Evaluating Demand Planning Strategy in the Retail Channel

by
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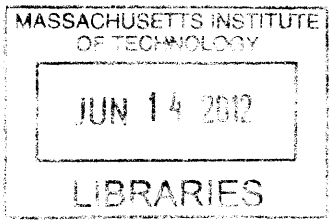

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Abstract

In 2007 Dell began selling through the retail channel. Five years later, the retail channel is still in the early stages relative to competitors and is growing rapidly. Short product lifecycles, long lead times and a high mix of configurations create a complex supply chain. Dell had decided to introduce a Build to Plan fulfillment strategy.

Dell has been known for its direct consumer strategy and the retail channel adds an additional stage in the supply chain between Dell and the end consumer. This change impacts the visibility of true demand, resulting in the bullwhip effect. Better collaborative processes such as S&OP and CPFR can improve the channel forecast accuracy, inventory levels, on time delivery, and sales revenue.

The personal computer industry has become commoditized; promotions and price have a high impact on the end consumer's purchase decision. Long lead times and high price fluctuation increase uncertainty. Forecasting at a SKU level is challenging and inaccurate. An aggregated approach can reduce the variability and postpone the customization. Forecast accuracy is a key metric that can be used to improve the supply chain. To improve that metric, the appropriate forecast must be tracked and compared to the actual sales.

A significant portion of any new planning process will need to account for updated software tools. These tools can help Dell's demand planners facilitate weekly conversations with retailers and ensure more accurate tracking of appropriate demand signals for forecasting.

The current product portfolio that allows high flexibility to retailers does not fit the low margins of the product. Demand segmentation can identify which SKU have high volatility and offer a different supply chain strategy for those with low volumes, or spotlight high costs in offering those SKU.

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1. Introduction

Dell had been best in class for many years selling personal computers directly to customers. In 2007, Dell experienced challenges to its direct model and decided to transform its strategy, which included entry into the retail channel. The entry was rapid and aggressive so there was little time to refine processes to fit the channel's complexities. The retail channel processes have been developing while the Channel as grown to over 60% of the consumer business.

This thesis explores the current lifecycle planning processes within Dell's retail channel to evaluate causes of forecast challenges. Best Practice processes like S&OP (Sales and Operations Planning) and CPFR (Collaborative, Planning, Forecasting and Replenishment) are evaluated and benchmarked to Dell's current state. This study analyzes Dell's historic sales patterns and demand signals to understand the sources of variability that are being experienced in the supply chain and the granular level at which forecasting is feasible due to the market challenges. It discusses the tradeoffs and complexities of selling a wide range of configurations and allowing the retailer's high flexibility to modify orders.

1.1. Problem Overview

This thesis explores whether Dell's operations strategy aligns with the retail consumer strategy in products, processes, and prices, or whether further transformation is required.

The retail channel exposes new challenges as planning occurs further in advance and requires collaboration internally and externally. The retail channel adds another layer between the manufacturer and the end consumer. This additional step increases the bullwhip effect and causes high variations upstream in the supply chain. Price fluctuations, long lead times, multiple forecasts and limited information sharing are observed at Dell's retail channel as possible causes for the bullwhip effect. The channel is incentivized by "sales in", the amount sold to the retailers, and not the actual demand. This leads to order batching, inflated orders and an excess of discount sales and other promotional measures. Further collaboration internally and externally is required to reduce uncertainty in the channel. S&OP and CPFR are processes that address collaboration across the channel and provide the framework for better communication and information sharing, driving an agreed one number forecast.

As Dell grew, demand planning involved more stakeholders, thus increasing the complexities of the process. (Different functions provide different forecasts, on a different granular level with different

time horizons. Forecasts are not tracked, measured or compared to one another in a systematic way, causing multiple forecasts to be sent to the supply chain. Promotions are planned later in the planning phase, causing high variability in the weekly sales as well as variations in price that affect the actual demand and disrupt the predictability for a given item. This results in costs of scrap, promotions and transshipments.

Dell's retail channel allows high flexibility to the retailers to change quantities and configurations until late in the cycle. Although Dell has altered its build to order model, in reality, Dell is still offering a wide range of products to retailers. An analysis of these products shows that a high percentage of them are sold in low volumes, yet a single supply chain strategy is applied across different products. With the current product mix, a more optimal strategy would be to create product segments and develop unique strategies for each one. Given the long lead times, numerous product configurations, and consumer's reliance on price, forecasting at the SKU level leads to inaccuracies. Furthermore, demand planning processes need to focus on an aggregated level with collaboration between sales, marketing, and supply chain and later break the plan into an item-level forecast.

1.2. Chapter Outline

This thesis is organized as described below:

Chapter 2: Provides background information about the organization, including history, market landscape and the retail channel.

Chapter 3: Describes the bullwhip effect and the symptoms that were diagnosed at Dell along with best practice to reduce the effect.

Chapter 4: Introduces the Sales and Operations Planning Framework, defines the activities required for initiating the process, methods of implementations and executive engagement, forecasting within S&OP and benchmarking Dell's current S&OP to best practice.

Chapter 5: Describes the Collaborative, Planning, Forecasting and Replenishment (CPFR) framework, current CPFR at Dell and linking CPFR to S&OP

Chapter 6: Frames the current demand planning methodologies at Dell. Describes the organizational context, the current life cycle planning process, and the demand planner role in replenishment and engaging CPFR as well as portraying the challenges with the current demand planning process

Chapter 7: Explores forecasting models and their applicability to Dell's retail channel

Chapter 8: Evaluates Dell's supply chain strategy and examines the variance in products at Dell that effect demand planning

Chapter 9: Recommends a new lifecycle planning process and delineate further activities required to improve the demand planning process

Chapter 10: Summary

2. Background

2.1. Company Background

Founded in 1984, Dell Inc. has emerged as the world's leading direct-sale computer vendor. Currently, Dell Inc. designs, develops, manufactures, markets, sells, and supports a wide range of products which are customized to individual customer requirements. Products include desktop personal computers, software and peripherals, servers and networking, services, and storage. Dell's sells its products through a single Commercial business, which includes Large Enterprise, Public, Small and Medium Business, and Consumer. Headquartered in Round Rock, Texas, Dell today has annual sales of $62 Billion USD, net income of $3.5 Billion and employs over 100,000 people worldwide. Its major competitors are HP, Acer, and Apple. (Wall Street Journal 2012)
Third parties manufacture a percentage of the client products that are sold under the Dell brand. The use of contract manufacturers has been expanded and to achieve goals of customer service, cost efficiencies and faster delivery times. The Dell owned manufacturing facilities are located in Austin, Texas; Penang, Malaysia; Xiamen, China; Hortolândia, Brazil, and Chennai, India.
Dell's consumer segment reported $1.9 Billion revenue, a 4 percent decline from previous year. (10-K Annual Report 2012) Revenue weakness was largely concentrated in the United States. Dell also reported a shortage of disk drives hurt its ability to sell higher-end computers in its fiscal fourth-quarter, helping to push earnings down by nearly a fifth.

