THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF SUPPLY CHAIN AND INFORMATION SYSTEMS

BENEFITS OF ALIGNING SUPPLY AND DEMAND: CASE PACK OPTIMIZATION

ALEXA L. SWAHN

SUMMER 2011

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Finance
with honors in Supply Chain
and Information Systems

Reviewed and approved* by the following:

Robert A. Novack
Associate Professor of Supply Chain and Information Systems
Honors Adviser/Thesis Supervisor

John C. Spychalski
Professor Emeritus of Supply Chain Management
Faculty Reader

*Signatures are on file in the Schreyer Honors College

Abstract

The purpose of this thesis is to determine the optimal case pack size for four of a retailer's beauty products and to show the benefits of aligning supply and demand. The optimal case pack size will be modeled in Excel using a delivery agent cost, inventory holding cost, corrugate cost, and vendor processing cost. A simulation that uses the costs from the Excel model and also incorporates excess inventory into meeting demand will be used to more accurately determine optimal case pack size. An expanded simulation which includes a store processing cost along with the costs from the simulation will also be used to determine optimal case pack size. Optimal case pack size will also be determined for the stock keeping units of one of the four beauty products.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES CONTINUED

Acknowledgements

I would like to thank my thesis supervisor Dr. Novack and Professor Bansal for all of their help and support. I would also like to thank everyone at the company for which the topic of this thesis is on for all of their help and for the opportunity to work on my thesis for their company.

Introduction:

This thesis will help a retailer determine the optimal case pack size for their beauty products. The company has used case pack models in the past for other product lines and wants a new model for the four beauty products: beauty product A, beauty product B, beauty product C, and beauty product D. This thesis will show how the optimization of case pack size improves the alignment of supply and demand. The optimal case pack size will be modeled in Excel using delivery agent cost, inventory holding cost, corrugate cost and vendor processing cost. This thesis will also use a simulation to produce a more accurate optimal case pack model. This simulation will incorporate the same costs used in the previous model but will incorporate excess inventory into meeting demand. An expanded simulation which includes a store processing cost will also be used to determine optimal case pack size. Both the simulation and the expanded simulation will allow for a more accurate conclusion to be reached. Optimal case pack size will also be determined for the stock keeping units of beauty product D. For the Excel model and for both simulations, the optimal case pack size will be the lowest total cost for seven possible case pack sizes: twelve, eighteen, twenty four, thirty, thirty six, forty, and forty eight units per case. A sensitivity analysis will also be performed on all four of the beauty products using varying costs of capital: thirteen, fifteen, and twenty percent. All product brand names used in this thesis are disguised.

Background:

A retailer conducted an inventory optimization analysis on fifteen beauty products which revealed that network inventory could be reduced from 15.4 weeks of supply to 7.5 weeks of supply while maintaining a ninety nine percent in stock rate (company

presentation[1]). The store portion of the reduction was from 7.6 to 4.3 weeks of supply (company presentation[1]). The reduction in inventory was a result of the specific safety stock setting at both the individual store and product item level (company presentation[1]). Inventory positioning between vendor and store as well as investment in safety stock for components were also key drivers for the results of the optimization (company presentation[1]).

To determine if the recommended store safety stock settings from the model were sufficient to maintain store in stock levels of ninety nine percent or better a one hundred stock keeping unit pilot made up of ten stores and ten items was conducted over a nine week period (company presentation[1]). The stores used in the pilot had different levels of demand variability, were geographically diverse and had diversity in volume. Table 1 shows the stores that were selected for the pilot. The items used in the pilot were used in the inventory optimization analysis. Table 2 highlights the stock keeping units that were chosen for the pilot. Over the nine week period, one safety stock setting was chosen for each store. For six of the nine weeks the stock keeping units were monitored and data was gathered daily. This included data on actual sales, sales forecast, coverage duration, and inventory level at the store and vendor. As a result of the pilot, store inventory was reduced by thirty three percent and there was a forty four percent reduction in days of supply (company presentation[1]). It was also found that the case pack, which is a box holding a case of product and that varies in size, drives surplus inventory in low volume stores (company presentation[1]). At the end of the pilot, days of supply fell to forty six days but the average days of supply should be approximately twenty two days (company

[1] This information was taken from a presentation by the company which will remain anonymous and is the topic of this thesis

presentation[1]). Figure 1 shows the reduction in days of supply as a result of the pilot. For the stores in the pilot, the case pack of thirty six units represents less than ten days of supply for twenty stock keeping units (company presentation[1]). On average, one thirty six unit case pack is equal to forty days of supply (company presentation[1]). Figure 2 illustrates these findings. On average, one thirty six unit case pack is equal to sixty five days of supply instead of seven days of supply for all of the stores in the network (company presentation[1]). The current case pack of thirty six units represents more than three weeks of supply for seventy two percent of all the stock keeping units (company presentation[1]). This is shown by figure 3. The current case pack size of thirty six units per case is the reason why this retailer is not reaching the recommended target of the model.

Table 1: Store selection (company presentation[1])

Decile	Transp Zone	Store	State	Legacy Store	Avg of Weekly Sales U	Avg Variability
2-4	1	1	CA	1	371	30%
2-4	1	2	CA	2	432	49%
2-4	1	3	CA	3	304	95%
2-4	2	4	OH	4	80	52%
2-4	2	5	OH	5	142	59%
2-4	2	6	OH	6	28	81%
2-4	3	7	OH	7	76	61%
2-4	4	8	NY	8	506	35%
2-4	4	9	NY	9	193	56%
2-4	4	10	NY	10	74	129%

Table 2: Stock keeping unit selection (company presentation[1])

SKU	Product	Total Sales 2009
1000001	Beauty Product B	$2,080,953.00
1000002	Beauty Product B	$1,665,482.00
1000003	Beauty Product B	$1,275,850.00
1000004	Beauty Product B	$1,005,851.00
1000005	Beauty Product B	$963,637.00
1000006	Beauty Product B	$948,104.00
1000007	Beauty Product B	$901,636.00
1000008	Beauty Product B	$860,702.00
1000009	Beauty Product B	$855,964.00
1000015	Beauty Product B	$56,027.00

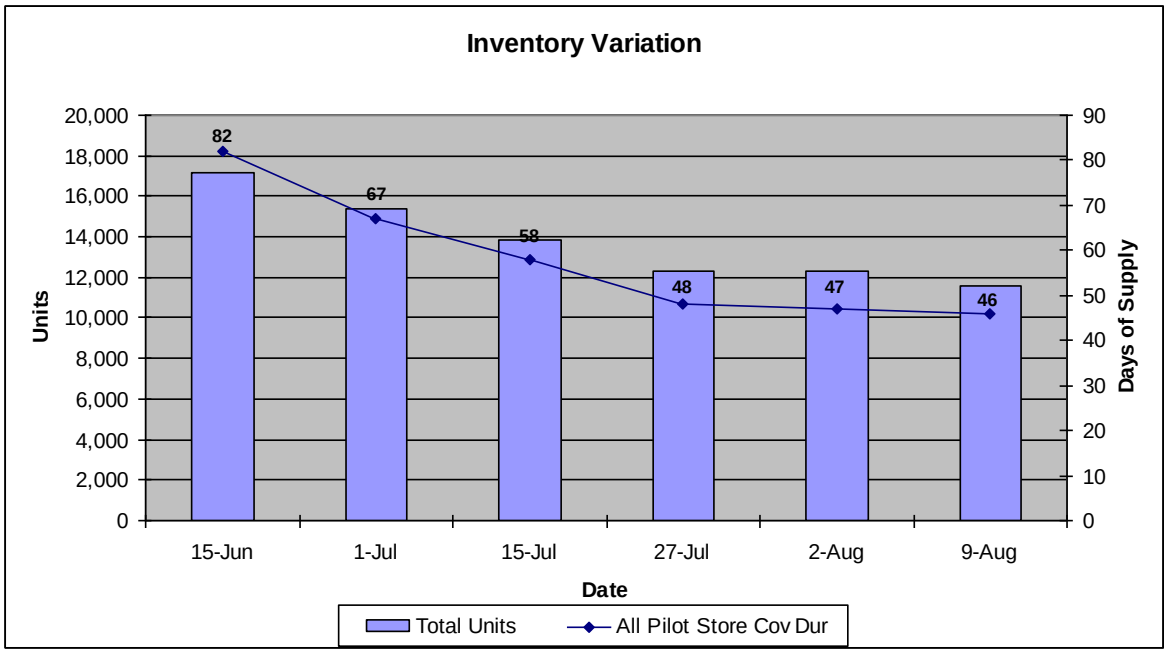

Figure 1: Pilot impact on days of supply (company presentation[1])

