EVALUATING AN OCEAN SHIPMENT STRATEGY WITHIN DELL'S DIRECT MODEL SUPPLY CHAIN

By

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Submitted to the MIT Sloan School of Management and the Department of Mechanical Engineering in Partial Fulfillment of the Requirements for the Degrees of

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AND
Master of Science in Mechanical Engineering

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1.0 Abstract

In 2007, Dell made the decision to make another attempt at selling computers through the retail channel in an effort to stimulate growth. Dell has been extremely successful in the direct channel and they are now trying to adapt their capabilities and their supply chain so they can meet the challenges and requirements of the new distribution channel. Retailers require large orders on specific dates, they want multiple configurations available to them, they want the most competitive prices, and they want to delay purchase commitments as long as possible.

Before 2007, Dell had been manufacturing their notebooks in Dell-owned facilities in Asia. They would then fly the notebooks to the Dell merge center in Nashville, TN before shipping them to the retailer distribution centers. Dell has now begun outsourcing much of the notebook manufacturing to manufacturing partners, or contract manufacturers, in Asia and is continuing to look for other ways to cut costs. One opportunity for significant savings is to switch the method of product transportation from air shipment to ocean shipment. There are a number of issues associated with this option so the change needs to be done correctly or all of the savings could be lost due to other costs such as expedites, excess and obsolescent inventory, and retailer penalties. The difference in lead-time between air and ocean shipment is significant.

To evaluate the positive and negative effects of an ocean shipment strategy at Dell I explored two specific cases. The first case analyzed involved notebook orders to Dell's largest customer in the retail channel. The main concern regarding ocean shipment in the retail channel is the risk of order cancellation while the finished product is on the water. Therefore, the approach I used was to determine a break-even point and what the cancellation risk would have to be for the costs and benefits to cancel each other out. The second case analyzed involved orders to one of Dell's largest commercial customers. This customer was selected because they typically order a standard configuration and because a finished goods inventory is already maintained by a third party to fulfill their orders. This case allowed me to determine how much additional inventory would have to be maintained due to the increase in lead time. These two scenarios cover a variety of products and channel issues, and have applicable lessons to other customers.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

* Note: Data contained in the figures and tables has been changed from actual data and are meant only to convey approximate trends and to show how data was used in the analysis

2.0 Introduction to Ocean Versus Air

By 2007, most of Dell notebooks were being built in Asia, where manufacturing was cost-competitive, and then shipped to the end customers around the world. Traditionally, the method of shipment has been airfreight because of the extremely short transportation lead-times. These short lead-times enabled Dell to build overseas but maintain the direct model supply chain. As fuel prices continue to increase, the cost difference between ocean and air shipment has grown. The significant increase in transportation cost has Dell and other companies rethinking their use of ocean shipment to send finished goods from Asia.

Although the transportation cost difference makes ocean shipment significantly cheaper than air shipment, there are a number of other factors to consider. The increased transportation lead-time also increases pipeline inventory costs and reduces commodity price declines for Dell. The increased lead-time also results in an increased risk of order cancellation or changes and may therefore increase Dell's excess and obsolescence (E&O) costs.

Companies that have been successful in utilizing an ocean shipment strategy have also had a different supply chain structure. Companies like HP handle the longer lead-times by building to a forecast, maintaining a finished goods inventory, having a large distribution network, and by offering very little customization. In this thesis, I will evaluate the overall savings to Dell and feasibility of implementation of an ocean shipment strategy.

3.0 Dell Overview

3.1 Organizational Assessment (Three Lens Analysis)

In 2007, Dell made the decision to make another attempt at selling computers through the retail channel in an effort to stimulate growth. Dell has been extremely successful in the direct channel and they are now trying to adapt their capabilities and their supply chain so they can meet the challenges and requirements of the new distribution channel. Retailers require large orders on specific dates, they want multiple configurations available to them, and they want the most competitive prices.

Prior to 2007, Dell had been manufacturing their own notebooks in Asia and then flying them to the Dell merge center in Nashville, TN before shipping them to the retailer distribution centers. They have now begun outsourcing much of the notebook manufacturing to manufacturing partners in Asia and are continuing to look for other ways to cut costs. One opportunity for significant savings is to switch the method of product transportation from air shipment to ocean shipment. There are a number of issues associated with this option so the change needs to be done correctly or all of the savings could be lost due to other costs such as expedites, excess and obsolescence, and retailer penalties. The difference in lead-time between air and ocean shipments is significant. It may be necessary for the notebooks to be built based on a forecast rather than a purchase order, which is currently the standard. Dell does not maintain a finished goods inventory and is reviewing the effect different strategies have on inventory levels throughout the supply chain.

There are a number of possible approaches to this problem. One approach would be to ocean ship the "risk free" portion of the forecasted demand and air ship the variability in the forecast. It is also possible to develop hybrid supply chains with various fulfillment methods based on the customer and channel needs or based on the specific product being sold (high vs. low margin, time in product lifecycle, etc.). It is also possible that these approaches will be intermediate steps that will set the company up for their next potential strategy (ocean ship all, build in region, etc.)

The ultimate goal of this project is to determine the overall effects of an ocean shipment strategy on Dell. This will include analyses to determine overall cost savings or increases, as well as inventory level changes and fit with the company.

3.1.1 Strategic Design Analysis

Over the past 20+ years Dell has become an industry leader through the execution of their direct model strategy. They traditionally produced all of their products in their own manufacturing facilities and then avoided retailers by shipping directly to the end customer. This strategy allowed them to provide the lowest cost PC with the shortest lead times and most flexibility. In response to a variety of factors to keep the company competitive, they have decided to enter the retail channel and leverage partners to manufacture some its products. The goal is to gain as much market share as fast as possible and then find a way to make it more profitable.

My project will look at the effects of this change in strategy and will focus on ways to cut costs and make it more profitable. To do this work I was placed on the Global Analytics team within Global Operations and was also temporarily assigned to the Global Retail Fulfillment Operations (GRFO) team for two weeks. The Global Analytics team is part of the governance organization, which receives data input from many of the other teams and provides oversight by reporting on a number of performance metrics. This is good placement in that I received access to a lot of data and it allows contact with multiple teams throughout the supply chain. The time spent with the GRFO team was also extremely valuable because they are the group that would be responsible for implementing any ocean shipment strategy within the retail channel.

Implementing the process and any tools developed from my project should be possible without any changes to the structure of the organization. In the past year, Dell has developed a "playbook" which describes the processes and procedures to be used by various parties within the supply chain. My findings and recommendations could easily be adapted to the playbook format and added to their standard operating procedures.

3.1.2 Cultural Analysis

Almost all of the Dell internship projects this year, not just the LFM internships, have been related to the retail channel in some way or another. To me, this indicated the company's commitment to the new strategy and their willingness to provide the necessary resources to make it a successful endeavor. None of the projects are about whether or not Dell is following the correct strategy by entering retail and using manufacturing partners. The strategy is assumed to be correct and the Dell team adapts and does what is necessary to make it work.

The way in which the company entered the retail channel and leverages manufacturing partners seems to fit the norms of the company but may not be in complete agreement with some of the values. At Dell, it seems very common to pick a direction or business strategy without detailed planning and then flex the workforce to make the strategy work. During the Executive Speaker Series someone commented that this was intentional. They said that for Dell it is better to make a quick decision and deal with problems as they arise instead of taking longer to plan and avoid those problems. It is clear that this is a norm within Dell and it gives them the competitive strength of being able to react quickly.

However, it is not clear how these two major changes fit Dell's values. The company had long been advocates of the direct model and avoided the retail channel. Dell had also been strongly against outsourcing but they are now leveraging manufacturing partners within its global manufacturing network. In 2008, there were internal rumors that the company would be moving to a 100% outsourcing model. The President of Global Operations released an internal statement that they are considering all options. The feedback posted by the employees was neutral to negative against this idea. This is unusual because all of the other blogs have feedback that is extremely positive about all company decisions.

3.1.3 Political Analysis

There was very little obvious politicking during my internship. I worked on a few cross-functional teams and everyone seemed comfortable working together. Retail is a subgroup of the larger organization so most of the people know each other and can work together to get things done. They align their goals very early on and there is minimal disagreement as the projects progress. The pace is so fast and decisions are required so quickly that there really isn't time to argue or play politics. Everyone has to work together to get the job done or it won't happen in time.