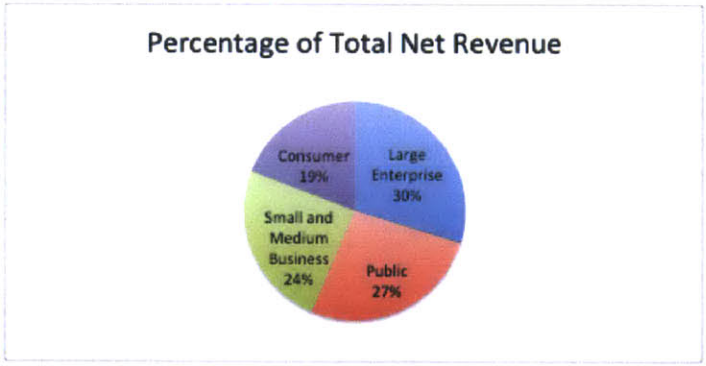

Figure 1- Dell's revenue by segment 2012 (Dell Inc 2012)

Dell Consumer segment share has been decreasing in the past few years. Due to a shift in product demand away from desktop computers along with competitive pricing and low margins, Dell has been looking to position itself as an end-to-end IT solutions provider and has been identifying areas

to expand their offerings (Segrera 2011). Dell has been focusing on an acquisition strategy on products and solutions that can be stitched together from the edge to the core to the cloud..

2.2. PC Market

In the past decade, desktops and laptops products have experienced a steady decline in prices that has led to an increase in demand for the consumer market. Worldwide mobile PC shipments to consumers are forecast to reach almost 250 million units by 2015 (Trefis Team 2011) however growth is slowing down (IDC 2011).

As consumers purchase multiple PCs the desire for specifications decrease, consumers pay less attention for hardware specifications, products are becoming a commodity and margins are smaller. (Waterman 2011). Dell's notebook prices have been decreasing in the past several years and based on analyst expectations are expected to continue to decrease (Trefis 2011)

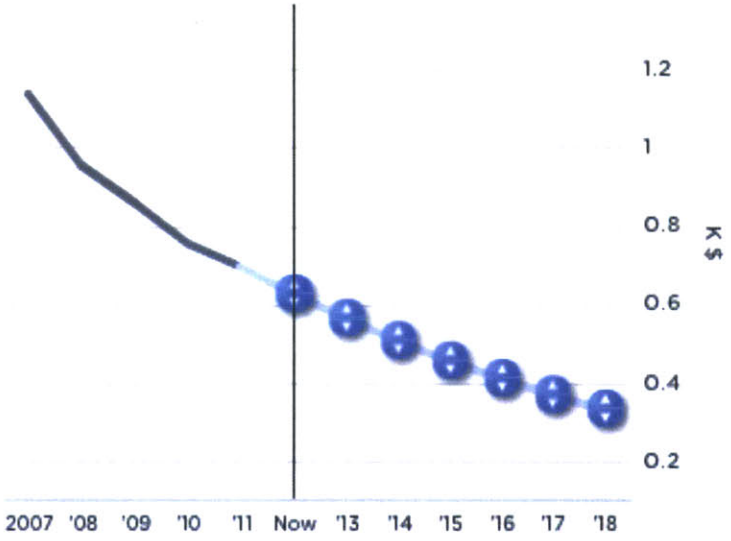

Figure 2 - Dell Notebook and Netbook Pricing (Trefis)

Brand recognition and perception have become more important for PC vendors selling to consumers, as soft factors drive demand and sales in commoditized markets, such as PCs. (Gartner 2010) As new products such as tablets, mobiles, and smart TV have entered the market, consumers are left with products that have multiple capabilities such as Internet browsing, content streaming and computing and there are predictions that by 2015 more media tablets will be sold than PC's. Dell, Notebook and Netbook Market Share declined from 17.6% in 2005 to 12.5% in 2011 (IDC 2011)

Figure 3 - Dell's worldwide PC units market share (Wall Street Journal 2012)

2.3. Retail Background

The Computer Stores industry exhibits a high level of market concentration, with the four largest players in the industry (Best Buy, Apple, Fry's and RadioShack) accounting for 81.3% of total revenue. However, while the industry remains concentrated at the top, the remainder of the industry is characterized by a large number of small players.

Retailers of computers and consumer electronics have faced some challenges over the past decade due to rapid technological change, combined with increased production efficiency. This has resulted in retail prices falling drastically over the past five years. Increased competition from online-only operators and greater vertical integration from producers like Apple have also threatened industry growth. These factors contributed to the exit of former major player Circuit City and other smaller underperforming stores. (IBIS World 2012) On March 2012, Best Buy announced it is closing fifty stores after suffering losses in the fourth quarter.

Table 1 - Retail Price of computers trend **(D. Simchi-Levi 2010)**

Price of computers and peripheral equipment

Year	Price index	(% change)
2006	116.6	-13.8
2007	100.7	-13.6
2008	89.1	-11.5
2009	78.4	-12.0
2010	73.9	-5.7
2011	65.8	-11.0
2012*	60.3	-8.4

*Estimate

SOURCE: BUREAU OF LABOR STATISTICS

Retailers are no longer waiting to be the accidental beneficiaries of adapted manufacturing supply chain processes and applications but have become the innovators in the channel with advanced IT capabilities that allow knowledge sharing, digital connected processes, better inventory replenishment and fulfillment management (Parker, et al. 2012).

Dell began selling to retailers in North America in 2007. By 2011, the Retail Channel had grown to be approximately 60% of the consumer business with three major retailers (Wal-Mart, Best Buy, Staples) accounting for 70% of the business and several hundred thousand units sold every quarter. The Retail Channel brings different challenges than Dell has experienced in its early stages such as order sizes, scheduled orders, price wars and other special requirements made by the retailers. Dell's strategy to enter the market had to be aggressive, as its competitors have been selling to the retail channel for many years. This affects Dell's relationship with the major retailers and although Dell has altered its Build to Order model, the retailers still request specialized configurations and adjusted prices to match the competitors' offerings. The retailers dictate the product's buying cycle which it is set up by 3 cycles: Spring, Holiday and Back to School.

Dell has introduced a Build to Plan fulfillment strategy for the retail channel, which will be discussed further in detail later in chapter 8.

3. The Bullwhip Effect

3.1. Definition

The purpose of the supply chain is to provide the right output at the right time. As part of our mental models, human fail to account for actions that don't have a result yet. The bullwhip effect is the failure to account for inventory in the supply line and the time it takes to receive an order thus amplifying the order variability upstream in the supply chain. (Sterman 1989) The bullwhip effect was first identified and modeled by Forester in 1961 (Forrester 1961) who introduced the amplification of order variance. (E. Smith 2010) Sterman later identified these characteristics of the bullwhip effect:

1. Oscillations – inventories decline through the supply chain causing the different stakeholders to develop backlog. In order to response, orders are made to meet demand, growing larger at each stage. To meet demand, factories start to produce more causing inventory to rise.
2. Amplifications –The amplitude and variance of orders increases steadily from customer to retailer to manufacturer.
3. Phase lag – the order rate tends to peak later as one move from the retailer to the manufacturer.