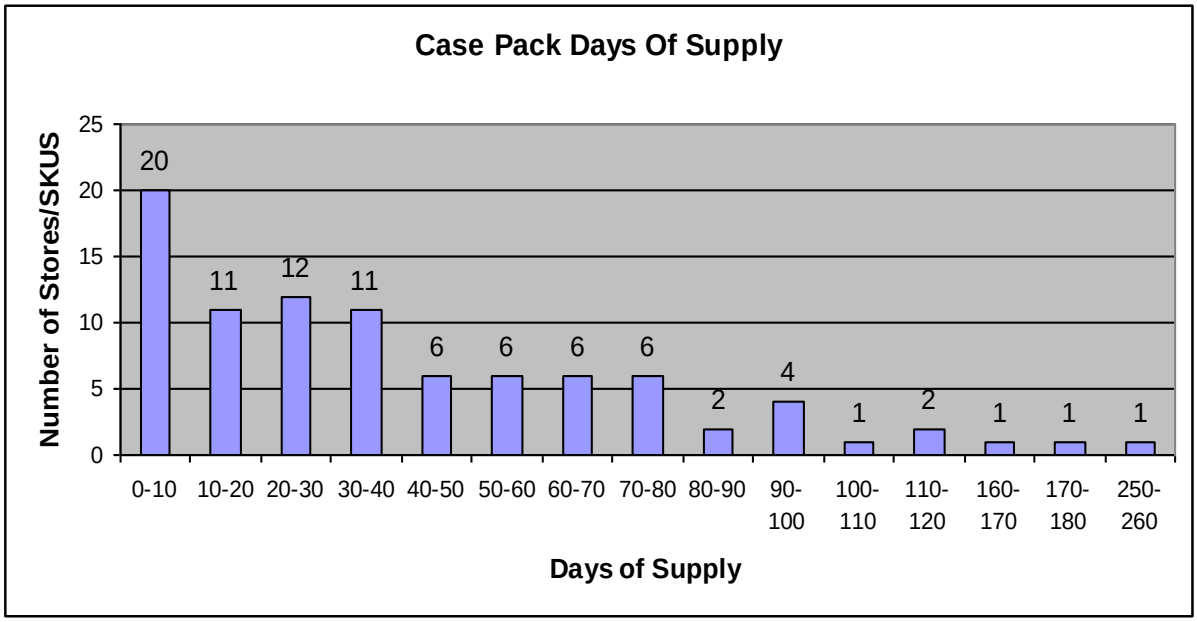

Figure 2: Case pack days of supply for pilot stores (company presentation[1])

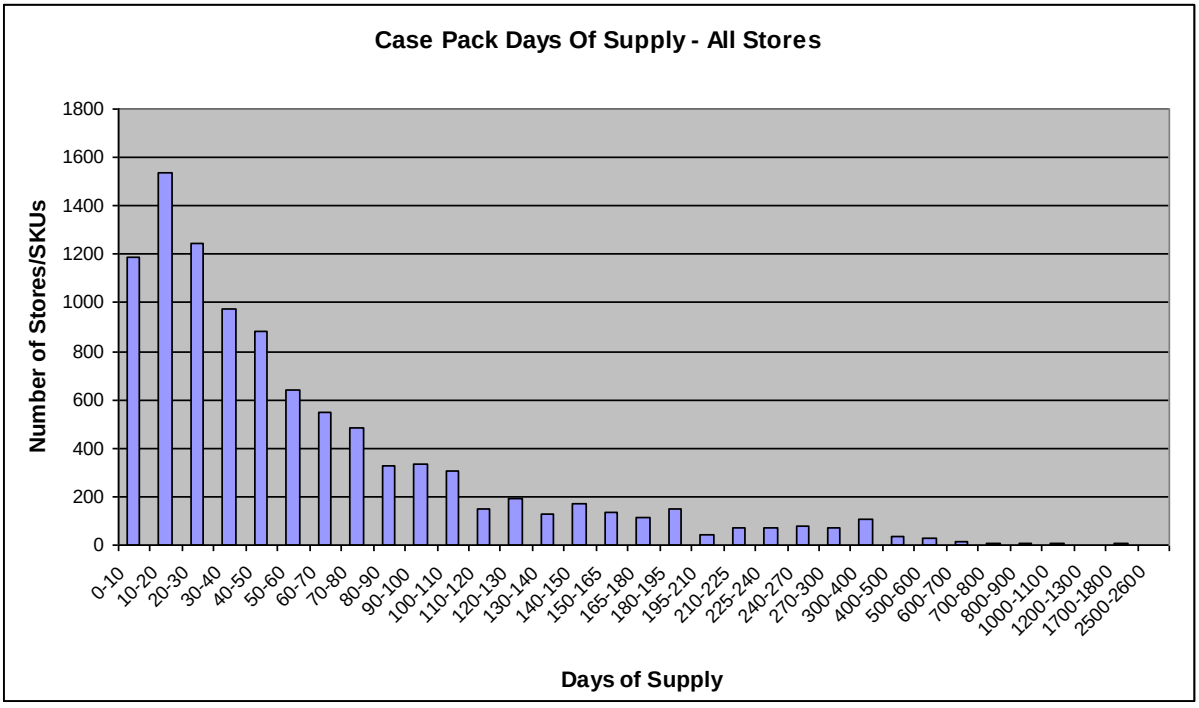

Figure 3: Case pack days of supply for all stores in network (company presentation[1])

Literature Review:

The right package size is an important decision that companies face. Companies are focusing on developing new package designs that fit the same product but use less material. For example, in June of 2007 General Mills began their "Right Size, Right Price" initiative. They started packaging their cereal into small boxes and selling it for similar prices. Kellogg's also ran a six month trial of a reduced package size in January of 2009. Their smaller cereal boxes used eight percent less materials while still holding the same amount of cereal. Kellogg's redesigned their cereal packages so more boxes could be packed into truck shipments, boxes would take up less space for retailers, and boxes would take up less pantry space for consumers. A case study titled "Phoenician Phoods, Breakfast Cereal Manufacturer and Distributor" highlights the importance of package size for cereal boxes. This case study shows the tradeoffs involved with choosing the right case pack size to help increase product sales while lowering inventory, transportation, and packaging costs (Banker, 2010). This case study also shows that case pack size is an important decision because cereal case pack size influences the profitability of stock keeping units (Banker, 2010). A case pack size that better corresponds to the rate of sales will achieve higher sales (Banker, 2010). The right size case pack also leads to a reduction in store labor associated with fewer trips to the back room (Banker, 2010). This case study also shows that cereal manufacturers such as Kellogg's and General Mills who reduced their package sizes gained market share.