There were also a number of reorganizations while I was there. I expected that this would have been an opportunity for people to try to grab power by adding personnel and responsibilities to their organization. There was very little of this however. I was in a few meetings where they were discussing which team should own a project. The discussion seemed to genuinely be about what would be best for the company and not what would be best for them or their own teams.

Another thing that struck me when I began was the informal atmosphere. There was not much structure and you can't find an organizational chart anywhere. In my first few meetings it was very difficult to figure out who the senior people were. The main source of power at Dell is based on knowledge and capability and not on position or time at the company. They frequently talk about the company as a meritocracy. LFMs start relatively low in the organization and have to work their way up just like a new hire from any other school. It is clear that those who came to Dell ready to work and prove themselves again have been rewarded accordingly.

3.2 Summary

Until the recent changes with leveraging manufacturing partners and retail, Dell's strategy and culture were very well aligned and politics was not much of an issue. The company had been growing so rapidly that there wasn't really time to plan or think ahead. This created a culture that made the company flexible and quick to respond, which became their competitive advantage and a main part of the company's strategy. I believe that Dell is now entering a phase where it is beginning to mature as a company. Changes in the industry are forcing changes of strategy. For these strategies to be successful there will also have to be some changes in the Dell culture.

My project is structured to enable Dell's new strategies but it will not be successful unless it can be done in a way that will fit with Dell's culture. It will have to be adaptable to many situations and easy to use. At the same time it also has to support the current strategic objectives within the retail channel. If I am able to do this then politics will not play any part in the implementation or success of the project.

4.0 Project Overview

Dell is in the process of reevaluating all aspects of its supply chain to meet the changing needs of customers and to cut costs. They have recently entered the retail channel, they are leveraging partners to manufacture some of their products, and the economic downturn is presenting challenges. One option currently being investigated is the use of ocean freight instead of airfreight. This has the potential to cut logistics cost significantly but could be challenging due to the additional lead-time and due to conflicts with the current business model. The goal of my project is to research opportunities within Dell that would allow them to realize the cost savings from ocean shipment with minimal impact on the rest of the supply chain.

4.1 Dell Supply Chain Background

4.1.1 Direct Model

When Dell began in 1984 the business model was to custom build PCs and sell them directly to the end user. By not selling through a third party retailer they were able to charge their customers less but still maintain higher margins. Until recently, orders were taken by phone or through the Dell website and then the product was built at a Dell factory and shipped directly to the customer.

4.1.2 Retail Channel Experience

In 2007 Dell entered into partnerships with a number of major retailers, including Best Buy, Staples, and Wal-Mart. Dell is doing this "to reach even more commercial customers and individual customers around the world." (10K report from Q4 2008). This is not their first time attempting to increase distribution by entering the retail channel however. There were earlier attempts at selling through large retail stores but they discontinued this in 1994 due to the low profit margins. Dell also sold through smaller kiosks in malls until they ramped up their new retail partnerships.

4.1.3 Commercial Business

Although most of the news about Dell relates to the consumer segment of the PC industry, most of their sales still come from corporate customers. In 2007, the majority of their sales were from the commercial business.

4.2 Problem Statement

Dell has been extremely successful using the direct model to sell PCs. They have maintained very short lead-times and have therefore been able to keep inventory levels extremely low. Due to changes within the industry there has been a shift in the company's strategy, which has led to entry into the retail channel, use of partners to manufacture some products, and now the consideration of ocean shipment of products instead of air shipment

4.3 Project Objectives

The main goals of this project and thesis are to determine:

- How shipping finished goods from Asia to the United States could affect costs and inventory levels
- Which products, customers, and channels are best suited to switch from air shipments to ocean shipments
- A repeatable process for making ocean shipment decisions

4.4 Approach

For this analysis all products and channels will be considered but the focus will be on two specific examples; orders to a large customer in the retail channel and orders to a large customer in the commercial channel. These two scenarios cover a variety of products and channel issues, and should accurately represent the ocean versus air dilemma for the entire business.

In the analysis of the retail channel I will complete a cost-benefit analysis of ocean shipping versus air shipping finished goods. This will be used to determine a "break-even point." At this point, the losses due to cancellations or changes in orders will negate the savings received due to the cheaper mode of transportation.

For the commercial customer, the supply chain is structured to include a third party, which maintains some inventory in order to meet very short lead-time requirements from the Service Level Agreement (SLA). In this case, I will estimate the change in inventory levels and cost due to the addition of an ocean ship option.

In both instances there will be a number of implementation issues that would have to be resolved. These issues and their potential solutions will also be discussed. The quantitative and qualitative results will both be used to determine a final recommendation regarding Dell's ocean shipment strategy.

5.0 Ocean Shipment Implementation Case Studies

5.1 Basic Supply Chain Structure

Notebooks for non-government customers in the United States are currently being built by a Dell-owned facility in Malaysia and also by multiple contract manufacturers in various locations in Asia. All products are built to order and it would require the approval of the President of Global Operations and the President of Global Consumer Group to approve building without a purchase order. The finished notebooks are then placed on airplanes and flown to Dell's merge center in Nashville, TN. Typically, Dell only pays for the space they use on the plane but have also chartered entire planes.

Desktops are built in multiple locations including Asia, the United States, and other parts of the world. Some desktops are partially built in Asia, ocean shipped to Los Angeles, placed on a train to Nashville, and then the last steps of construction, the customization, is completed before being sent off to the customer. Desktops will not be considered for most of this discussion because work has already been done to reduce desktop transportation costs.

5.2. Main Considerations

There are a number of factors that must be considered before making the decision of how to ship finished products from Asia to the United States. The factors that have the greatest effect on an ocean shipment strategy are cost, forecast accuracy, and lead-time. The main costs are transportation cost, inventory and holding costs, excess and obsolescence (E&O) costs, and commodity price declines. Forecast accuracy will be evaluated as it changes over time using both Dell and independent calculations. Lastly, it is important to consider lead-times for transportation, manufacturing, and commodities.

5.2.1 Costs

The main reason for considering the switch to an ocean shipment strategy is to reduce overall cost to Dell. In recent years, the rising price of oil has increased transportation cost relative to the overall cost. There is also a widening gap between the cost of placing products on the water and sending them by air. The cost of transportation is not the only cost affected by a change in shipment strategy. When switching to an ocean shipment strategy from an air shipment strategy there are a number of other costs that also change and can be significant. The longer lead-times associated with ocean shipping result in increased inventory costs, decreased commodity price declines, and an increased risk of excess and obsolescence (E&O).

Note: All costs have been changed slightly from actual numbers.

5.2.1.1 Transportation Cost

Transportation costs are calculated on a frequent basis by Dell's logistics team. There can be large variations in the difference between costs of air shipping and ocean shipping depending on fluctuations in fuel prices. One of the main reasons for Dell considering ocean shipment was the significant increase in fuel prices over the past few years.

There are some minor sources of error in the cost estimates. One source of error in this estimation is that the cost is provided per box and is independent of volume shipped or specific product (i.e. type of notebook). In reality the average cost per box will change slightly based on a number of variables including the size and weight of the specific product, the product mix being shipped, and the volume (full container or partial container).

Air transportation is from Asia to Nashville, Tennessee. All ocean shipment is from Asia to Long Beach, California and then to Nashville via train or team truck.

Mode of Transportation	Cost per Notebook
Air	$20.00
Ocean-Rail	$3.00
Ocean Truck	$4.00

Table 5.1: Transportation Cost by Mode of Transportation (Not actual costs)

5.2.1.2 Pipeline Inventory Cost

Inventory cost becomes an important factor due to the significant increase in transportation lead-time, which increases length of time the finished product is owned by

Dell. This increase in inventory includes the additional pipeline inventory but ignores additional safety stock that may be required because the airfreight option is still available. The increase in inventory cost was estimated for three product cost groups (low, middle, and high end). Using an estimated cost of capital of 10% along with a known increase in lead-time it was possible to determine the approximate increase in inventory costs for each of the three price bands of products. Additional holding costs (e.g. handling costs) are ignored because they are assumed to be included in the quoted transportation costs.

Example:

C_{inv} = Cost per Unit * Cost of Capital * (Δ Lead-Time / 1 yr)

WACC = 10%

Δ Lead-Time = Ocean LT – Air LT

$\Rightarrow C_{inv} = \$1000 * 10\% * (33 \text{ days} - 5 \text{ days}) / 365 \text{ days}$

= \$7.69

5.2.1.3 Commodity Price Declines

Within each computer are a number of commodities such as memory, microprocessors, and storage, which are bought by Dell from outside suppliers. It is important to consider the prices of these commodities when evaluating an ocean shipment strategy. The prices of many commodities can drop significantly over relatively short periods of time and must be accounted for due to the increased lead-time of ocean shipping.