The bullwhip effect was experienced in the beer game where participants (students, managers, analysts, and so on) play the roles of customers, retailers, wholesalers, and suppliers of a popular brand of beer. The participants cannot communicate with each other and must make order decisions based only on orders from the next downstream player. The results of the game were similar in different groups. Order quantities grew as each participant placed its orders causing extreme variations in the supplier on the other end.

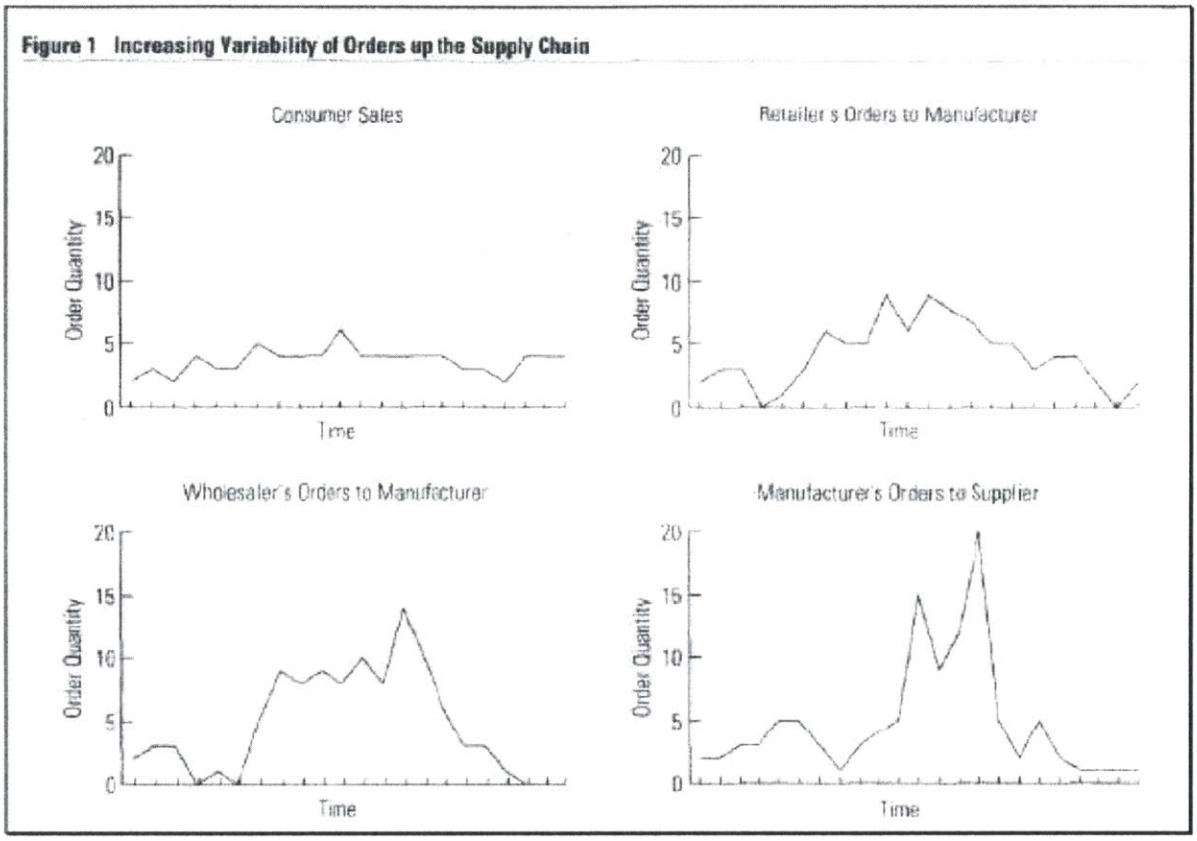

Figure 4- Example of the Increase in Order Variation Moving Up the Supply Chain (Lee, Padmanabhan and Whang 1997)

The organization that is not at the supply chain's downstream end, receives orders that are not a reflection of the true, end-customer demand. The farther up the supply chain one progresses; orders tend to vary increasingly above and below the true demand. This increased variation causes upstream organizations to either carry excessive buffer inventory or to go through extreme efforts to fill orders, or to do both. The bullwhip effect cause unstable production schedules and unnecessary costs in supply chain in inventory, transportation costs and lost orders but mainly causes instability in the supply chain (Sterman 2006)

3.2. Bullwhip Effect Causes

Lee, Padmanabhan and Whang recognized demand forecast updating, order batching, price fluctuating and shortage gaming, as the causes of the bullwhip effect (Lee, Padmanabhan and Whang 1997)

Demand Forecast Updating – As later will be discussed, forecast is usually based on past performance. Within each organization, there are many functions that use forecasting including

production scheduling, capacity planning and material requirement planning. The result of the beer game demonstrates that each player projects the demand pattern as they observe from the order's places and use individual judgment to adjust the demand signal.

Order Batching – In different supply chains different inventory policies define the order schedule. It is common that organizations accumulate inventory before placing an order so that when demand materializes, the company may not immediately place an order with its supplier but instead use its safety stock. Some companies do not order frequently, or order weekly, biweekly, or even monthly. There are associated costs such as transportation costs that determine the cycle order time. Not every stage of the supply chain may be using the same order frequency causing different safety stock in different levels.

Price Fluctuation - Manufacturers and distributors periodically have special promotions like price discounts, quantity discounts, coupons, rebates, and so on. All these promotions result in price fluctuations. Additionally, manufacturers offer trade deals (e.g., special discounts, price terms, and payment terms) to the distributors and wholesalers, which are an indirect form of price discounts. When a product's price is low, a customer will buy bigger quantities than needed and stock up for the future once forward buying becomes the norm. Therefore the customer-purchasing pattern does not reflect its consumption or true demand. The purchasing pattern will suffer from higher variations due to these promotions.

Supply chain costs may increase due to wide swings in factory utilizations. Companies often have to run their factories overtime at certain times and be idle at others. Alternatively, companies increase inventory to anticipate swings in demand. With an increase in shipments, companies may also have to pay premium freight rates to transport products or air shipment instead of ocean. Stocking for a longer period of time can cause handling costs to rise. So what has started as a price discount, ended as an increase costs for the supply chain as a whole.

Shortage Gaming –Once demand exceeds supply, manufacturers usually allocate to customers based on their initial orders. Another common human behavioral is to exaggerate on the real need so that in cases of shortage, they will have enough supply. Customers may place multiple orders and cancel later all other duplicate orders. Since it's difficult to distinguish the "gaming" from the true demand, variations in orders are signaled throughout the supply chain.