Another company that successfully changed their packaging is PartyLite Gifts Inc. This direct seller of candles worked with Chicago Consulting to find their optimal package size. The company was interested in lowering their transportation costs by

shipping fewer cartons. At first the company had four carton sizes that it used to ship its products to customers. After they analyzed their package sizes, a new mix of sizes that led to an eight percent annual reduction in carton use were implemented. To find the optimal carton size, Chicago Consulting charted the dimension and weight of each box, along with the percentage of space utilized (Berger, 2009). This information was fed into a simulation model which showed the cost of transportation, corrugated material and amount of "void fill" (Berger, 2009). As a result, the company now uses six carton sizes consisting of less cardboard and millions of dollars in savings. According to Joe Salerno at PartyLite Gifts Inc. "a trip through the grocery store demonstrates that it's hard to find optimal packaging at the consumer pack level and even harder to find it at the case pack level". However, according to Terry Harris at Chicago Consulting "by reducing the size of a box of macaroni and cheese to its optimal dimensions, a producer can realize a forty two percent increase in product within a pallet and a similar level of savings on transportation". The right package size can significantly benefit a company's supply chain.

There is evidence that multipacks of products are a better option than single items. For example, Georgia-Pacific worked with Honest Tea to move the brand into club stores by transitioning to a twenty four drink multipack. The new option gave the brand more shelf appeal and visibility. It was also forty one percent lighter which allowed for savings on shipping and fuel costs (Smorch, 2010). A research study on reducing stock outs in retail shows that case packs are also significant to a company's supply chain effectiveness. The study found that ninety one percent of the items were allocated shelf space based on case pack size and eighty six percent of the inventories on shelves are in

excess of seven days of supply (Corsten, 2007). Optimal case pack size is an important aspect of every company's supply chain.

A master's thesis titled "Optimization of Ship-Pack in a Two-Echelon Distribution System" highlights the importance of optimizing case pack size for a major U.S. retailer. An optimization model was used to determine the optimal warehouse case pack combination when shipping from a distribution center to a store. The model incorporates a distribution center replenishment cost, distribution center picking cost, receiving cost at the store, extra handling cost at the store if there are units that do not fit onto the shelf, the average inventory cost of a stock keeping unit for a store, and the fixed order cost of a stock keeping unit for a store (Wen, 2011). The major assumptions of the model are a constant and known demand rate and uniform distribution of the inventory position at stores at the time of the order (Wen, 2011). The model shows that the optimal case pack configuration is an each and a case thus reducing the total cost from a distribution center to a store.

Methodology:

To find the optimal case pack size for the four beauty products, a separate model in Excel was created for each beauty product. Each beauty product has twenty two different stock keeping units that are represented in approximately one thousand stores. The assumptions for all four of the models were the same. These assumptions were that stores received shipments weekly, inventory was not carried over from week to week, there was a one hundred percent service level, demand was constant, and there was a constant transportation cost per case regardless of case pack size. It was also assumed

that the inventory policy was the same for all stock keeping units. Demand data from 2009 was used for all of the Excel models.

Optimal case pack size was determined based on the lowest total cost for the seven different case pack sizes that were considered in the model. The lowest total cost is the sum of the delivery agent cost, vendor processing cost, corrugate cost, and inventory holding cost. A distribution center cost is not included is this calculation because the products are directly shipped to the stores. The seven case pack sizes are twelve, eighteen, twenty four, thirty, thirty six, forty, and forty eight units per case. For each case pack size, the weekly demand was divided by the case pack size to determine how many cases per week would be needed to meet demand while maintaining a one hundred percent service level. This number was then rounded up to the nearest whole number.

For the delivery agent cost, there are fifty eight districts each with a different cost per case regardless of case pack size. Table 3 shows the delivery agent costs for each district. Each store was matched to its district and associated cost per case. Delivery agent cost for each of the seven sizes was then calculated by multiplying the cost per case by the number of cases needed to meet weekly demand. For the vendor processing cost, there is a fixed vendor processing cost per case of $0.61. The vendor processing cost for each of the seven case pack sizes was calculated by multiplying the fixed vendor processing cost per case by the number of cases needed to meet weekly demand. For the corrugate cost, there is a fixed corrugate cost per square inch of $.0006. This cost was used to find the cost per case for each of the seven case pack sizes. Corrugate cost was then calculated by multiplying the cost per case by the number of cases needed to meet weekly demand. Table 4 shows the corrugate cost calculation per case for each of the

beauty products. For the inventory holding cost, a sensitivity analysis was performed using a thirteen percent, fifteen percent, and twenty percent cost of capital. Inventory holding cost was calculated by multiplying one half of the average inventory by the value of each item by the cost of capital taken on a weekly basis. The value of each item was given as $0.97 for product A, $0.83 for product B, $1.10 for product C, and $0.98 for product D.

The total cost per week for each of the seven case pack sizes was then determined by adding up the delivery agent cost, vendor processing cost, corrugate cost, and inventory holding cost for each of the twenty two stock keeping units in each store. The total cost per year was then calculated by multiplying the total cost per week by fifty two weeks. Optimal case pack size for each beauty product was then determined by taking the lowest total cost for each of the seven case pack sizes. Appendix A shows an example of the case pack model spreadsheet.

The same costs and calculations that were used in the original case pack model were used in both the simulation and the expanded simulation. The simulation and expanded simulation also use the same assumptions as the original case pack model. However, both the simulation and the expanded simulation looked at demand on a weekly basis and carried excess inventory that was not used to meet demand from a given week into the following week to meet that week's demand for a given store and stock keeping unit. If the ending inventory was more than the following week's demand, it was also assumed that the store would not receive a shipment for the given stock keeping unit that week. The expanded simulation also assumed that there was a fixed store processing cost of $0.40 per case included in the total cost calculation. The store processing cost for

each of the seven case pack sizes was calculated by multiplying the fixed store processing cost per case by the number of cases needed to meet weekly demand. Total cost per year for a given store and stock keeping unit was calculated by adding up the sum of all costs for fifty two weeks. The total cost per year for a given case pack size and cost of capital was then calculated by adding up the total cost for all stock keeping unit and store combinations. The optimal case pack sizes for the stock keeping units of beauty product D were determined using the simulation with a fifteen percent cost of capital. Appendix B shows an example of the simulation spreadsheet. To see a detailed list of all formulas see Appendix C.

Table 3: Delivery agent cost by district

District	$/Case	District	$/Case	District	$/Case	District	$/Case
1	$1.37	16	$1.90	31	$1.54	46	$1.99
2	$0.81	17	$1.75	32	$1.04	47	$1.64
3	$3.90	18	$1.43	33	$1.97	48	$1.44
4	$1.82	19	$1.31	34	$1.91	49	$1.36
5	$1.78	20	$2.16	35	$1.83	50	$1.89
6	$1.88	21	$1.67	36	$3.03	51	$1.82
7	$1.69	22	$1.92	37	$1.59	52	$2.11
8	$1.77	23	$2.01	38	$1.53	53	$3.82
9	$1.90	24	$1.27	39	$1.03	54	$2.33
10	$1.99	25	$1.76	40	$1.68	55	$2.91
11	$1.50	26	$1.33	41	$2.06	56	$3.26
12	$1.91	27	$1.50	42	$2.16	57	$3.72
13	$1.83	28	$1.65	43	$1.26	58	$2.80
14	$2.42	29	$1.71	44	$1.74		
15	$1.53	30	$1.61	45	$2.00		

Table 4: Corrugate cost calculation

Style	Length	Width	Height	Cost/Case	Units/Case
2000001				0.044437	12
				0.066656	18
				0.088874	24
				0.111093	30
	15.875	**12.875**	**6.625**	**0.133311**	**36**
				0.148123	40
				0.177748	48
2000002				0.041971	12
				0.062957	18
	13.125	**8.75**	**6.625**	**0.083942**	**24**
				0.104928	30
				0.125913	36
				0.139903	40
				0.167884	48
2000003				0.044754	12
				0.067131	18
	12.5	**8.375**	**7.5**	**0.089508**	**24**
				0.111885	30
				0.134262	36
				0.14918	40
				0.179016	48
2000004				0.038139	12
				0.057208	18
				0.076277	24
				0.095347	30
	19.6875	**8.75**	**7.4375**	**0.114416**	**36**
				0.127129	40
				0.152555	48

Results:

As the results show, as case pack size increases inventory holding and corrugate costs tend to increase because larger case packs result in more products tied up in inventory as well as more corrugate that is needed for each case. Also consistent with the results, as case pack size increases the delivery agent and vendor processing costs tend to decrease because fewer cases need to be shipped and processed. The delivery agent and vendor processing costs appear to have the largest effect on the total cost for each product because they have the greatest contributions to the total cost for each product. The corrugate and inventory holding costs appear to have the smallest effect on the total cost for each product because they have the smallest contributions to the total cost for each product. The results of the sensitivity analysis for inventory holding cost are also consistent for products A, B and C. For product D the optimal case pack size varies by the levels of inventory holding cost.