The prices of these commodities change frequently based on factors such as industry demand and time on the market. Although prices can go up if there is a quick change in supply, perhaps from a commodity supplier going out of business or being unavailable for other reasons, the prices typically trend down over time. It is difficult to predict when commodity prices will drop and by how much. It is possible, however, to analyze the historical changes in price from month to month and determine a reasonable estimate of how much commodity prices will decrease during a given month on average. This is not a smooth curve. For example, it would not be 2% each month, but may be 0% one month and 4% the next. This makes it difficult to determine in advance exactly what the decrease in cost would be. The slope of the decline also varies by commodity as can be seen in Figures 5.1-5.4.

At Dell the average, or expected, commodity price declines per month could be determined relatively easily. The configurations that were going to be offered to retailers in the upcoming selling season were known (Table 5.2). These parts could then be matched with parts in the supply system and their part numbers could be determined. With part numbers the historical and forecasted costs of all parts could be found. This was done for multiple configurations representing three price bands for the finished product; high end, middle end, and low end (Figure 5.5). It was then determined what an average percent price decline would be for each price group over a given amount of time. This relevant period of time would be the increase in lead-time due to ocean shipping relative to air shipping, because the commodities would be purchased that much earlier by Dell.

Example:

C_{PD} = Cost per Unit * Avg. % Decline per Year * Δ Lead-Time

⇒ C_{PD} = \$500 * 12% * (33 days – 5 days) / 365 days

= \$4.60

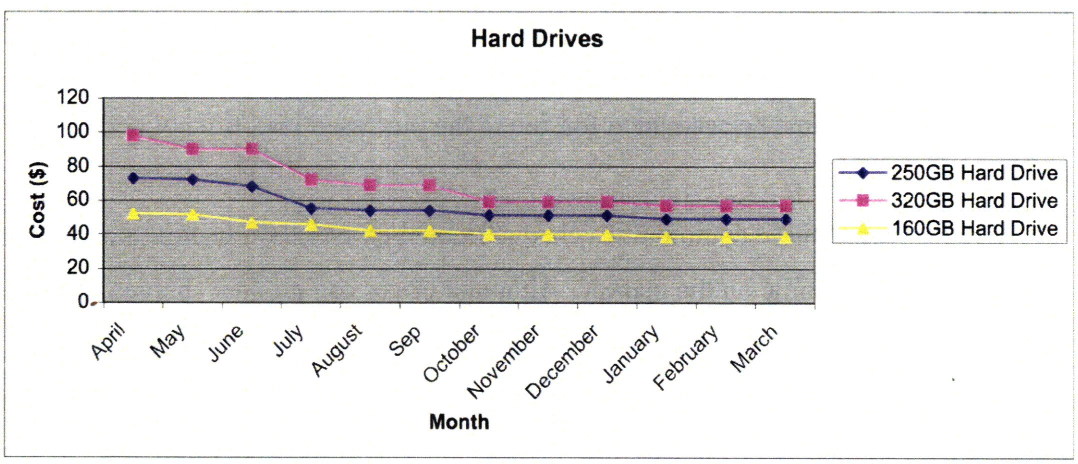

Figure 5.1: Various Hard Drive Prices Over Time (Not actual costs)

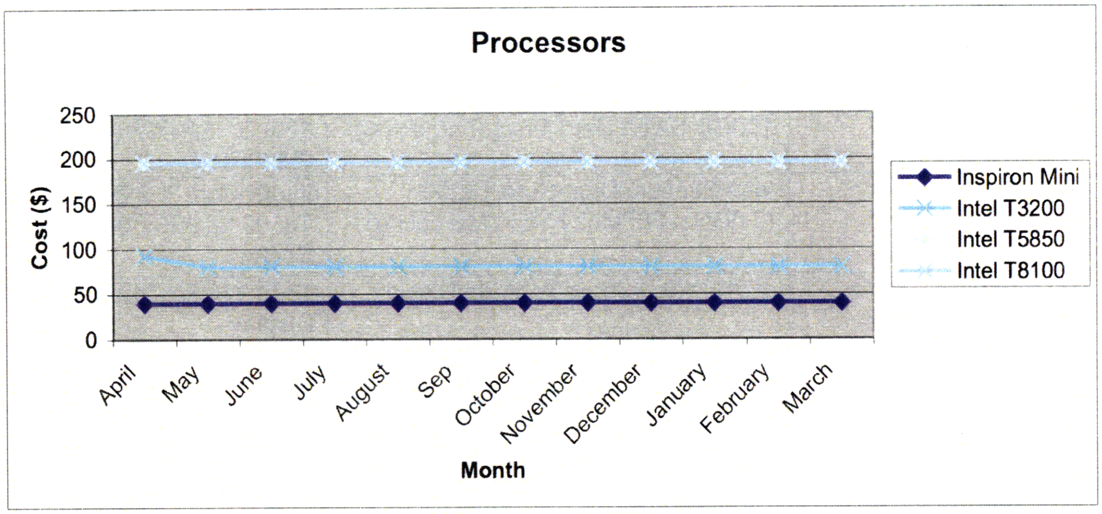

Figure 5.2: Various Processor Prices Over Time (Not actual costs)

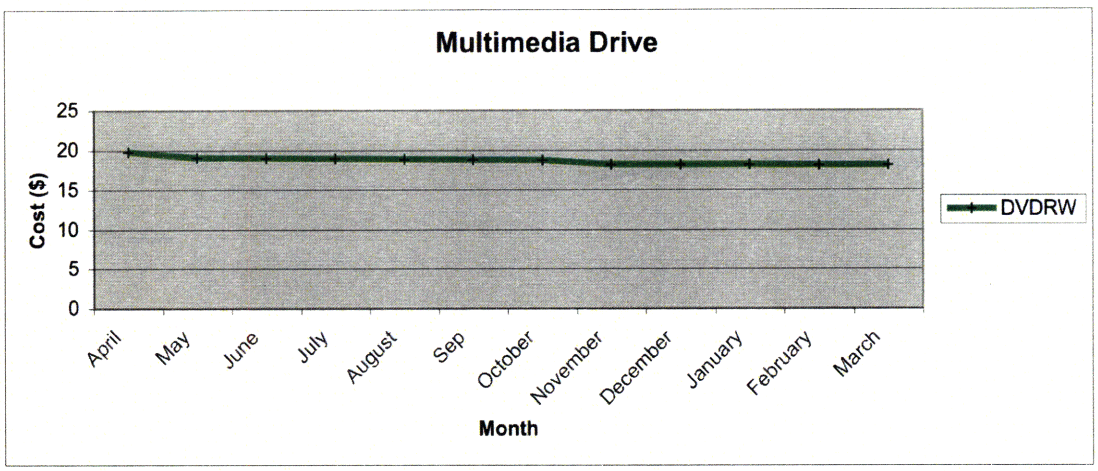

Figure 5.3: Multimedia Drive (e.g. Blu-ray or DVD) Prices Over Time (Not actual costs)

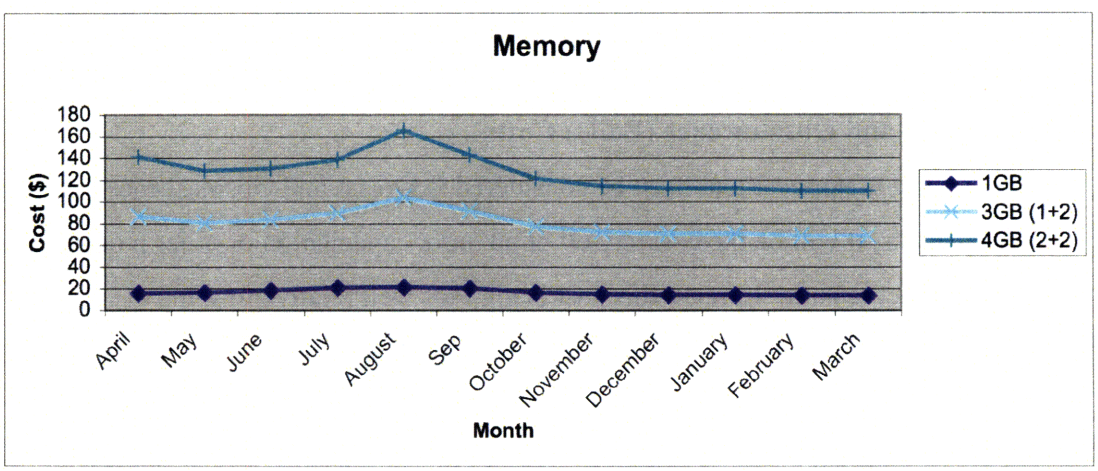

Figure 5.4: Memory Prices Over Time (Not actual costs)