Lead-time - long lead times can cause weeks of safety stocks. The amount of safety stock contributes to the bullwhip effect, therefore long lead-time increases the effect. In addition, long lead-time can increase the time real information processes though the supply chain. For instance, if market

dynamics shift and demand is decreasing it will take time for the manufacturer to adjust to the change. Bullwhip effect solutions

Lee, et al, (Lee, Padmanabhan and Whang 1997) poses two methods to counter each of the causes of the bullwhip effect: information sharing and channel alignment. Information sharing means all stages in the supply chain work off the same demand portfolio specifically the end – customer demand and an indication of the expected variability of future demand from forecast. The initial information that is important to communicate is the POS (Point of Sale) data to keep the conversation of demand related to the end consumer demand. Organizations must avoid multiple demand forecast updates and send one signal. These days there are many Electronic Data Information (EDI) tools that can assist to real data streaming through the supply chain. Sharing sales, capacity and inventory data can also assist in reducing shortage gaming but more importantly encourage trust in the channel. Channel Alignment is a coordination of pricing, inventory planning, transportation and ownership throughout the supply chain. Upstream partners can access demand and inventory data through Vendor Managed inventory (VMI) tools and CRP (continues replenishment program) can help order batching but also assist with fluctuation prices. (Coughlin 1998)

3.3. Bullwhip Effect at Dell

This thesis focuses on the end consumer consumption pattern which will be referred to as "sales though", the retailer order pattern which will be referred as "sales in" and the replenishment signaled upstream through the supply chain called "Ladders". Further upstream, orders are aggregated with other channels such as the direct channel, public, small - medium business, and large enterprise.

A key finding for Dell's information sharing strategy is that Dell does not keep track of sales through but only "sales in". The sales through data collected in this study are taken from a 3rd party that collects retail sales data and provides Dell access to view its products' performance. Unfortunately, not all retail partners share information through the 3rd party's website and does not connect with the rest of Dell's data infrastructure. Since sales through data is not kept, "Sales in" is the key measure discussed between sales, marketing and supply chain when measuring performance, assigning the retailer as the end consumer.

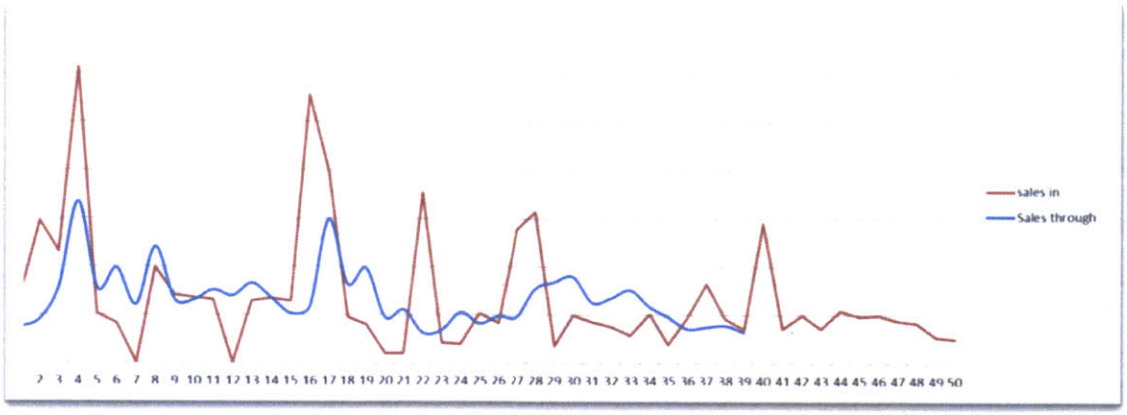

Figure 5 demonstrates the overall "sales through" pattern in comparison to "sales in" for a given line of business in a specific retailer. Dell's end consumer sales pattern is more stable than the retailer demand signal with less amplitude and less variation. The bullwhip effect is noticeable in this case.

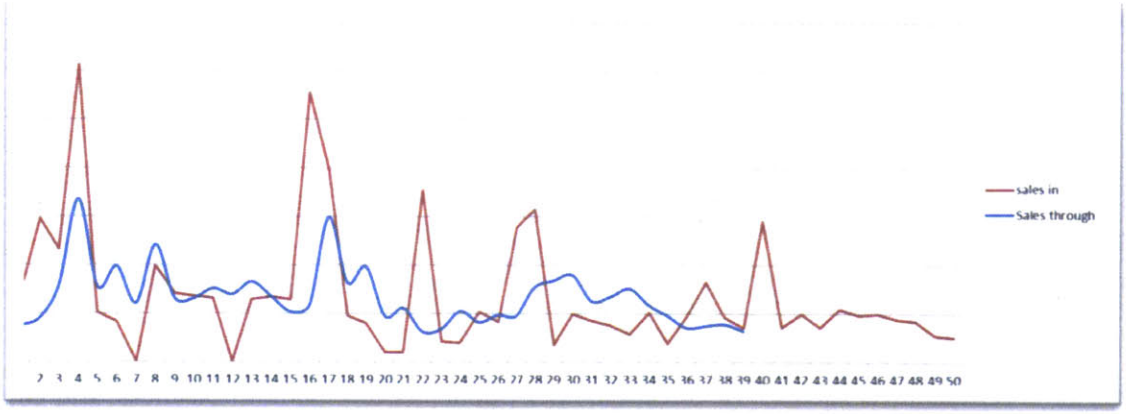

Figure 5- Dell's Bullwhip effect

Dell recognizes its revenue when products are shipped out. Therefore, sales teams are incentivized to improve "sales in" which is directly correlated to revenue. As seen in **Figure 5**, the peaks in "sales in" typically occur near the end of each quarter. These peaks cannot be simply attributed to actual demand, which shouldn't inherently correlate with Dell's financial cycle.. The discrepancy between "sales in" and "sales through" results in inventory held at the retailer. This will result later in fewer "sales in" from the retailer while they are trying to sell the inventory. Furthermore, once the retailers are at capacity with inventory, they will ask for other price discounts and promotions to help sell excess products, causing Dell further costs.

The common causes of the bullwhip effect occur at Dell as well:

Demand Forecast Updating – Chapter 8 will discuss the different functions that provide forecasts at Dell and update it periodically. The retailers change their forecasts frequently, causing different stakeholders to update demand with personal judgment. Since the discussion revolves around "sales in", the forecast is not associated with the actual "sales through". In addition, after the demand planner signals the required orders, material planners and master schedulers update the forecast based on their judgment along with information from other channels. Sales teams and retailers with limited analysis usually determine these quantities. It is common that sales expectations are not met, causing the supply chain upstream to order a lower quantity than sales have requested and causing shortages later.

