20	34
Weekly Loss Sales	Unit Short in a week	Units	168	142	168
		$	$ 336.68	$ 283.00	$ 336.68
Annual Loss Sales	Yearly Unit Short	Units	8754	7358	8754
		$	$ 17,555.53	$ 14,756.49	$ 17,555.53
Weekly Labor Costs	# of review per week * Labor hour per review * unit labor cost		$ 37.50	$ 52.50	$ 37.50
Yearly Labor Costs	Weekly labor cost * 52		$ 1,950.00	$ 2,730.00	$ 1,950.00
Total Weekly Cost			$ 374.18	$ 335.50	$ 374.18
Total Annual Cost			$ 19,505.53	$ 17,486.49	$ 19,505.53