Beauty product A has an optimal case pack size of forty units per case for a thirteen percent, fifteen percent, and twenty percent cost of capital. Table 5 shows how total cost varies by case pack size for beauty product A. Beauty product B has an optimal case pack size of forty eight units per case for a thirteen percent, fifteen percent and twenty percent cost of capital. Table 6 shows how total cost varies by case pack size for beauty product B. Beauty product C has an optimal case pack size of forty eight units per case for a thirteen percent, fifteen percent and twenty percent cost of capital. Table 7 shows how total cost varies by case pack size for beauty product C. Beauty product D has an optimal case pack size of twenty four units per case for both a thirteen percent and fifteen percent cost of capital. For a twenty percent cost of capital beauty product D has

an optimal case pack size of eighteen units per case. Table 8 shows how total cost varies by case pack size for beauty product D.

Tables 9, 10, and 11 show the overall total cost results for all beauty products for thirteen, fifteen, and twenty percent costs of capital. The overall results for lowest total cost by beauty product and cost of capital are given in table 12. As the cost of capital increases for each of the beauty products, the total cost increases. Each of the beauty products also have lowest total costs around two million dollars. Table 13 shows the optimal case pack size for each beauty product by the cost of capital. Beauty products B and C have the same optimal case pack size of forty eight units per case while the optimal case pack sizes for beauty products A and D are less than forty eight units per case.

The results of the simulation and expanded simulation are significantly different than the results of the original case pack model. Tables 14, 15, and 16 show the overall total cost results of the simulation for thirteen, fifteen, and twenty percent costs of capital. Tables 17, 18, and 19 show the overall total cost results of the expanded simulation for thirteen, fifteen, and twenty percent costs of capital. Table 20 shows the overall lowest total cost results for the simulation. Each of the beauty products now have lowest total costs around one million dollars instead of two million dollars. Table 21 shows the overall lowest total cost results for the expanded simulation. These costs are slightly higher than the lowest total costs for the simulation because of the inclusion of the store processing cost. For both the simulation and the expanded simulation, the decreased costs are a result of ordering approximately half as many cases overall for each stock keeping unit and store combination. Similar to the original excel model, as the cost of capital increases for each of the beauty products, the total cost increases.

Table 22 shows the optimal case pack sizes for the simulation. The optimal case pack sizes are now higher for beauty products A and D. Beauty products A, B, and C now all have optimal case pack sizes of forty eight units per case for thirteen, fifteen, and twenty percent costs of capital. Beauty product D now has an optimal case pack size of thirty units per case for thirteen, fifteen, and twenty percent costs of capital. Table 23 shows the optimal case pack sizes for the expanded simulation. The results are the same as the simulation except beauty product D now has an optimal case pack size of thirty six units per case for a thirteen percent cost of capital. Table 24 shows the total cost by stock keeping unit for beauty product D using a fifteen percent cost of capital. Table 25 shows the optimal case pack size by stock keeping unit for beauty product D using a fifteen percent cost of capital. The optimal case pack sizes vary for the twenty two stock keeping units of beauty product D. Stock keeping units with a similar cost structure also have similar optimal case pack sizes.

Table 5: Beauty product A results

UPC	12	18	24	30	36	40	48
DA Cost	$1,876,832.88	$1,624,664.60	$1,516,659.04	$1,464,362.64	$1,435,203.64	$1,422,829.20	$1,405,200.16
Inventory Holding Cost	$16,646.07	$21,426.30	$26,503.00	$31,866.30	$37,370.64	$41,105.90	$48,596.16
Corrugate Cost	$51,091.52	$65,763.41	$81,345.06	$97,806.73	$114,701.10	$126,165.70	$149,155.42
Vendor Processing Cost	$696,380.88	$597,573.08	$554,370.44	$533,244.92	$521,127.88	$515,894.08	$508,249.56
Total Cost	**$2,640,951.36**	**$2,309,427.39**	**$2,178,877.53**	**$2,127,280.60**	**$2,108,403.26**	**$2,105,994.89**	**$2,111,201.29**

***13% cost of capital**

UPC	12	18	24	30	36	40	48
DA Cost	$1,876,832.88	$1,624,664.60	$1,516,659.04	$1,464,362.64	$1,435,203.64	$1,422,829.20	$1,405,200.16
Inventory Holding Cost	$19,207.01	$24,722.66	$30,580.38	$36,768.81	$43,119.96	$47,429.89	$56,072.49
Corrugate Cost	$51,091.52	$65,763.41	$81,345.06	$97,806.73	$114,701.10	$126,165.70	$149,155.42
Vendor Processing Cost	$696,380.88	$597,573.08	$554,370.44	$533,244.92	$521,127.88	$515,894.08	$508,249.56
Total Cost	**$2,643,512.29**	**$2,312,723.74**	**$2,182,954.92**	**$2,132,183.10**	**$2,114,152.58**	**$2,112,318.87**	**$2,118,677.62**

***15% cost of capital**

UPC	12	18	24	30	36	40	48
DA Cost	$1,876,832.88	$1,624,664.60	$1,516,659.04	$1,464,362.64	$1,435,203.64	$1,422,829.20	$1,405,200.16
Inventory Holding Cost	$25,609.34	$32,963.54	$40,773.84	$49,025.08	$57,493.29	$63,239.85	$74,763.32
Corrugate Cost	$51,091.52	$65,763.41	$81,345.06	$97,806.73	$114,701.10	$126,165.70	$149,155.42
Vendor Processing Cost	$696,380.88	$597,573.08	$554,370.44	$533,244.92	$521,127.88	$515,894.08	$508,249.56
Total Cost	**$2,649,914.63**	**$2,320,964.63**	**$2,193,148.38**	**$2,144,439.37**	**$2,128,525.91**	**$2,128,128.84**	**$2,137,368.45**

***20% cost of capital**

Table 6: Beauty product B results

UPC	12	18	24	30	36	40	48
DA Cost	$2,642,741.40	$2,106,134.16	$1,858,579.32	$1,721,453.76	$1,641,982.68	$1,605,520.80	$1,551,857.32
Inventory Holding Cost	$20,980.59	$24,724.76	$28,769.46	$33,037.59	$37,560.27	$40,658.50	$46,906.78
Corrugate Cost	$74,853.59	$88,211.89	$102,642.36	$117,870.03	$134,005.51	$145,059.55	$167,351.87
Vendor Processing Cost	$1,027,537.68	$807,274.00	$704,501.20	$647,214.88	$613,179.32	$597,382.76	$574,322.32
Total Cost	**$3,766,113.26**	**$3,026,344.81**	**$2,694,492.34**	**$2,519,576.27**	**$2,426,727.78**	**$2,388,621.61**	**$2,340,438.29**

***13% cost of capital**

UPC	12	18	24	30	36	40	48
DA Cost	$2,642,741.40	$2,106,134.16	$1,858,579.32	$1,721,453.76	$1,641,982.68	$1,605,520.80	$1,551,857.32
Inventory Holding Cost	$24,208.37	$28,528.57	$33,195.53	$38,120.30	$43,338.77	$46,913.65	$54,123.20
Corrugate Cost	$74,853.59	$88,211.89	$102,642.36	$117,870.03	$134,005.51	$145,059.55	$167,351.87
Vendor Processing Cost	$1,027,537.68	$807,274.00	$704,501.20	$647,214.88	$613,179.32	$597,382.76	$574,322.32
Total Cost	**$3,769,341.04**	**$3,030,148.62**	**$2,698,918.41**	**$2,524,658.97**	**$2,432,506.28**	**$2,394,876.76**	**$2,347,654.72**