Order Batching - Retailers are encouraged to make large batch orders covering the entire cycle. The majority of retailers order in advance large quantities and stock the different stores for the first few weeks. As actual sales materialize, future orders are adjusted. The result is that the upfront batched orders do not always correlate with actual demand. **Figure 6** exhibits the "Ladders" for a given SKU pattern in comparison to actual demand. It is notable that the "ladders" have higher amplitudes and variation than the actual demand. The supply planners that translate these orders would interpret demand as unstable and would de-risk these quantities based on their personal judgment. For example, if material planning and master schedulers reduced the order quantities, and sales were higher than expected, an expensive rush order would be needed. This event can further reinforce the bullwhip effect as planners may over compensate on future orders because of the stock out. It was not possible to quantify the material-planning pattern since the appropriate customer order data was not available upstream in the supply chain. The build signal sent upstream consolidates demand from all customers and once sent, cannot be tracked back to the customer orders that comprise the judged demand signal.

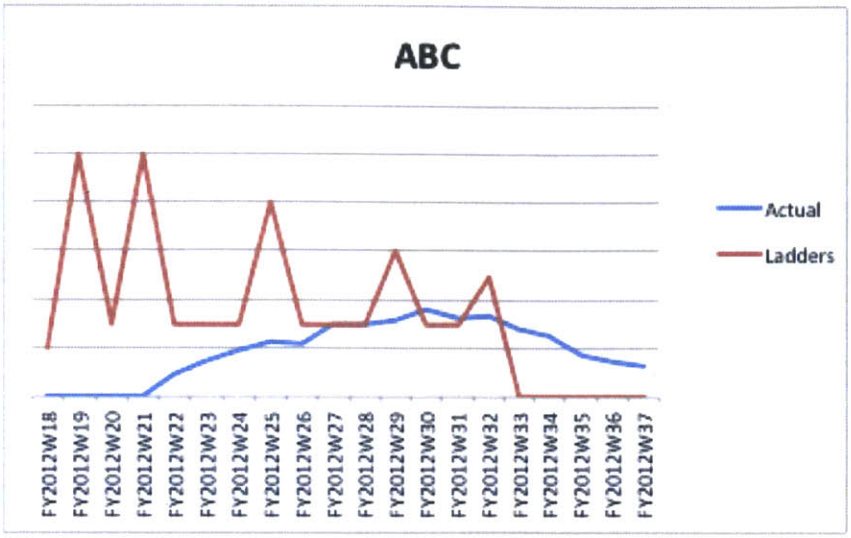

Figure 6 - Actual Sales vs. Ladders for SKU ABC

Price Fluctuations – Dell entered the retail channel later than its competitors, and competitive pricing was the method to enter the market. Promotions, discounts and rebates are common in the retail channel, both between suppliers and retailers and also between retailers and the end consumer. In order to get commitment from retailers, suppliers can give discounts or rebates for certain products that may cause negative margins but can improve market share in that price band. Upstream suppliers to PC manufacturers may offer these incentives to make their offerings more attractive. In addition, during the sales cycle, if sales volume is not as expected, manufacturers may offer retailers promotions and discounts that are passed on to the end-consumer, sometimes dropping the price of a certain SKU by more than $100. These discounts and promotions make it challenging to learn the true demand, as the end-consumer learns to expect retailer to lower prices in certain times of the year. Furthermore, when price is substantially reduced, the same product is now competing with existing products in the new price band, potentially causing cannibalization. Burst sales are a common sales strategy used by retailers of Dell products. For example, one particular retailer has many burst sales during the season. Frequently, the retailer sells more than expected in these sales, causing Dell to transfer products between locations. As sales teams expect this phenomenon, they would order larger quantities ahead of time to maange this problem. **Figure 7** demonstrates the order pattern of a burst SKU. It can be observed that there was a sudden one-time order of a large quantity but the actual sale pattern was less radical and lasted a few weeks.

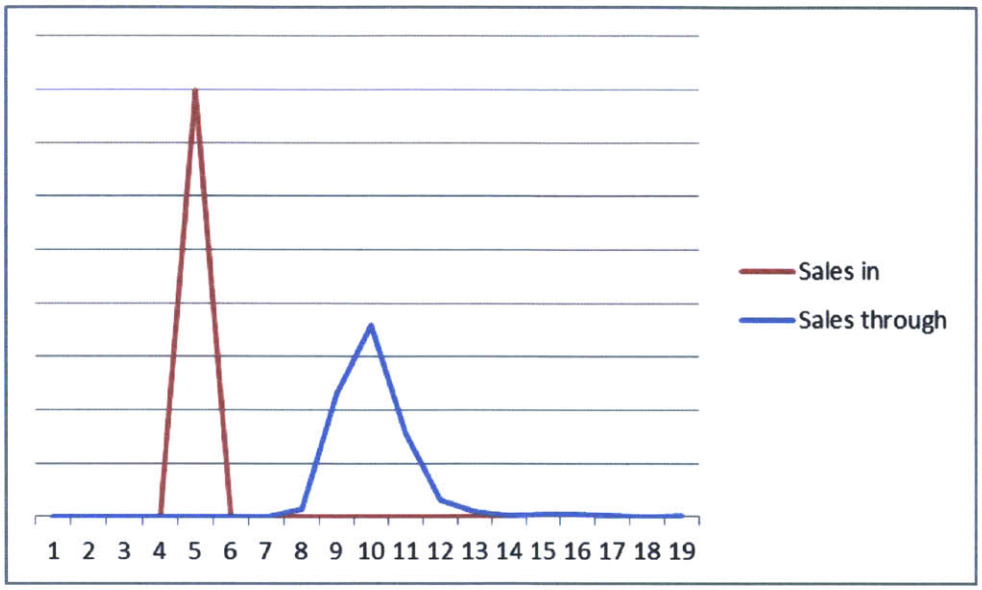

Figure 7 - Burst SKU Order pattern vs. actual sale

Shortage Gaming – Dell's agreement commitment with many of its retailers may also include a lock period period when the retailer cannot back out of a commitment on orders. So, if a retailer requests an order to be received July 31st, up until July 17th it can back out and cancel its order. This structure and agreement allows retailers to order large amounts and cancel orders if sales are less than expected. These changes in order quantities throughout the cycle cause variations in the order sizes and increases mistrust of the supply chain further upstream. In reality, the products are already on the ocean during that time frame so Dell has to find a solution for the "Left to Sell" inventory.

Lead Time – Dell has been increasing its number of ocean shipments as part of a cost-competitive initiative which has increased its lead times. This implies that if demand is different than expected there is no flexibility in adjusting the quantities that are already on the ocean. To reduce the likelihood of stocking out due to high demand and lacking the time to adjust for it, retailers order high quantities upfront.

Channel Management and collaboration in the retail channel can help Dell reduce its bullwhip effect. Clearer planning processes and information sharing between Dell and the Retailers and also within Dell can increase the trust between different stakeholders and reduce the hedging that occurs in different stages.