Commodity	Inspiron 1525 Black	XPS M1330 product (red)
HDD	160GB SATA Hard Drive (5400RPM)	320GB* SATA Hard Drive (5400RPM)
Processor	Intel Pentium Dual-Core T3200 (2.0GHz, 667Mhz FSB, 1MB cache)	Intel® Core™ 2 Duo Processor T8100 (2.1GHz/800 FSB/ 3MB Cache)
Display	15.4" WXGA TrueLife Wide Display	13.3" WXGA TrueLife™ Wide Display
Memory	3GB Shared Dual Channel DDR2 at 667MHz	4GB* Shared Dual Channel DDR2 at 667MHz
Graphics Cards	Intel Graphics Media Accelerator X3100	128MB Nvidia
Multimedia Drive	CD / DVD writer (DVD+/-RW Drive)	CD / DVD writer (DVD+/-RW Drive)

Table 5.2: Sample Inspiron & XPS Configurations Offered

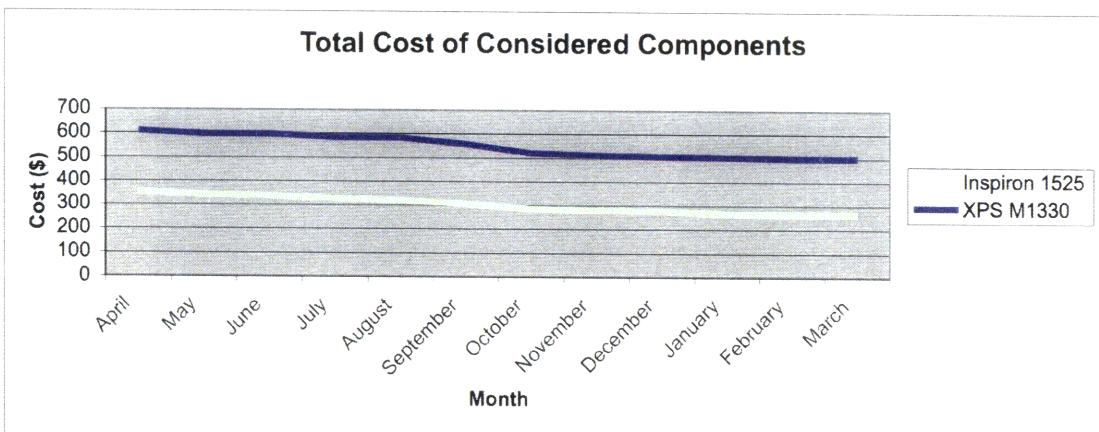

Figure 5.5: Total Commodity Price Decline for Inspiron and XPS Notebooks (Not actual costs)

5.2.1.4 Excess and Obsolescence (E&O) Costs

The last major cost that must be considered is Excess and Obsolescence (E&O). For this analysis, it will be the cost to Dell of an order cancellation or order modification after the product is built. In retail this cost is high for Dell relative to some of its competitors because products are configured and packaged to be unique to each customer. If a shipment to Best Buy is cancelled, it would have to be repackaged and possibly reconfigured before it could be sold to a third party. This has not been a problem for Dell in the past because they only built to order. Dell still builds to order for retailers but the order can be cancelled anytime before the shipment is delivered. It is estimated that any E&O could be sold to a discounter for 60-70% of the original cost.

Cost of E&O is one of the best ways to quantify the increased risk of ocean shipment. One of the main concerns with building to a forecast and/or ocean shipping is the high level of risk associated with the uncertainty. Estimating E&O costs places a dollar value on that risk and can be used to determine if the transportation cost savings justify the increased risk. There is no historical data to quantify the increase in E&O with increased lead-time but estimates can be made using historical forecast accuracy data, which will be discussed in the following section.

Example:

$C_{E\&O}$ = Original Cost per Notebook * (1 – Salvage %)

$\Rightarrow C_{E\&O}$ = \$500 * (1 – 70%)

= \$150

Note: This is the E&O cost for one notebook. If only 1 out of 100 notebooks become obsolete then the amortized E&O cost would be \$1.50 per notebook.

5.2.2 Forecasts

One of the main reasons for opposition to an ocean shipment strategy is the increased risk of changes or cancellation of orders that will raise the probability of excess and obsolescence (E&O) for Dell. With a cost-benefit analysis it is possible to determine how much change or forecast error could be afforded when ocean shipping. To completely understand that risk it is necessary to understand the accuracy of their forecasts, or advanced ordering information. If Dell is to build to a forecast for an ocean shipment strategy and there is little room for error to realize the transportation savings, then the forecast has to be much more accurate.

It is also important to see how the forecast accuracy changes over time. Ocean shipping requires products to be built about four weeks earlier than air shipping. This four-week difference can make a significant difference in the accuracy of the forecast. One way to evaluate Dell's forecast accuracy is to compare the actual sales in a given month with the master procurement plan. The master procurement plan is updated on a weekly basis and estimates the volume of expected sales in a given month. Plotting the change in accuracy over a time period equivalent to the difference in transportation lead-times might show how important an extra month can be. In some cases accuracy can improve by as much as 30% by delaying a month before building. The typical trend can be seen in the plots for XPS and Inspiron notebooks (Figure 5.6). Forecasts become even more uncertain when trying to predict at the configuration level, rather than the more aggregate family level.

Forecast Accuracy Calculation:

|Actual Sales – Forecasted Sales| / Forecasted Sales

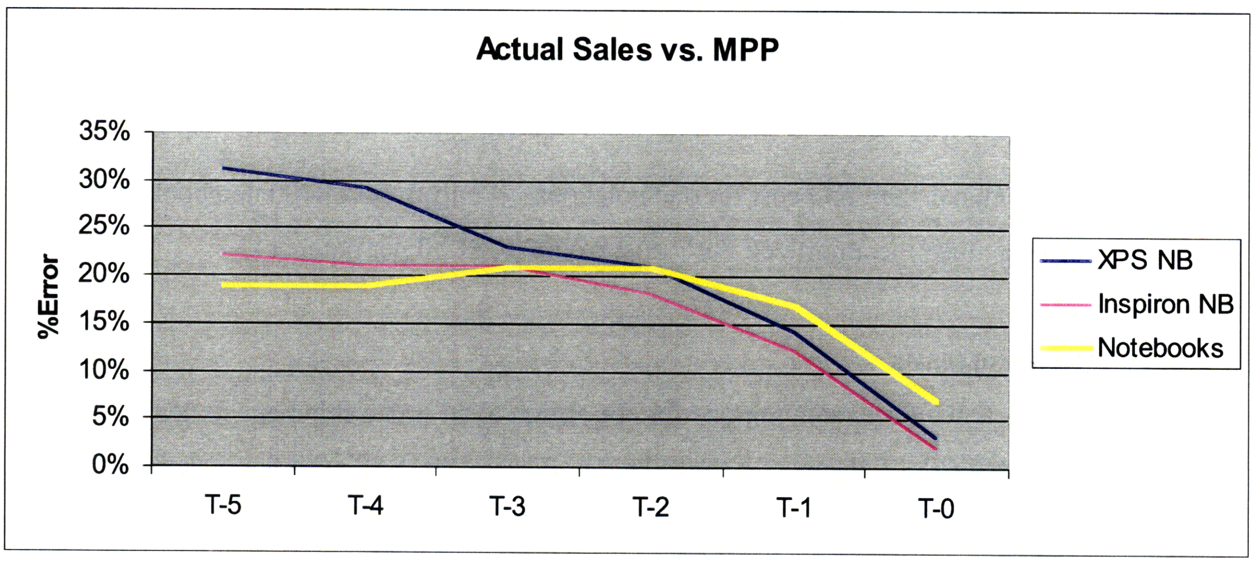

Figure 5.6: Forecast Accuracy Changes Over Time (Weeks)

In the past Dell has been able to very accurately forecast the demand for their products. This success was when they were selling mainly through the direct channel. With direct access to all the sales data they were able to model and predict sales much more easily. Also, if sales were falling short of forecast, it was very easy to modify prices to demand shape and meet their sales numbers.