***15% cost of capital**

UPC	12	18	24	30	36	40	48
DA Cost	$2,642,741.40	$2,106,134.16	$1,858,579.32	$1,721,453.76	$1,641,982.68	$1,605,520.80	$1,551,857.32
Inventory Holding Cost	$32,277.83	$38,038.10	$44,260.70	$50,827.07	$57,785.03	$62,551.54	$72,164.27
Corrugate Cost	$74,853.59	$88,211.89	$102,642.36	$117,870.03	$134,005.51	$145,059.55	$167,351.87
Vendor Processing Cost	$1,027,537.68	$807,274.00	$704,501.20	$647,214.88	$613,179.32	$597,382.76	$574,322.32
Total Cost	**$3,777,410.50**	**$3,039,658.15**	**$2,709,983.58**	**$2,537,365.74**	**$2,446,952.54**	**$2,410,514.65**	**$2,365,695.79**

***20% cost of capital**

Table 7: Beauty product C results

UPC	12	18	24	30	36	40	48
DA Cost	$3,011,373.56	$2,336,806.16	$2,025,017.28	$1,850,318.60	$1,743,831.96	$1,695,012.80	$1,624,595.96
Inventory Holding Cost	$31,042.71	$35,796.40	$41,056.95	$46,587.68	$52,444.00	$56,495.69	$64,702.16
Corrugate Cost	$71,663.32	$82,637.41	$94,781.60	$107,549.51	$121,069.59	$130,422.54	$149,367.49
Vendor Processing Cost	$1,146,202.20	$881,149.88	$757,981.12	$688,070.24	$645,470.28	$625,803.88	$597,255.88
Total Cost	**$4,260,281.78**	**$3,336,389.86**	**$2,918,836.96**	**$2,692,526.04**	**$2,562,815.83**	**$2,507,734.92**	**$2,435,921.49**

***13% cost of capital**

UPC	12	18	24	30	36	40	48
DA Cost	$3,011,373.56	$2,336,806.16	$2,025,017.28	$1,850,318.60	$1,743,831.96	$1,695,012.80	$1,624,595.96
Inventory Holding Cost	$35,818.51	$41,303.54	$47,373.41	$53,755.02	$60,512.31	$65,187.34	$74,656.34
Corrugate Cost	$71,663.32	$82,637.41	$94,781.60	$107,549.51	$121,069.59	$130,422.54	$149,367.49
Vendor Processing Cost	$1,146,202.20	$881,149.88	$757,981.12	$688,070.24	$645,470.28	$625,803.88	$597,255.88
Total Cost	**$4,265,057.58**	**$3,341,897.00**	**$2,925,153.41**	**$2,699,693.37**	**$2,570,884.14**	**$2,516,426.56**	**$2,445,875.67**

***15%cost of capital**

UPC	12	18	24	30	36	40	48
DA Cost	$3,011,373.56	$2,336,806.16	$2,025,017.28	$1,850,318.60	$1,743,831.96	$1,695,012.80	$1,624,595.96
Inventory Holding Cost	$47,758.01	$55,071.39	$63,164.54	$71,673.36	$80,683.08	$86,916.45	$99,541.78
Corrugate Cost	$71,663.32	$82,637.41	$94,781.60	$107,549.51	$121,069.59	$130,422.54	$149,367.49
Vendor Processing Cost	$1,146,202.20	$881,149.88	$757,981.12	$688,070.24	$645,470.28	$625,803.88	$597,255.88
Total Cost	**$4,276,997.09**	**$3,355,664.84**	**$2,940,944.55**	**$2,717,611.71**	**$2,591,054.91**	**$2,538,155.67**	**$2,470,761.12**

***20%cost of capital**

Table 8: Beauty product D results

UPC	12	18	24	30	36	40	48
DA Cost	$1,515,536.88	$1,452,152.00	$1,434,861.48	$1,426,345.44	$1,423,991.92	$1,422,997.68	$1,422,115.24
Inventory Holding Cost	$13,195.13	$18,880.63	$24,825.63	$30,801.83	$36,877.72	$40,937.19	$49,072.88
Corrugate Cost	$37,842.23	$54,147.63	$71,197.57	$88,336.36	$105,761.38	$117,403.52	$140,735.81
Vendor Processing Cost	$549,993.08	$524,648.80	$517,384.92	$513,546.80	$512,373.16	$511,897.36	$511,358.12
Total Cost	**$2,116,567.32**	**$2,049,829.05**	**$2,048,269.60**	**$2,059,030.43**	**$2,079,004.18**	**$2,093,235.75**	**$2,123,282.06**

***13% cost of capital**

UPC	12	18	24	30	36	40	48
DA Cost	$1,515,536.88	$1,452,152.00	$1,434,861.48	$1,426,345.44	$1,423,991.92	$1,422,997.68	$1,422,115.24
Inventory Holding Cost	$15,225.15	$21,785.34	$28,644.95	$35,540.57	$42,551.22	$47,235.22	$56,622.56
Corrugate Cost	$37,842.23	$54,147.63	$71,197.57	$88,336.36	$105,761.38	$117,403.52	$140,735.81
Vendor Processing Cost	$549,993.08	$524,648.80	$517,384.92	$513,546.80	$512,373.16	$511,897.36	$511,358.12
Total Cost	**$2,118,597.34**	**$2,052,733.76**	**$2,052,088.92**	**$2,063,769.17**	**$2,084,677.68**	**$2,099,533.78**	**$2,130,831.73**

***15% cost of capital**

UPC	12	18	24	30	36	40	48
DA Cost	$1,515,536.88	$1,452,152.00	$1,434,861.48	$1,426,345.44	$1,423,991.92	$1,422,997.68	$1,422,115.24
Inventory Holding Cost	$20,300.20	$29,047.12	$38,193.27	$47,387.43	$56,734.95	$62,980.30	$75,496.75
Corrugate Cost	$37,842.23	$54,147.63	$71,197.57	$88,336.36	$105,761.38	$117,403.52	$140,735.81
Vendor Processing Cost	$549,993.08	$524,648.80	$517,384.92	$513,546.80	$512,373.16	$511,897.36	$511,358.12
Total Cost	**$2,123,672.39**	**$2,059,995.54**	**$2,061,637.24**	**$2,075,616.03**	**$2,098,861.41**	**$2,115,278.86**	**$2,149,705.92**

***20% cost of capital**

Table 9: Total cost overall results 13% cost of capital

Total Cost 13% Cost of Capital							
Product	12	18	24	30	36	40	48
A	$2,640,951.36	$2,309,427.39	$2,178,877.53	$2,127,280.60	$2,108,403.26	$2,105,994.89	$2,111,201.29
B	$3,766,113.26	$3,026,344.81	$2,694,492.34	$2,519,576.27	$2,426,727.78	$2,388,621.61	$2,340,438.29
C	$4,260,281.78	$3,336,389.86	$2,918,836.96	$2,692,526.04	$2,562,815.83	$2,507,734.92	$2,435,921.49
D	$2,116,567.32	$2,049,829.05	$2,048,269.60	$2,059,030.43	$2,079,004.18	$2,093,235.75	$2,123,282.06