IT systems that can capture and trace the signals that are sent to the suppliers and the retailers in different point of time is one of the main barriers in enhancing information sharing and channel

alignment. Currently, order data cannot be traced back to the supplier and related to a specific customer.

This thesis will focus on process that can improve collaboration in the different planning processes throughout the organization such as S&OP (Sales and Operations) to reach an alignment of a baseline forecast and CPFR (Collaborative Planning, Forecasting and Replenishment) between the retailers and Dell that will be discussed in Chapter 4.

4. S&OP

4.1. Background

Demand Planning is more of a people issue than observed on first sight. (Wallace and Stahl 2008) In many organizations, different stakeholders have different views on what demand should look like. Sales have a customer centric view, marketing people focus on product lines, and merchandizing people focus on which promotions to run on which product. The initial goal of S&OP, which emerged in the 1980's, was to create the visibility necessary to balance supply with demand and align both sides of the organization on a frequent and regular basis to improve customer service, minimize inventory, cut down production and align revenue with profit and budget. (Chaman L. Jain 2006) Representatives from Marketing, Sales, Production Finance and other members of the management team agree on one number to forecast. In essence, by increasing communication, all of the value-added business units of the firm could agree on and work off a single set of numbers. This "one-forecast" planning leads to greater responsiveness, less waste, and less finger pointing. (Smith, Andraski and Fawcett 2011)

Table 2 - Performance Improvement Attributable to S&OP (Palmatier and Crum n.d.)

Benefits	Range of Percent Improvement
Increased Forecast Accuracy	18-25%
Increased Sales Revenue	10-15%
Improved On-Time Delivery	10-50%
Reduced Inventory	18-46%
Reduced Safety Stock	11-45%
Increased Productivity	30-45%

Long term, the market place and demand needs to drive the production but in short term manufacturing constraints may determine the production rate. An effective sales and operations process needs to address the following issues: an objective for customer service, project backlog and customer lead time, inventories and finished goods inventories investments, cash flows and profit, budget for material and drive capital investment decisions. (Gray 2007)

S&OP is a tactical planning process with a planning horizon of 6 months to 2 years and set into buckets of months or weeks. (L. Lapide 2011) The results are a set of activities that describe the selling, marketing and product launches over the planning horizon as well as matching the strategic goals by setting a supply plan to source manufacture and store the material and finished goods.

4.2. Process

Similar to Uriarte (Uriarte 2010) applied an S&OP framework to the consumer goods industry, one can break the Sales and Operations process into 5 steps; Data gathering, Sales Planning, Supply Planning, Partnership meeting and executive meeting. (Grimson and Pyke 2007)

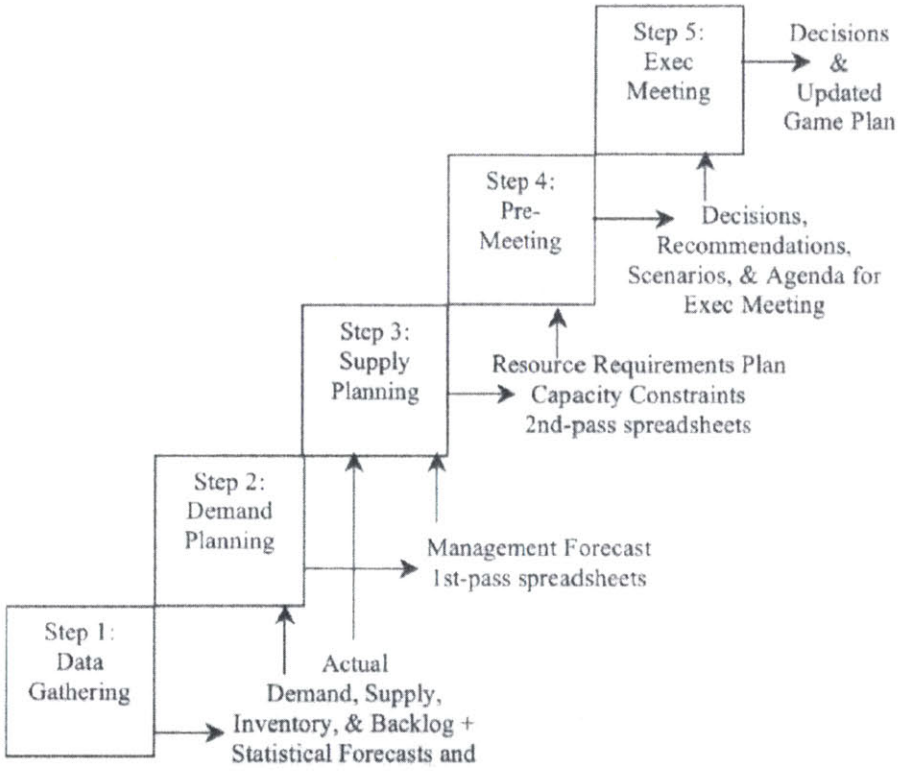

Figure 8 - Sales and Operation Process (Wallace &Stahl, 2008)

In the first step of S&OP, data is gathered to build a baseline demand forecast that is unconstrained by what the company can produce. This forecast is updated by known promotions, seasonality and new product information data. One of the decisions made in this step is the forecast horizon, which is determined based on the product and the selling cycle. This step's output is a statistical forecast. In the second step, the aggregated forecast is reviewed and analyzed by the different representatives from sales and marketing. The result of this step is a consensus forecast. At the same time,

Operation teams determine inventory policies, capacity constraints and supply chain strategy. The Operation teams must use the baseline forecast to reach a supply chain strategy.

The third step requires the planning function to meet the operation team and reach a consensus. Stakeholders from different function must be represented in these meetings: Sales and marketing (demand management, forecasting, etc.), operations (purchasing, inventory management, supply chain operations, master production scheduling, etc.), and finance. (Grimson and Pyke 2007) The output is a constrained demand plan. A key decision for successful implementation is the frequency of these meeting and the personnel.

The fourth step goal is to distribute and implement the plan. A balance between the supply and demand should be achieved. This balance and agreement requires management approval. The main stakeholders at this step are sales and operations, although it is usually the operation team that adjusts the production goals to the sales plans.

In the fifth step, executive management approves the demand plan and measures the effectiveness of the S&OP process by including past forecasts, assumptions and comparing the forecast to the business plan.

4.3. S &OP Implementation

S&OPO requires functional silos to be broken down and managers must work together towards a common goal regardless of the individual incentives. This requires a change in company culture, including incentives scheme that requires change management effort (Grimson and Pyke 2007). Initial steps are required to educate the organization about S&OP, develop the process and the metrics of success. (Milliken 2008) The following steps are crucial to build the foundation for S&OP implantation within executive management:

- Educate management – Top management must be educated of the benefits of the process for the business in order for a top- down process to succeed. This step will provide an in-depth understanding of the S&OP process and generate commitment toward the process. Leadership team must agree on a champion for the S&OP implementation. Milken suggests that if the champion is the supply chain leader, he or she will have a harder time communicating S&OP is a business process. The head of finance may be a good fit as the goal of S&OP is to improve bottom line performance
- Determine S&OP team members – S&OP requires participation and commitment from different functions, but more importantly the leadership of each business should participate.