For the retail channel, multiple groups within Dell are working to more precisely track historic forecast accuracy and to improve forecasts. With less than two years experience in this channel they are still developing models to forecast and track accuracy. The retail channel is also much different in terms of how much control Dell has in meeting their sales numbers. For example, now it may be Wal-Mart deciding when to run a large promotion and Dell may not find out until they get a new large order. The accuracy will continue to improve as they gather more historic data, gain closer ties with their new retail partners, and as they develop more sophisticated models.

5.2.3 Lead-times

Although the transportation cost savings are very attractive, there are also significant effects on lead-times by ocean shipping instead of air shipping. These increased lead-times need to be evaluated because of their effects on overall cost and customer service level. It is also necessary to consider lead-times when deciding whether ocean shipment is compatible with a build-to-order strategy or if a build-to-forecast strategy would be required.

Note: All lead-times have been changed slightly from actual numbers.

5.2.3.1 Transportation lead-times

The transportation times used in this analysis are estimates from the logistics group based on the average time it takes to get from point A to point B using different modes of transportation (Table 5.3). An additional buffer period will be added to the transportation time via ocean because of the decreased frequency and flexibility associated with that mode of transport. Airplanes leave multiple times everyday and can be chartered if necessary. Ships on the other hand leave less frequently, will not adjust their schedule to accommodate Dell, and it is not reasonable to charter an entire freighter.

Mode of Transportation	Lead-time (days)
Air	7
Ocean-Rail	35
Ocean Truck	28

Table 5.3: Lead-Time for Various Modes of Transportation (Not actual lead-times)

5.2.3.2 Manufacturing cycle times

Manufacturing cycle times most likely will not be affected by the transportation method but need to be considered because of their effect on overall lead-time. The change in transportation lead-time needs to be considered relative to the overall lead-time for calculations such as change in required inventory levels.

The only scenario in which the shipment strategy can increase or decrease the manufacturing cycle time is when it shifts production to a time period when capacity is limited. For example, if they had built some notebooks four weeks early for black Friday then they would not have been so close to producing at capacity right before Thanksgiving. This may have decreased manufacturing cycle time. Conversely, ocean shipping for the spring refresh selling season would have shifted production to an already busy time period. This may have increased manufacturing cycle time.

5.2.3.3 Commodity Lead-Times

Commodity lead-times are also assumed to be unaffected by the shipment strategy. Dell will just take receipt of parts a month earlier when ocean shipping the finished goods.

5.2.4 Other Cost Considerations

There are a number of other factors that could affect the overall cost comparison between ocean and air transportation but were beyond the scope of the project. For example, there is a difference in the environmental impact between the two modes. If limits or a tax were placed on carbon emission then there would be more incentive to ocean ship.

There are also additional concerns associated with ocean shipment that could lead to unexpected costs. Using ocean freight could lead to higher levels of theft in transit and more cases of damaged boxes and products. Also, if there were an accident the losses would be much greater for a ship because of the larger volumes they carry.

5.3 Customer Cases

Dell has numerous customers within their commercial business and within the new retail channel business. As a flexible company that specializes in customization, there are many differences between the ways they handle each customer. Instead of analyzing each of these customers individually, I will analyze the largest customer in each of these channels. Despite the minor differences between each customer, these two cases give a representative sample and can be used to demonstrate learning that can be applied to many of Dell's customers.

5.3.1 Case 1: Large Retail Customer

This customer was chosen because it is Dell's largest customer in the retail channel and it is one of the largest electronics retailers in the world. This customer's volume of demand is very important because products are unique to individual retail customers after they leave the factory. It is not yet possible to ship a container of notebooks from Asia to the United States and then decide to distribute them to a different customer. Therefore, if an ocean shipment strategy is at all viable within the retail channel, it would seem most likely to be able to show this with this retailer.

5.3.1.1 Retail Customer Requirements

There are a number of requirements unique to the retail channel that Dell is adapting to meet. The Dell supply chain has been designed to handle high volumes but not necessarily high volumes over very short periods of time. Retailers often buy a significant portion of their expected demand up front in what is called channel fill. They will then order lower volumes throughout the selling season to maintain inventory in stores. Occasionally they will run large promotions, sell out quickly, and need to order large quantities on short notice, or burst orders. One of Dell's competitive advantages in the market is their flexibility and ability to respond quickly to these demands. One problem, however, has been that the retailers are not paying Dell a premium for this value-added responsiveness. Margins are already reduced in this channel because the retailers have to take a cut, which makes it difficult to keep the channel profitable for Dell.

5.3.1.2 Previous Attempts to Ocean Ship

Although Dell has not ocean shipped any notebooks as of 2008, there have been attempts made to do so. One pilot program had intended to ship up to three containers per week of one notebook family to their largest retail customer. This was expected to begin in the weeks prior to the holiday selling season so Dell began negotiations with the retailer extremely early. It was determined that Dell would need the purchase order about eight weeks before the retailer could take receipt of the products. The retailer, however, only wanted to commit about two weeks before taking receipt of the order. The solution was for Dell to place the purchase order, build early, ship via ocean, and then transfer the order to the retailer when the purchase order was officially received. There would not have been any financial commitment by the retailer before they placed the purchase order, which means it would have been build-to-forecast. Due to various unrelated complications, the ocean shipment did not occur.

5.3.1.3 Cost-Benefit Analysis of Ocean Shipment

The intention of this analysis is to weigh the benefits of ocean shipping with the costs of ocean shipping. This will be used to find a break-even point. The significance of this point is that it determines what percentage of units shipped can become E&O before all of the cost savings are negated. In a sense, it quantifies how much cancellation (or forecast accuracy) risk can increase by ocean shipping before it no longer has a cost advantage over air shipping. It can also be used to determine what percentage of the demand to ship to realize some cost savings while minimizing risk. This analysis looks at the incremental costs and benefits of ocean versus air and is calculated on a per unit basis.

Costs of Ocean Shipping

- Increased pipeline inventory costs for Dell
- Increased handling costs
- Loss of savings due to commodity price declines
- Increased cost due to excess inventory

Benefit of Ocean Shipping

- Decreased transportation costs

Variables:

C_{Inv} = Inventory Cost

= Cost per Unit * Cost of Capital * (Δ Lead-Time / 1 yr)

C_{Hold} = Holding Cost (handling costs)

= 0; included in transportation cost

C_{PD} = Average Loss of Price Decline Savings

= Cost per Unit * Avg. % Decline per Year * Δ Lead-Time

C_{Trans} = Difference in cost between modes of transportation

= $\Delta\ C_{Trans,Air} - C_{Trans,Ocean}$

$C_{E\&O}$ = Cost per unit of Excess and Obsolescence

= Original Cost per Notebook * (1 – Salvage %)

$P_{E\&O}$ = Probability that a marginal unit becomes E&O

Break-even Point:

Cost of Ocean Shipping = Benefit of Ocean Shipping

$$C_{Inv} + \cancel{C_{Hold}} + C_{PD} + P_{E\&O} * C_{E\&O} = C_{Trans}$$

This equation can then be used to solve for the value for $P_{E\&O}$ (percent of units that are excess) under a number of different scenarios. One scenario looks at the effect of the product value on $P_{E\&O}$ for ocean-rail and ocean-truck shipment (Tables 5.4 & 5.5). Three different product price ranges were examined; high end (~$1000), mid-range (~$750), and low end (~$500). We found that as the product became more valuable the room for error decreased; that is, we could afford less risk of obsolescence or order cancellation. For a high end product only about 1% of units could become E&O before all cost savings from ocean shipment were lost. For low end products the percent of excess can go up to about 7%, which is still relatively low when considering the forecast accuracies.