Table 10: Total cost overall results 15% cost of capital

Total Cost 15% Cost of Capital							
Product	12	18	24	30	36	40	48
A	$2,643,512.29	$2,312,723.74	$2,182,954.92	$2,132,183.10	$2,114,152.58	$2,112,318.87	$2,118,677.62
B	$3,769,341.04	$3,030,148.62	$2,698,918.41	$2,524,658.97	$2,432,506.28	$2,394,876.76	$2,347,654.72
C	$4,265,057.58	$3,341,897.00	$2,925,153.41	$2,699,693.37	$2,570,884.14	$2,516,426.56	$2,445,875.67
D	$2,118,597.34	$2,052,733.76	$2,052,088.92	$2,063,769.17	$2,084,677.68	$2,099,533.78	$2,130,831.73

Table 11: Total cost overall results 20% cost of capital

Total Cost 20% Cost of Capital							
Product	12	18	24	30	36	40	48
A	$2,649,914.63	$2,320,964.63	$2,193,148.38	$2,144,439.37	$2,128,525.91	$2,128,128.84	$2,137,368.45
B	$3,777,410.50	$3,039,658.15	$2,709,983.58	$2,537,365.74	$2,446,952.54	$2,410,514.65	$2,365,695.79
C	$4,276,997.09	$3,355,664.84	$2,940,944.55	$2,717,611.71	$2,591,054.91	$2,538,155.67	$2,470,761.12
D	$2,123,672.39	$2,059,995.54	$2,061,637.24	$2,075,616.03	$2,098,861.41	$2,115,278.86	$2,149,705.92

Table 12: Lowest total cost overall results

		Lowest Total Cost	
Product	13%	15%	20%
A	$2,105,994.89	$2,112,318.87	$2,128,128.84
B	$2,340,438.29	$2,347,654.72	$2,365,695.79
C	$2,435,921.49	$2,445,875.67	$2,470,761.12
D	$2,048,269.60	$2,052,088.92	$2,059,995.54

Table 13: Optimal case pack size results

		Optimal Case Pack Size	
Product	13%	15%	20%
A	40	40	40
B	48	48	48
C	48	48	48
D	24	24	18

Table 14: Total cost simulation results for 13% cost of capital

			Total Cost 13% Cost of Capital				
Product	**12**	**18**	**24**	**30**	**36**	**40**	**48**
A	$1,981,395.51	$1,565,118.95	$1,389,414.27	$1,302,099.73	$1,255,304.96	$1,236,015.54	$1,215,507.46
B	$3,332,879.14	$2,433,203.82	$2,015,308.70	$1,785,372.20	$1,645,023.63	$1,580,303.54	$1,492,440.66
C	$3,798,273.54	$2,729,382.28	$2,226,414.36	$1,943,792.63	$1,770,809.58	$1,689,657.76	$1,577,680.64
D	$1,307,799.50	$1,192,342.67	$1,158,111.40	$1,149,690.37	$1,151,315.70	$1,155,520.40	$1,166,696.11

Table 15: Total cost simulation results for 15% cost of capital

Total Cost 15% Cost of Capital

Product	**12**	**18**	**24**	**30**	**36**	**40**	**48**
A	$1,983,173.90	$1,567,201.38	$1,391,850.56	$1,304,921.00	$1,258,531.83	$1,239,519.39	$1,219,581.22
B	$3,335,436.88	$2,435,973.22	$2,018,332.99	$1,788,684.35	$1,648,645.87	$1,584,142.02	$1,496,728.89
C	$3,802,143.35	$2,733,508.26	$2,230,853.78	$1,948,586.09	$1,775,994.84	$1,695,116.94	$1,583,713.67
D	$1,308,978.91	$1,193,937.52	$1,160,153.92	$1,152,197.17	$1,154,295.44	$1,158,819.46	$1,170,636.70

Table 16: Total cost simulation results for 20% cost of capital

Total Cost 20% Cost of Capital

Product	12	18	24	30	36	40	48
A	$1,987,619.89	$1,572,407.46	$1,397,941.28	$1,311,974.18	$1,266,599.00	$1,248,279.00	$1,229,765.62
B	$3,341,831.22	$2,442,896.74	$2,025,893.72	$1,796,964.73	$1,657,701.46	$1,593,738.22	$1,507,449.46
C	$3,811,817.88	$2,743,823.22	$2,241,952.34	$1,960,569.76	$1,788,957.99	$1,708,764.87	$1,598,796.22
D	$1,311,927.43	$1,197,924.64	$1,165,260.22	$1,158,464.16	$1,161,744.80	$1,167,067.11	$1,180,488.18

Table 17: Total cost expanded simulation results for 13% cost of capital

Total Cost 13% Cost of Capital

Product	12	18	24	30	36	40	48
A	$2,298,503.11	$1,812,666.15	$1,606,623.07	$1,503,325.33	$1,447,100.56	$1,423,447.94	$1,397,106.66
B	$3,866,803.54	$2,818,610.22	$2,330,967.10	$2,062,361.87	$1,897,069.23	$1,820,686.74	$1,716,231.06
C	$4,407,298.34	$3,162,275.88	$2,575,749.16	$2,245,547.83	$2,042,825.58	$1,947,404.56	$1,815,047.44
D	$1,517,331.90	$1,381,235.47	$1,339,547.40	$1,327,832.37	$1,327,774.90	$1,331,352.80	$1,341,716.51

Table 18: Total cost expanded simulation results for 15% cost of capital

Total Cost 15% Cost of Capital

Product	12	18	24	30	36	40	48
A	$2,300,281.50	$1,814,748.58	$1,609,059.36	$1,506,146.60	$1,450,327.43	$1,426,951.79	$1,401,180.42
B	$3,869,361.28	$2,821,379.62	$2,333,991.39	$2,065,674.03	$1,900,691.47	$1,824,525.22	$1,720,519.29
C	$4,411,168.15	$3,166,401.86	$2,580,188.58	$2,250,341.29	$2,048,010.84	$1,952,863.74	$1,821,080.47
D	$1,518,511.31	$1,382,830.32	$1,341,589.92	$1,330,339.17	$1,330,754.64	$1,334,651.86	$1,345,657.10

Table 19: Total cost expanded simulation results for 20% cost of capital

Total Cost 20% Cost of Capital							
Product	12	18	24	30	36	40	48
A	$2,304,727.49	$1,819,954.66	$1,615,150.08	$1,513,199.78	$1,458,394.60	$1,435,711.40	$1,411,364.82
B	$3,875,755.62	$2,828,303.14	$2,341,552.12	$2,073,954.40	$1,909,747.06	$1,834,121.42	$1,731,239.86
C	$4,420,842.68	$3,176,716.82	$2,591,287.14	$2,262,324.96	$2,060,973.99	$1,966,511.67	$1,836,163.02
D	$1,521,459.83	$1,386,817.44	$1,346,696.22	$1,336,606.16	$1,338,204.00	$1,342,899.51	$1,355,508.58

Table 20: Lowest total cost simulation overall results

		Lowest Total Cost	
Product	13%	15%	20%
A	$ 1,215,507.46	$ 1,219,581.22	$ 1,229,765.62
B	$ 1,492,440.66	$ 1,496,728.89	$ 1,507,449.46
C	$ 1,577,680.64	$ 1,583,713.67	$ 1,598,796.22
D	$ 1,149,690.37	$ 1,152,197.17	$ 1,158,464.16

Table 21: Lowest total cost expanded simulation overall results

		Lowest Total Cost	
Product	13%	15%	20%
A	$1,397,106.66	$ 1,401,180.42	$1,411,364.82
B	$1,716,231.06	$ 1,720,519.29	$1,731,239.86
C	$1,815,047.44	$ 1,821,080.47	$1,836,163.02
D	$1,327,774.90	$1,330,339.17	$1,336,606.16

Table 22: Optimal case pack size simulation results

		Optimal Case Pack Size	
Product	13%	15%	20%
A	48	48	48
B	48	48	48
C	48	48	48
D	30	30	30

Table 23: Optimal case pack size expanded simulation results

		Optimal Case Pack Size	
Product	13%	15%	20%
A	48	48	48
B	48	48	48
C	48	48	48
D	36	30	30