"The business cannot achieve a one number forecast unless everyone is driven by the same set of numbers" (Milliken 2008) S&OP decisions affect the financial business plans and as such leadership have to approve those. Each function must be represented and arrive prepared to present the data in a summarized way so that the issues discussed are those that require leadership input.

- Schedule S&OP meeting and process steps – S&OP meetings should be scheduled at least 12 months in to the future. The key process steps and milestones should be scheduled in the calendar, specified in working days so that everyone can contribute and plan their work ahead.
- Identify planning groups, planning horizon and resources available – Demand and supply planning use a different aggregation group for planning purposes. . It is recommended that S&OP focuses on total volume for product groups, demand planning should be grouped based on similarities in market segments and customer groups, and supply planning products should be grouped based on resources. Fewer product groups are better and each group selected should represent a significant percentage of total revenue in the business.
- Design and test S&OP data software – Software is the most difficult task in S&OP. Strong software can benefit the baseline forecast and the collaborative planning. Most ERP systems do not provide a solution for S&OP and it helps if the supply chain planning processes has software tools. It is imperative to get a commitment on technology resources before beginning the S&OP implementation and to manage these tasks as critical path components.
- Develop S&OP level performance measures – As with any business management process measurements are needed to gain improvements and take corrective actions. S&OP scorecards should include metrics and Key Performance Indicators (KPIs) representing all participants. It is also critical that all business-level metrics are included in the S&OP process to emphasize that this is the only planning process in use
- Develop and issue S&OP meeting agenda and conduct first meeting – The S &OP meeting is an action- oriented. The objective of the executive meeting is to approve the final number so the focus should be on resolving current issues and making final decisions on proposals that were made along the process and generate further actions.

Studies suggest starting implementation with a pilot in one product family, which has low complexity but significant value to the business so that executives can engage in the effect of S&OP on strategy and financial performance. (Grimson and Pyke 2007). In the early stages of the

Table 3 - S&OP integration framework (Grimson and Pyke 2007)

	Stage 1 No S&OP Processes	Stage 2 Reactive	Stage 3 Standard	Stage 4 Advanced	Stage 5 Proactive
Meetings & Collaboration	• Silo Culture • No meetings • No collaboration	• Discussed at top level management meetings • Focus on financial goals	• Staff Pre-Meetings • Executive S&OP Meetings • Some supplier / customer data	• Supplier & customer data incorporated • Suppliers & customers participate in parts of meetings	• Event driven meetings supersede scheduled meetings • Real-time access to external data
Organization	• No S&OP organization	• No formal S&OP function • Components of S&OP are in other positions	• S&OP function is part of other position: Product Manager, Supply Chain Manager	• Formal S&OP team • Executive participation	• Throughout the organization, S&OP is understood as a tool for optimizing company profit.
Measurements	• No measurements	• Measure how well Operations meets the sales plan	• Stage 2 plus: • Sales measured on forecast accuracy	• Stage3 plus: • New Product Introduction • S&OP effectiveness	• Stage 4 plus: • Company profitability
Information Technology	• Individual managers keep own spreadsheets • No consolidation of information	• Many spreadsheets • Some consolidation, but done manually	• Centralized information • Revenue or operations planning software	• Batch process • Revenue & operations optimization software – link to ERP but not jointly optimized • S&OP workbench	• Integrated S&OP optimization software • Full interface with ERP, accounting, forecasting • Real-time solver
S&OP Plan Integration	• No formal planning • Operations attempts to meet incoming orders	• Sales plan drives Operations • Top-down process • Capacity utilization dynamics ignored	• Some plan integration • Sequential process in one direction only • Bottom up plans - tempered by business goals	• Plans highly integrated • Concurrent & collaborative process • Constraints applied in both directions	• Seamless integration of plans • Process focuses on profit optimization for whole company

4.4. Forecast within S&OP

Forecasters and Planners are being asked to plan for increased number of sales channels, shorter lifecycles and multiple product lines. Quantitatively based forecast is becoming less effective in capturing the different dynamics and changing business environment. This requires greater collaboration within the organization to understand where the business is going. (L. Lapide summer 2006)

In S &OP, Top down & Bottom up forecasting can support accountability and commitment. The top down forecast is forecasting the aggregated groups while bottom-up is forecasting the individual components separately and then adding to the aggregated group. In S&OP, where different functions meet to agree on a forecast, the discussion should begin with a baseline forecast that reflects the marketing and sales perspective through a top- down forecast while product groups forecast brand- level using bottom up forecast and then adding it up to an aggregated forecast. The result of a consensus demand/supply forecast is achievable only with accountability and

implementation process, technology is not required since it is more important to have a well-understood S&OP business process than it is to have elegant software. (L. Lapide 2005)
Grimson & Pyke argue that the next level of S&OP integration should be not only about communicating and coordinating plans among the different functions but also revising the plans to optimize profits throughout the organization. Profit optimization accounts for the effects of sales efforts on operations and vice versa, with the goal of maximizing profitability. They proposed an integrated framework that uses one to five ranking across five dimensions. Table 3 illustrates the different dimensions and the level of maturity an organization may be in.
Meeting & Collaboration – The effectiveness of the human component in S&OP. In stage one, financial goals drive sales effort and no planning meetings or collaboration exists. Stage five consists of regular discussions with customers, suppliers and in between function. Real time access to data and information occurs and meetings are schedule on a regular base far in advance.
Organization – The organization dimension focuses on the corporate S&OP structure. Stage one is where there is no S&OP function in the company while in stage five the organization had a formal team with executive level participation.
Measurements – Measurements apply to both company performance as well as effectiveness of the S&OP process. In stage one; the company has no measurements, while in stage five, Operations meets the sales plans. Both sales and operations functions are measured on forecast accuracy and profitability. Al functions collaborate on setting prices and adjusting inventories and production plans to achieve higher profits. At this stage, the effectiveness of the S&OP process is also measured and that is usually seen by the improvements in forecast accuracy.
Information Technology – Focuses on an information process rather than a business process. In stage one, the company is using individual spreadsheets and there is no consolidation of information. In stage four, company is using revenue and operations optimization software, while there is a centralized information center. It employs an S&OP automated tool sharing information about sales and information. Stage 5 is a real time integrated solutions that optimize sales decisions along with operations decisions. This can allow quick reaction to the market and changes in demand.
S &OP Plan integration – Measures how effectively company builds its sales plans and operations plans and how they interface. At stage one, the company, there is no S&OP planning and operations trying to meet orders. At stage five, a seamless process that optimizes supply and demand to maximize profitability is in place. Ensuring that issues are raised by all team members, heard and responded to, achieves better integration.

commitment from all different stakeholders. In order to get agreement, each organization needs to participate and provide a view to the developed forecasts by reviewing and revising it.