	C_{Inv}	+ C_{PD}	$C_{E\&O}$	P(E&O)	=	C_{Trans}
Low End	$2.73	$3.46	$135.00	7.26%	=	$16.00
Middle	$4.10	$5.19	$202.50	3.31%	=	$16.00
High End	$5.47	$6.92	$270.00	1.34%	=	$16.00

Table 5.4: Ocean/Rail Break-Even Analysis

	C_{Inv}	+ C_{PD}	$C_{E\&O}$	P(E&O)	=	C_{Trans}
Low End	$3.64	$4.62	$135.00	6.47%	=	$17.00
Middle	$5.47	$6.92	$202.50	2.28%	=	$17.00
High End	$7.29	$9.23	$270.00	0.18%	=	$17.00

Table 5.5: Ocean/Truck Break-Even Analysis

This break-even analysis can then be used to determine what volume to ocean ship. For example, Dell may forecast a demand of 100,000 units. If there is a forecast error (σ) of 10,000 units then three standard deviations would be 30,000 units. If Dell, built and ocean shipped 70,000 units (μ-3σ) then there would be 0.27% risk of building more than the actual demand. This significantly reduces the risk of E&O but allows Dell to realize transportation cost savings. In this example, 70% of units could be ocean shipped instead of air shipped with minimal risk of E&O.

Another scenario considered was to evaluate how sensitive $P_{E\&O}$ is to changes in transportation cost for a lower end product (Table 5.6). Again, C_{Trans} is the difference in cost between ocean and air shipment and not the absolute cost of either. As expected, it was determined that as the transportation cost difference increases the margin for error also increases. This is important because the gap between ocean and air shipping costs is growing. If this trend continues the cost savings from ocean shipment will increase and the risk of E&O will be less significant in terms of relative cost. Therefore, ocean shipment will become more and more attractive.

	C_{Inv}	+ C_{PD}	$C_{E\&O}$	P(E&O)	=	C_{Trans}
$C_{Trans/2}$	$2.74	$0.29	$160.00	3.42%	=	$8.50
1.5*C_{Trans}	$2.74	$0.29	$160.00	14.04%	=	$25.50
2*C_{Trans}	$2.74	$0.29	$160.00	19.36%	=	$34.00

Table 5.6: Sensitivity to Transportation Costs

5.3.1.4 Potential Challenges

Although the transportation cost savings are attractive there are a few other issues to consider. First, inventory levels will go up slightly and can appear even higher to investors if Dell has a large volume of product in transit at the close of a quarter. Secondly, it would most likely be necessary to maintain some finished goods inventory due to the timing differences between shipment arrivals and customer demand. This is something Dell has avoided in the past. Lastly, there is some uncertainty about how an ocean shipment strategy will affect Dell's competitiveness.

One potential issue with an ocean strategy is the timing of individual shipments. Dell and their investors are used to having very low inventory levels on the books at the end of each quarter. If there is a large shipment on the water at the end of the quarter it could give the wrong impression to investors when they read the quarterly report. One solution to the timing issue is to educate the investors. However, it may be necessary to ensure there are no large ocean shipments in transit at the close of each quarter.

If the ocean shipped portion of the demand is built to a forecast it will also be necessary to maintain a finished goods inventory. Even if the percent of demand that is ocean shipped is low there will be some lag between the time it arrives in the United States and the time it is purchased by the retailer. At sites in Reno and Nashville, Dell is already in the process of determining how to maintain a finished goods inventory buffer for retailers. Therefore the ocean shipped portion of demand could reduce costs and serve as the inventory buffer in the retail channel.

The last thing to consider is whether a switch in shipment strategy will decrease flexibility and reduce the customer service level. Some of Dell's competitive advantages have been their flexibility, ability to customize, and quick response time. If Dell began to ocean ship everything there would definitely be a loss of competitive advantage. Dell could potentially ocean ship a large portion of demand but maintain the capability of air shipping when necessary. This would allow them to maintain their competitive advantage but realize some of the cost savings the competition is already getting.

5.3.1.5 Case I Summary

Retail customers buy from Dell because of their flexibility, short lead-times, and the configurability of products. Unfortunately, margins are thin in the retail channel and customers are not willing to pay a premium for this service. Dell must do as much as possible to reduce operating costs while still serving their customers' needs.

In this case, Dell can reduce costs by ocean shipping but would either need to build to forecast or receive purchase orders from their customers more than a month earlier. As a relatively new entrant into the retail channel it might be unrealistic to expect the early commitment from customers.

As the transportation cost difference between ocean and air grows and with forecast accuracy improving the attractiveness and feasibility of ocean shipment is going to continue to increase. If Dell is going to be successful this time they may need to make some fundamental changes to their supply chain. There are a lot of similarities between being able to ocean ship and being successful in the retail channel. Both require a lot of planning, excellent coordination, accurate forecasts, and the confidence to build before an end customer is known.

5.3.2 Case II: Large Commercial Customer

Since most of Dell's current business still comes from selling to commercial customers, it is important to evaluate the feasibility of using ocean shipment with the commercial channel. In this case, we evaluate the effects of an ocean shipment strategy on one of their largest commercial clients. This customer is potentially a good fit for an ocean shipment strategy because of their high volume of demand, the limited number of configurations required, and the existence of a finished goods inventory already used to fulfill their orders.

5.3.2.1 Customer Requirements

For this customer Dell has a service level agreement (SLA) for 6 days at a 98% service level. This means that Dell has 6 days from the time the order is placed to the time the computer is delivered to a specific worker at the customer. They should meet this commitment for at least 98% of the units ordered. Close to 95% of all orders are from three standard configurations (Table 5.7). There is a 12-day SLA for non-standard configuration. This customer orders more than 30,000 units per year of which about 70% are notebooks and 30% are desktops.

Latitude D630	93.1% of Notebooks
OptiPlex 755	95.5% of Desktops
Precision M6300	91.5% of Workstations

Table 5.7: Percent of Orders that are a Standard Configuration

5.3.2.2 Current Process

In order to meet the short lead-time requirements Dell has set up a supply chain that is different than most of their business. Instead of selling directly to the customer, Dell builds to a forecast and sells the expected demand to a third party who maintains a finished goods inventory of the three standard configurations. Dell determines the level of inventory with a goal of maintaining it at about 2-3 weeks worth of inventory. When the customer places an order the third party company ensures it arrives within the 6-day SLA. For non-standard configurations Dell uses the traditional build-to-order system, bypasses the third party, and ensures delivery within the 12-day SLA.

5.3.2.3 Analysis of the Effects of Ocean Shipment Effects on Inventory Levels

Most companies that utilize an ocean shipment strategy also build to a forecast. Most of Dell's supply chain operates as build to order, which makes it difficult to determine the actual effects on inventory. Since the supply chain for this customer already incorporates build-to-forecast it is possible to see the theoretical change in inventory levels needed as a result of switching from air shipment to ocean shipment.

For this calculation, we assume that the lead-time for all replenishments to the third party is the ocean shipping lead-time, rather than the air shipping lead-time. That is the lead-time for replenishing the third party would be 51 days, rather than the current 18 days. We do not consider the fact that air shipment would still be available as a means of expediting when the third party stocks out or is about to stock out. This means that it may not be necessary to increase inventory as much as these calculations would indicate.

What this calculation does provide is an upper limit on what the expected inventory increase would be.

Also not considered are potential reductions in inventory levels if the current system was made more efficient. After reviewing the 2008 inventory levels it is clear that levels are being maintained by the third party that are well above the goal of 2-3 weeks inventory; thus there is room for improvement in inventory management (Figure 5.7), regardless of the mode of shipping.

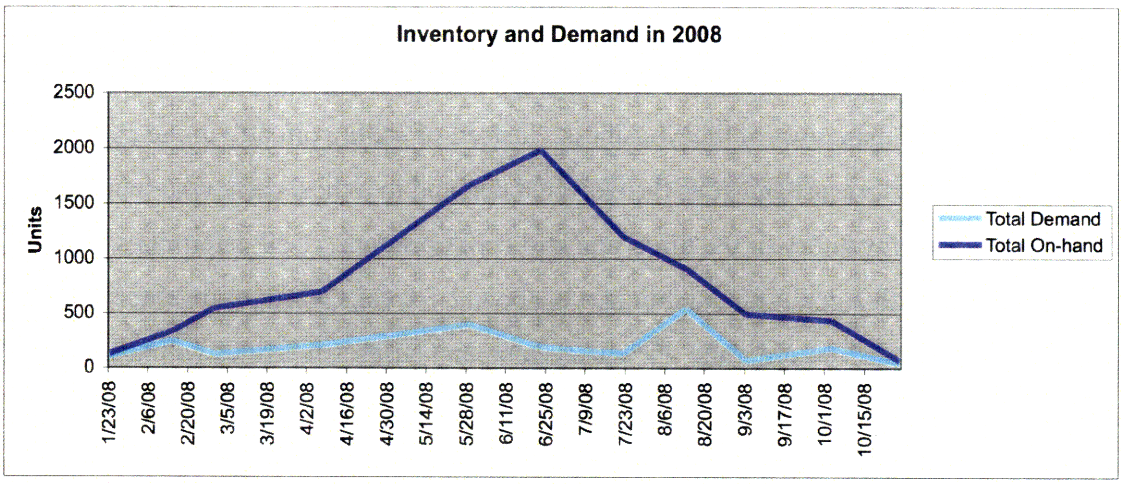

Figure 5.7: Inventory Levels and Customer Demand in 2008

Change in Inventory Level Calculation:

This calculation is done to determine the theoretical increase in required safety stock held by the third party if all replenishment orders were fulfilled using ocean shipment instead of air shipment.