Table 24: Total cost by SKU for product D

Total Cost by SKU for Product D

SKU	12	18	24	30	36	40	48
100001	$ 80,783.06	$ 74,667.87	$ 73,498.50	$ 73,534.37	$ 73,920.77	$ 74,353.77	$ 75,275.87
100002	$ 37,130.52	$ 37,545.05	$ 37,982.07	$ 38,419.08	$ 38,856.09	$ 39,147.44	$ 39,730.12
100003	$ 12,581.75	$ 12,697.05	$ 12,844.84	$ 12,992.63	$ 13,140.42	$ 13,238.95	$ 13,436.01
100004	$ 134,955.79	$ 102,259.05	$ 88,757.82	$ 82,635.94	$ 79,337.08	$ 78,437.23	$ 77,648.98
100005	$ 73,936.19	$ 72,137.05	$ 72,181.27	$ 72,631.46	$ 73,347.74	$ 73,821.26	$ 74,871.88
100006	$ 73,763.77	$ 72,205.32	$ 72,301.49	$ 72,835.84	$ 73,541.37	$ 74,034.79	$ 75,051.14
100007	$ 97,412.95	$ 81,994.84	$ 77,122.78	$ 75,707.57	$ 75,349.42	$ 75,518.96	$ 76,129.34
100008	$ 70,372.82	$ 70,814.76	$ 71,495.81	$ 72,271.85	$ 73,062.54	$ 73,594.54	$ 74,668.55
100009	$ 76,777.39	$ 73,183.76	$ 72,685.14	$ 73,091.97	$ 73,661.73	$ 74,071.69	$ 75,083.24
100010	$ 80,105.87	$ 74,367.00	$ 73,296.44	$ 73,324.81	$ 73,755.93	$ 74,195.59	$ 75,101.97
100011	$ 119,520.34	$ 93,756.43	$ 83,941.65	$ 79,285.59	$ 77,665.09	$ 77,287.85	$ 76,964.07
100012	$ 83,781.69	$ 75,853.63	$ 73,800.31	$ 73,645.62	$ 74,022.82	$ 74,361.67	$ 75,297.28
100013	$ 80,355.75	$ 74,822.09	$ 73,590.57	$ 73,707.71	$ 74,151.03	$ 74,540.94	$ 75,479.21
100014	$ 78,624.05	$ 74,136.93	$ 73,406.42	$ 73,456.76	$ 74,001.89	$ 74,403.85	$ 75,273.20
100015	$ 79,731.04	$ 74,480.78	$ 73,158.32	$ 73,257.55	$ 73,666.96	$ 74,042.70	$ 74,920.04
100016	$ 17,284.60	$ 17,050.76	$ 17,106.00	$ 17,248.48	$ 17,426.37	$ 17,543.85	$ 17,794.28
100017	$ 17,526.99	$ 17,078.57	$ 17,100.88	$ 17,248.48	$ 17,410.67	$ 17,522.76	$ 17,756.82
100018	$ 17,666.92	$ 17,338.98	$ 17,433.39	$ 17,548.59	$ 17,722.04	$ 17,844.38	$ 18,093.93
100019	$ 3,193.54	$ 3,208.39	$ 3,245.74	$ 3,283.08	$ 3,320.43	$ 3,345.33	$ 3,395.12
100020	$ 3,103.58	$ 3,140.13	$ 3,176.68	$ 3,213.23	$ 3,249.78	$ 3,274.15	$ 3,322.88
100021	$ 3,171.05	$ 3,208.39	$ 3,245.74	$ 3,283.08	$ 3,320.43	$ 3,345.33	$ 3,395.12
100022	$ 67,199.27	$ 67,990.67	$ 68,782.07	$ 69,573.46	$ 70,364.85	$ 70,892.45	$ 71,947.64

Table 25: Optimal case pack size by SKU for product D

SKU	Standard Deviation	Optimal Case Pack Size
1	225.82	24
2	31.7	12
3	19.2	12
4	499	48
5	158.04	18
6	157.86	18
7	366.7	36
8	83.44	12
9	196.51	24
10	227.8	24
11	495.7	48
12	237.44	30
13	257.53	24
14	227.42	24
15	247.82	24
16	129.4	18
17	163.79	18
18	140.66	18
19	72.4	12
20	53.21	12
21	45.43	12
22	18.57	12

Table 26: Standard deviation by product

Product	Standard Deviation
A	807.04
B	2,210.94
C	2,018.69
D	291.05

Conclusion:

The optimal case pack size for the four beauty products is generally higher because of the fixed transportation cost regardless of case pack size. It costs the same amount to send a case pack with twelve beauty products as it does to send a case pack with forty eight beauty products. The vendor and store processing costs are also contributing to the higher optimal case pack size. The delivery agent, vendor, and store processing costs all decrease as case pack size increases and all have the largest effect on the total cost. The total costs for the four beauty products are also different because each product has a different level of demand.

From the results of the simulation it can be concluded that the variability of demand is also contributing to the choice of optimal case pack size. The higher the variability of demand for a given beauty product, the higher that beauty product's optimal case pack size. Table 26 shows that the variability of demand for beauty products A, B and C is the highest and therefore the optimal case pack size for these beauty products is forty eight units per case. Beauty product D has the lowest level of demand variability and therefore has the lowest optimal case pack size of thirty units per case. This is also consistent with the stock keeping units for beauty product D as shown in table 25. The stock keeping units with the lowest levels of demand have optimal case pack sizes of twelve units per case while the stock keeping units with the highest levels of demand have optimal case pack sizes of forty eight units per case. With a higher variability of demand, more safety stock would be needed and therefore the optimal case pack size is higher.

In conclusion, the retailer should increase their current case pack size of thirty six units per case for beauty products B and D to the optimal case pack size of forty eight units per case. The current case pack size of twenty four units per case for beauty product A should also be increased to 48 units per case. The current case pack size of twenty four units per case for beauty product D should be increased to thirty units per case. Using the optimal case pack size has significant cost savings and is a beneficial alignment of supply and demand.

Limitations and Future Research:

The conclusions that were reached are limited to the assumptions that were used in the simulation. The conclusions are limited because annual demand data from 2009 was used and demand was assumed to be the same every week. Another limitation on the results is the assumption of the $0.40 per case store processing cost. More research and data on weekly demand would be needed to provide a more accurate conclusion. The optimal case pack size was also determined solely based on the lowest total cost and does not consider the impact on the weeks of supply.

More research could be conducted to determine why the optimal case pack size for beauty product D varies for different costs of capital. Future research could also include varying the transportation cost for the different case pack sizes. Future research could also be done on shipping less than full case.

Bibliography

Banker, Steve. "The Importance of Packaging in Supply Chain Management." *Logistics Viewpoints*. 21 June 2010. Web. 1 Dec. 2010.
< http://logisticsviewpoints.com/2010/06/21/the-importance-of-packaging-in-supply-chain-management/>

Berger, Brad. "PartyLite Gifts Encounters Incredible Shrinking Carton." *Global Logistics & Supply Chain Strategies*. 27 Feb. 2009. Web. 1 Dec. 2010.
< http://www.supplychainbrain.com/content/research-analysis/supply-chain-innovation-awards/single-article-page/article/partylite-gifts-encounters-incredible-shrinking-carton-1/>

Corsten, Daniel and Thomas W. Gruen. "A Comprehensive Guide to Retail Out of Stock Reduction in the Fast Moving Consumer Goods Industry." University of Colorado at Colorado Springs. 2007. Web. 1 Dec. 2010.
< http://www.rw3.com/ufiles/file/Article5.pdf>

Crowell, Jim, Dan Lynch and Terry Tremwel. "Phoenician Phoods, Breakfast Cereal Manufacturer and Distributor". University of Arkansas. Web. 1 Dec. 2010.
< http://cscmp.org/downloads/public/academics/scmec/Paper7.pdf>