Variables:

Q = order quantity

z = number of standard deviations of protection the safety stock will cover

σ = standard deviation of demand per week

μ = mean of demand per week

r = review period (days)

SS = Safety stock

L = lead-time (days)

= Transportation Time + Manufacturing Cycle Time + Order Processing Time / Buffer

$L_{air} = 5 + 8.5 + 5 = 18.5$ days

$L_{ocean} = 33 + 8.5 + 10 = 51.5$ days

r = 7 days

Inventory Level = $r\mu/2 + z\sigma\sqrt{(r + L)}$ = Cycle Stock + Safety Stock

Assumptions:

1. Review period (r) is unchanged
2. Mean of demand (μ) is unchanged
3. Service level will be kept constant, and no change in demand variability => $z_{air} = z_{ocean} = z$; $\sigma_{air} = \sigma_{ocean} = \sigma$
4. Cycle stock [$r\mu/2$] is unchanged => Δ inventory level = Δ safety stock
5. Lead-times are deterministic; there is some variability in lead-times but they are typically relatively stable

Calculations:

$$SS_{air} = z_{air}\sigma_{air}\sqrt{r + L_{air}} \tag{1}$$

$$SS_{ocean} = z_{ocean}\sigma_{ocean}\sqrt{r + L_{ocean}} \tag{2}$$

$$\frac{SS_{ocean}}{SS_{air}} = \frac{z\sigma\sqrt{r + L_{ocean}}}{z\sigma\sqrt{r + L_{air}}} = \frac{\sqrt{r + L_{ocean}}}{\sqrt{r + L_{air}}}$$

Sub. (3)

$$\frac{SS_{ocean}}{SS_{air}} = \frac{\sqrt{7 + 51.5days}}{\sqrt{7 + 18.5days}} = \frac{\sqrt{58.5}}{\sqrt{25.5}} = 1.51$$

Switching from air shipment to ocean shipment increases the overall lead-time from 18.5 days to 51.5 days. This is an increase by a factor of about 2.8 times. To maintain the same service level the safety stock would have to increase by a factor of about 1.51 times. This means that if the level of safety stock were 100 units with air shipment then the safety stock level would have to increase to 151 units and the overall inventory level would increase by 51 units. Again, this is the theoretical increase in inventory level if the transportation lead-time were changed and air expedites were unavailable. In reality, air expedites would be available and it is unlikely inventory levels would have to increase nearly this much. After air expedites are incorporated the increased costs and transportation savings would again have to be weighed to determine if ocean shipping makes sense in this case.

5.3.2.4 Potential Challenges

Implementing an ocean shipment strategy for this customer could be relatively smooth. It is an idea that people working on the account had not seriously considered but were open to. The account executive believed the third party would just have to submit their purchase orders earlier, which he did not think would be a problem. He also agreed that they would most likely not have to carry additional inventory because the air ship option would still be available if a shorter lead-time were necessary.

The one change that would be necessary is an IT issue. They currently use an automatic entry system that places an order when the customer enters it in their system. This would have to be modified so that the order could be designated for ocean or for air shipment.

5.3.2.5 Case II Summary

If this customer is representative of many commercial customers, which I believe it is, then the incorporation of an ocean shipment strategy within the commercial channel may be very feasible. The transportation cost savings far outweigh the increase in safety stock and inventory costs. Dell already utilizes built-to-forecast and a finished goods inventory (through a third party) to meet short lead-time requirements for this customer. They can use this same model for other commercial customers. Most of the companies that use ocean shipment also utilize those two capabilities. Dell may not have to increase inventory on their books if they use this case as a model for other customers and incorporate a third party supply chain solutions company.

The commercial channel may also be a good fit for an ocean shipment strategy because of the more predictable customer requirements. In this case, almost 95% of orders were from a predetermined configuration. This means they would only need to keep one configuration of notebook, desktop, and workstation in stock. Fewer configurations make it easier to forecast and will reduce the risk of overage or E&O.

6.0 Process Improvement and Model Implementation

6.1 Recommendations

The most effective implementation of an ocean shipment strategy by Dell may be through a more flexible supply chain that offers hybrid solutions based on the specific product and customer. These supply chains may include build-to-order, build-to-forecast, ocean shipment, air shipment, or various combinations of these capabilities. Within the retail channel for example, Dell may build-to-forecast, ocean ship, and maintain a finished goods inventory for the high volume, low risk portion of demand. They would then be able to build-to-order and air ship the variable or unpredictable demand. This solution would allow them to realize the significant cost savings of ocean shipment but also maintain the flexibility and speed that make them so competitive in the industry.

Within the commercial channel some customers only want one configuration throughout the year, while another might offer employees the ability to configure whatever they want. The first customer would be a good fit for ocean shipment, but the second customer may be better served by air shipment. Having a flexible supply chain with hybrid solutions tailored to individual customers would allow Dell to meet different customer needs at the lowest cost possible.

Successful implementation of a new hybrid supply chain will require a number of new capabilities. Some features and changes that may be necessary are the ability to build to a forecast, standardization of packaging and labeling, rethinking how configurations are offered, maintaining some finished goods inventory, increasing the distribution network, and improving IT capabilities.

6.2 Potential Supply Chain Capabilities

Partially Build to a Forecast:

It is not realistic to ask retail customers to submit purchase orders six weeks earlier so Dell can build-to-order and ocean ship. Dell needs to maintain the ability to configure-to-order but there may need to be paid a premium for this service. It is also not necessary to configure to order for every product and every customer. Dell can cut costs significantly by building some products based on a forecast. They could build a safe percentage of some of their higher volume and more stable configurations based on the expected demand. Dell would be able to air ship the uncertain demand with the configure-to-order side of the supply chain. This would allow Dell to realize some cost savings from build to stock while maintaining the competitive strength of build to order

Standardization:

One change that will reduce the risk associated with ocean shipment is an increase in standardization. Currently, when a notebook leaves a factory in Asia it is uniquely packaged and labeled for a specific retailer. Therefore, if the intended retail customer changes or cancels their order, the notebook will have to be sold to a discounter at a loss or repackaged and relabeled by Dell. If Dell is going to build to stock at all, they will need to standardize the packaging and labeling so a product can leave the factory and be sold through multiple channels to multiple customers without being reworked.

Configuration Offerings:

The proliferation of configurations makes it more difficult to accurately forecast the demand. Two possible solutions are to reduce the number of configurations offered or to produce below the expected demand for some of the less common configurations. Reducing the number of configurations offered by Dell would allow for risk pooling and would improve forecast accuracy. The problem with this option is that customers want that variety. Providing customers with lots of choices is one of Dell's competitive strengths. The other option is to continue producing a large variety of configurations but in lower volumes. Instead of producing to meet all of the demand Dell could discontinue production when the demand starts to taper off. When the supply of a particular configuration runs out at a retailer, the customers will just have to buy another configuration or configure to order through Dell directly.

Finished Goods Inventory:

If Dell is going to begin building any portion of demand to a forecast and ocean shipping then it will be necessary to maintain some finished goods inventory, which is being considered.

Distribution Network:

One thing that would help Dell execute an ocean shipment strategy is a large distribution network within the retail channel. They are currently partnered with only a handful of retailers. These partners are some of the largest electronics retailers in the world but having so few partners limits Dell's ability to risk pool and would require forecasts to be much more accurate. Some of Dell's competitors have an easier time building to a forecast because they have more retailers they can sell their products through. They have the ability to redirect orders to a different customer in the event of a cancellation.

IT Improvements:

A successful hybrid supply chain approach will require significant IT improvements. If Dell chooses to maintain finished goods warehouses with multiple configurations, then they will need to be able to track, match, and locate those specific configurations. Ultimately, the process could be similar to that used by Amazon. For example, a consumer could go online to configure the notebook they want and this would be cross-referenced with what is in stock. If that configuration is not in stock, the customer could be given the option of buying something similar that is in stock or paying a little extra to get the exact configuration.

The same IT improvements would make ocean shipment much more viable in the retail channel also. Assuming packaging and labeling were standardized, a sophisticated IT infrastructure could be used to match excess and obsolete inventory with new orders. That would significantly decrease the cost of E&O per unit since it wouldn't have to be sold to a discounter at a loss. From the analysis of Case I, lower E&O costs mean ocean ship becomes even more attractive.

6.3 Implementation

Supply Chain Modeling Team:

One thing that would help decision-makers evaluate various scenarios and product lines is a cross-functional supply chain modeling team. It does not seem as though there is one supply chain solution that can be applied to all customers. A modeling team would be able to evaluate the needs and requirements for each customer and develop a hybrid solution that best meets customer needs but still fits with an overall company strategy. There are currently multiple teams that utilize modeling techniques, but they are working on very specific problems. An ideal modeling team would have members from multiple functional groups, would understand the overall strategy, and be in a position to influence specific tactical decisions. This group would be able to evaluate different customers and product lines and decide on the best hybrid supply chain solution. During the transition to ocean shipment, this group could select and initiate pilot programs based on the probability of success.

6.4 Attributes for Ocean Shipping

6.4.1 Time in Product Lifecycle

The best time in the product lifestyle to ocean ship seems to be Middle of Life (MOL), which accounts for about 50% of the product value. At this point the product is already launched so forecasts are more accurate. By MOL factories have also worked out most of the problems that typically cause delays during the Channel Fill phase. Any delays at the factory make it difficult to be ready in time for the earlier ocean shipment date. During MOL there is also not the high risk of order decommits that are present at End of Life (EOL). Also, if there are decommits during MOL there is still time to find an alternate distribution channel before the product depreciates.

6.4.2 Product Attributes

The main product-specific attributes that seem to effect the decision of whether or not to ocean ship are the products size, weight, and cost. As size and weight increase the difference in transportation cost between ocean and air shipment also increases. This results in ocean shipment being a more attractive option for larger and heavier product. As product price increases the effect of inventory cost and price declines increases. Therefore, higher cost items benefit more from the short lead-times associated with air shipment and are generally not as well suited with an ocean shipment strategy.

6.4.3 Customer and Channel Attributes

The decision to ocean ship or air ship is also heavily dependent on the specific customer. The volume of demand, frequency of orders, and number of desired configurations can affect the shipment strategy. Ocean shipment becomes a more attractive solution when the customer has higher volumes and fewer configurations because of the increased forecast accuracy. Higher volumes can also result in economy of scale benefits. For example, the transportation cost per unit decreases if Dell can fill an entire shipping container rather than just a partial container. If a customer orders more frequently, it may be easier to meet their requirements using air shipment since there is more flexibility in the scheduling of airplanes.

7.0 Alternatives to Explore

Ocean shipment of finished goods from Asia may be one way to reduce logistics costs but there are a number of other alternatives Dell will want to explore. Some of these alternatives involve retailer pick-up at the manufacturing sites, manufacturing in-region to meet local demand, or outsourcing logistics.

7.1 Retailer Pick-up in Asia

One potential change to the traditional supply chain is an option for retailer pick-up. Under this arrangement the retailer would take receipt of the goods when they leave the factory and handle their own logistics. There are a number of potential benefits to Dell but it may be difficult to sell this idea to some retailers.

Shipping a LTL container costs a lot more than shipping a full container and it may be difficult for Dell to fill entire containers. If a retailer, such as Wal-Mart is already shipping a lot of products from Asia to the US they may be able to save money by putting all of their products in one container. Dell would have to split the cost savings with the retailer, assuming the retailer could do it for less.

This is a good alternative for Dell because they don't have the inventory on the books while the product is on the water. Dell also doesn't assume an increased risk of E&O despite the extended lead-time. There would be no need to build to a forecast and Dell could continue to build to order.

It may be difficult to get retailers to agree to this however. Retailers appreciate the short lead-time at a low cost. The retailer would be taking receipt earlier but they would either have to wait longer to get the product onto the shelves or they would have to pay to air ship.

7.2 In-Region Manufacturing

As transportation costs increase one option that may get more attention is in-region manufacturing. Under this scenario Dell would have factories in each of the major markets and those factories would be responsible for producing to meet the demand of that region. This would significantly reduce lead-times and minimize the effects of changing transportation costs. If Dell cannot make ocean shipment work then the only option will be to continue air shipping. If airfreight continues to get more expensive and other companies build in-region, or build to a forecast and then ocean ship, then Dell may not be able to keep their costs as low as the competition.

7.3 Outsourcing Logistics

Another option is to outsource logistics to a company that specializes in that area. A company like Amazon or UPS might be able to ship Dell's products more efficiently and at a lower cost. Dell's recent move to leverage partners to build some of its products might make this option less likely. With some third-party manufacturing and logistics Dell could potentially never take ownership of the product they are selling.

7.4 Future LFM Projects at Dell

Original Design Manufacturing (ODM) versus Dell Manufacturing:

An LFM project could compare the costs and benefits of Dell manufacturing with the use of manufacturing partners and could also look at the effects of this transition on Dell's supply chain and their competitiveness. This project could evaluate how to smoothly shift capacity and also determine the optimal balance between Dell-owned manufacturing and manufacturing partners.

Operations & Supply Chain Metrics:

The Global Analytics team is responsible for collecting data from various organizations and reporting on performance of the supply chain. They are continuously evaluating which metrics to use and how to use those to improve the supply chain. An LFM intern could develop new metrics to measure the performance of the retail channel and new ODM partners.

Forecasting for Retail:

Forecast models within the retail channel are still being developed. An LFM intern could analyze the historic forecast accuracy within the retail channel and work to develop a more robust forecasting model. Most of the current work is being done from a sales and marketing perspective. This project could focus on making the model more useful for the procurement and fulfillment teams.

8.0 Conclusion

The cost savings from ocean shipping finished goods cannot be ignored. Many of Dell's competitors have been very successful in outsourcing manufacturing and ocean shipping large orders to the United States. These companies have a much different supply chain strategy though. Dell is a company that prides itself on the direct model. They build to order, have short lead-times, and maintain little to no inventory. Incorporating the long lead-times associated with ocean shipping makes this approach difficult, if not impossible. There has been talk about negotiating with large retailers for earlier commitments. This would still be build to order but they would be able to ocean ship the finished goods. Companies that have been successful ocean shipping hold higher finished goods inventory levels, build to a forecast, and have more distribution options within the retail channel.

I believe Dell can maintain most aspects of their traditional supply chain but also realize cost savings from ocean shipping. This will require a hybrid approach and some changes to their current supply chain structure. Within the retail channel it is going to be necessary to partially build to a forecast and to maintain some level of finished goods. By "partially" build to a forecast I mean they can determine the forecasted demand for a given selling season and retailer and then build the low risk portion of that demand (e.g. 2 standard deviations below the demand). These orders would then be ocean shipped to Dell facilities in the U.S. with the expectation of being maintained in inventory for a very short period. The variation in demand, or balance between what was built to forecast and the actual demand, can be built to order and flown to the U.S. As forecasts and relationships with retailers improve air shipments should become less frequent and will become a method of expediting rather than the normal method of transportation.

Within the commercial channel ocean shipping will have to be handled on a case-by-case basis. Large customers that require a few standard configurations are best suited for this model. Dell's flexibility and ability to offer different configurations in low volumes to some of the smaller customers must be maintained. For those smaller customers they can have the option of buying one of the standard configurations at a lower cost or customizing to their needs for a small premium. If cost is key to a customer, Dell should not be charging them extra for the option to customize if they are not willing to pay for that capability.

In each of these cases efforts need to be made to standardize their products in such a way that they can be sold through multiple channels and different customers after they are built and packaged. If a product is built and packaged in such a way that it can only be sold to one specific customer, then Dell is placing itself at a much higher risk. If a product can be diverted to a different customer while it is on the ocean, then Dell not only assumes less risk but gains flexibility.

Dell has the opportunity to save a great deal on logistics costs by incorporating ocean shipment into their supply chain. Implementation of this shipment strategy may require some changes in Dell's business model however. The degree to which they decide to implement ocean shipment will determine how significant those changes will need to be.

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