Smorch, Pat. "Optimization and Sustainability- A Winning Combination." *Global Cosmetics Industry*. New York: Mar 2010. Vol. 178, Iss. 3; pg. 56

Wen, Naijun. "Optimization of Ship-Pack in a Two-Echelon Distribution System." MS thesis. Massachusetts Institute of Technology, 2010. Web. 11 April. 2011. < http://dspace.mit.edu/bitstream/handle/1721.1/61903/706826069.pdf?sequence=1>

APPENDIX A: Example of case pack model spreadsheet

SKU	Style		Store	Net Sales U	Transportation Zone	DA Cost/Case	Weekly Demand U
1000016	2000003	Beauty Product A	1	67	1	$1.27	1.288461538
1000016	2000003	Beauty Product A	2	67	2	$1.59	1.288461538
1000016	2000003	Beauty Product A	3	67	3	$1.69	1.288461538
1000016	2000003	Beauty Product A	4	67	4	$1.74	1.288461538
1000016	2000003	Beauty Product A	5	67	5	$1.77	1.288461538
1000016	2000003	Beauty Product A	6	67	6	$2.16	1.288461538
1000016	2000003	Beauty Product A	7	67	7	$2.16	1.288461538
1000016	2000003	Beauty Product A	8	67	8	$1.67	1.288461538
1000016	2000003	Beauty Product A	9	67	9	$1.53	1.288461538
1000016	2000003	Beauty Product A	10	67	10	$2.16	1.288461538
1000016	2000003	Beauty Product A	11	68	11	$1.69	1.307692308
1000016	2000003	Beauty Product A	12	68	12	$1.78	1.307692308
1000016	2000003	Beauty Product A	13	68	13	$1.43	1.307692308
1000016	2000003	Beauty Product A	14	68	14	$1.36	1.307692308
1000016	2000003	Beauty Product A	15	68	15	$1.64	1.307692308
1000016	2000003	Beauty Product A	16	68	16	$1.68	1.307692308
1000016	2000003	Beauty Product A	17	68	17	$1.68	1.307692308
1000016	2000003	Beauty Product A	18	68	18	$1.82	1.307692308
1000016	2000003	Beauty Product A	19	68	19	$3.72	1.307692308
1000016	2000003	Beauty Product A	20	68	20	$1.91	1.307692308
1000016	2000003	Beauty Product A	21	68	21	$1.04	1.307692308
1000016	2000003	Beauty Product A	22	68	22	$1.43	1.307692308
1000016	2000003	Beauty Product A	23	68	23	$1.69	1.307692308
1000016	2000003	Beauty Product A	24	68	24	$2.11	1.307692308

APPENDIX B: Example of simulation spreadsheet

SKU	Store	Net Sales U	Transportation Zone	DA Cost/Case	Weekly Demand U	# Cases	# Cases 12	Excess Units
1000018	3	726	2	$ 1.83	13.9615385	1.1634615	2	10.0384615
				$ 1.83	3.9230769	0.3269231	1	8.0769231
				$ 1.83	5.8846154	0.4903846	1	6.1153846
				$ 1.83	7.8461538	0.6538462	1	4.1538462
				$ 1.83	9.8076923	0.8173077	1	2.1923077
				$ 1.83	11.7692308	0.9807692	1	0.2307692
				$ 1.83	13.7307692	1.1442308	2	10.2692308
				$ 1.83	3.6923077	0.3076923	1	8.3076923
				$ 1.83	5.6538462	0.4711538	1	6.3461538
				$ 1.83	7.6153846	0.6346154	1	4.3846154
				$ 1.83	9.5769231	0.7980769	1	2.4230769
				$ 1.83	11.5384615	0.9615385	1	0.4615385
				$ 1.83	13.5000000	1.1250000	2	10.5000000
				$ 1.83	3.4615385	0.2884615	1	8.5384615
				$ 1.83	5.4230769	0.4519231	1	6.5769231
				$ 1.83	7.3846154	0.6153846	1	4.6153846
				$ 1.83	9.3461538	0.7788462	1	2.6538462
				$ 1.83	11.3076923	0.9423077	1	0.6923077
				$ 1.83	13.2692308	1.1057692	2	10.7307692
				$ 1.83	3.2307692	0.2692308	1	8.7692308
				$ 1.83	5.1923077	0.4326923	1	6.8076923
				$ 1.83	7.1538462	0.5961538	1	4.8461538
				$ 1.83	9.1153846	0.7596154	1	2.8846154

APPENDIX C: Formulas

 # cases needed to meet weekly demand = (demand/52)/(case pack size)

-case pack size = 12, 18, 24, 30, 36, 40, 48

Delivery agent cost = (cost per case) x (# cases needed to meet weekly demand)

-cost per case given in table 3

Corrugate cost = (cost per case) x (# cases needed to meet weekly demand)

-cost per case given in table 4

Inventory holding cost = (#of units x .5 x value) x (cost of capital/52)

- # of units = (# cases needed to meet weekly demand x case pack size)

-cost of capital = 13%, 15%, 20%

value:

Product A = $0.97

Product B = $0.83

Product C = $1.10

Product D = $0.98

Vendor processing cost = ($0.61) x (# cases needed to meet weekly demand)

Store processing cost = ($0.40) x (# cases needed to meet weekly demand)

Total annual cost case pack model = (delivery agent cost + corrugate cost + inventory holding cost + vendor processing cost) x 52

-all costs are on a weekly basis

Total annual cost simulation = (delivery agent cost + corrugate cost + inventory holding cost + vendor processing cost)

-all costs are on an annual basis

Total annual cost expanded simulation = (delivery agent cost + corrugate cost + inventory holding cost + vendor processing cost + store processing cost)

-all costs are on an annual basis

Academic Vita of Alexa L. Swahn

EDUCATION:

The Pennsylvania State University — University Park, PA
Smeal College of Business, Schreyer Honors College — Class of August 2011
Bachelor of Science in Finance with Honors in Supply Chain and Information Systems
Minors in Statistics and International Business
Thesis Title: Benefits of Aligning Supply and Demand: Case Pack Optimization
Thesis Supervisor: Robert A. Novack

Education Abroad Program — Florence, Italy
Supply Chain and Manufacturing Management — May- July 2011

Georgia Institute of Technology
Logistics Management Certificate — August 2010

HONORS:

- Dean's List- all semesters
- Sam Wherry Honors Scholarship — January 2010 – Present

EXPERIENCE:

Raytheon Integrated Defense Systems — Andover, MA
Supply Chain Intern — May - Aug. 2010
- Led recycle/reuse initiatives for logistics green team and implemented sustainable packaging products with 3 year cost savings of $7,200
- Received Raytheon Six Sigma Specialist Certification for specialist project with 3 year cost savings of $275,578
- Assisted with daily inventory warehouse operations and analyzed root causes of inventory discrepancies using WaveTrak Warehouse Inventory Management System
- Helped run fundraiser for Blue Star Mothers which assisted in the purchase of electronics that aid in veteran rehabilitation and mobility

Raytheon Intelligence and Information Systems — Falls Church, VA
Finance Intern — June - Aug. 2009
- Prepared weekly cost tracking reports for management use
- Transferred 20 cost tracking reports to new excel version with macro
- Helped prepare engineering headcount report to forecast demand and increased efficiency in preparation

Vista Preparatory School — Andover, MA
Math Tutor — June - Aug. 2008
- Tutored high school students in algebra

ACTIVITIES:

Ski Club — University Park, PA
Member, Dance Marathon Committee — Sep. 2007- Sep. 2009
- Collaborated with a startup THON group of 8 to raise $16,000 through various fundraising efforts to support pediatric cancer and the Four Diamonds Fund

Cross Country Club — University Park, PA
Team Member — Aug. 2008 – Aug. 2010

SKILLS:

- Proficient in SAS, Minitab, Microsoft Word, PowerPoint, Excel, Access and Publisher