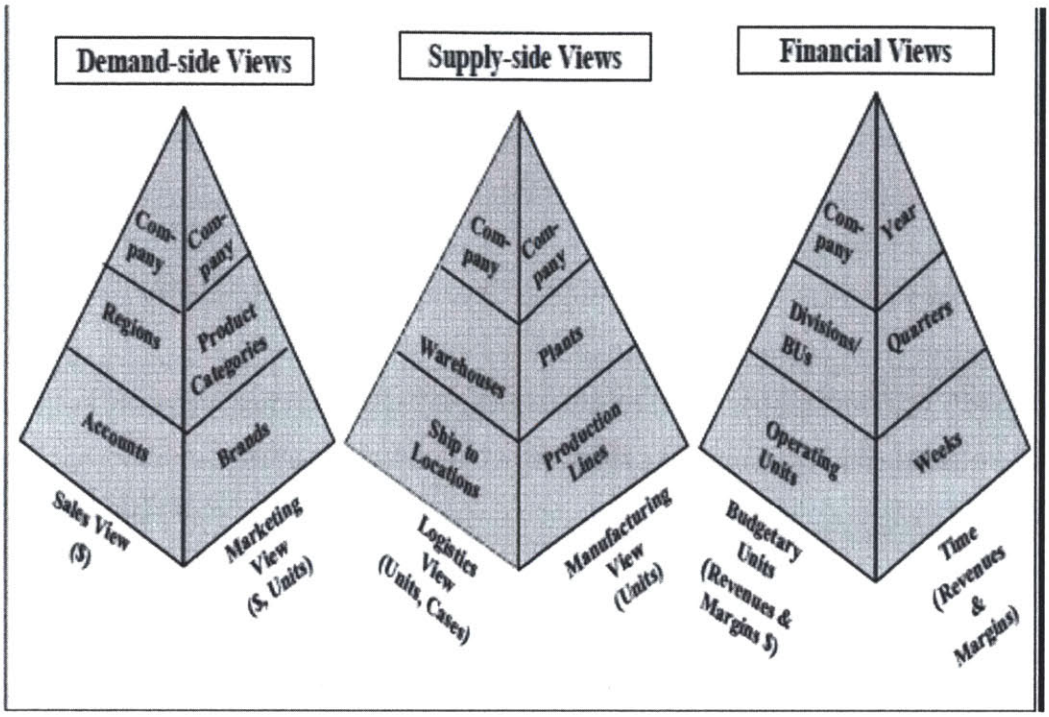

Figure 9 - views for each S&OP participant (Lapide, 2006)

Each organization needs to forecast based on the terms that are familiar to them. For instance, Sales usually forecasts dollars per channel then demand forecasts needs to be aggregated and then disaggregated to the different channels. Figure 9 illustrates the units that are usually important to each organization thus achieving another top down – bottom up view.

4.5. S&OP at Dell

According to Grimson & Pyke integration framework, Dell is currently in a standard stage of S&OP in most criteria.

Meeting and Collaboration – There are meetings across the organization in which discussions are focused on the future products and there are meetings with the retailers to discuss configuration and quantities. These scheduled meeting usually discuss urgent matters and abnormalities instead of long term planning based on real time data and the focus is still on financial goals. The right number to signal is not the focus of discussions and all stakeholders do not necessarily agree it.

Organization – Although S&OP is a common discussion in different unit of the business, up until recently there was no formal S&OP organization and the components spread across the

organization. During the time of this research, an S&OP organization was beginning to form within the Global Planning Operations. Milliken (2008) argued that in the beginning, a supply chain organization should not lead the S&OP since it would be more challenging to persuade that S&OP is a business process.

Measurements – Sales teams are incentivized by sales to the retailers and achieving financial goals, while Operations are mostly measured on how they meet the plan that the sales team is driving. Currently, sales teams are not measured on their inputs to the operations forecasts, therefore they are not held accountable for the demand signals they produce. Based on the Grimson & Pyke definition, this is the reactive stage of S&OP integration framework.

Information Technology – Current systems are not highly developed and individual managers keep their own spreadsheets that usually are shared on a share drive but updated manually.

S&OP Plan integration – There is a plan integration through discussions, however, sales plan drive operations. The main cause is that there are different functions, doing different forecasts and lack of knowledge sharing.

4.6. S&OP Assessment at Dell

Currently, S&OP at Dell is a set of planning and forecasting activities that are not necessarily aligned on an executive level thus causing overlaps in responsibilities. Millikin's key steps to implement S&OP (Milliken 2008) can be beneficial to Dell's transformation. Millikin suggests that implantation should be driven by finance or sales to engage all different stakeholders by ensuring that S&OP is more than a supply chain method but a business practice that is beneficial to the organization as a whole. There is a clear need to define the different stakeholders and decide who should be in the meetings once they are scheduled. Currently, there are numerous planning functions at Dell. It is essential to define the planning groups and the planning horizon for each group. The software tools are the key challenge to align on a one number forecast. Currently, there are opportunities to improve the sharing of data and it is recommended to think ahead about a powerful software solution to ensure a good implementation.

5. CPFR- Collaborative, planning, Forecasting and Replenishment

5.1. CPFR Background

CPFR is a business practice that combines the intelligence of multiple trading partners in the planning and fulfillment of customer demand. CPFR links sales and marketing best practices, such as category management, to supply chain planning and execution processes to increase availability while reducing inventory, transportation and logistics costs (VICS 2004). The term CPFR was first introduced in 1995 in connection with a pilot project between Wal-Mart, Warner-Lambert, Benchmarking partners, SAP and Manugistics (Danese 2007). In 2004, VICS created a framework to CPFR implementation that can be applied to many industries. At the center of the model is the end customer for whom a buyer and a seller, as collaboration participants, work together to satisfy the customer's demands.

Table 4 - Performance Improvements Attributable to CPFR (VICS 2010)

Benefits	Range of Percent Improvement
Increased Sales	10% to 30%
Increased Margin Rate	2% to 6%
Increased In-stocks	2% to 7%
Decreased Inventory	10% to 30%
Improved On Time Delivery	5% to 10%
Improved Forecast Accuracy	20% to 30%
Decreased Logistics and Operating Costs	10% to 28%

Most companies are involved with all activities at any given moment. CPFR programs have a calendar of weekly, monthly, quarterly, and annually activities that govern the collaborative planning and execution cycle. CPFR distinguishes the responsibilities between executive level such as aligning trading partner goals and strategies and tactical level ensuring that participants know each other's processes well enough.

Executive Level - includes cross-functional managers and process owners to define and redefine the specific tactics and deliverables of the CPFR engagement. In addition, an executive annual or semi-annual management meeting of the trading partners is described to define and redefine strategies, align organizational goals, allocate resources, and establish high-level measures to document progress.

Tactical Level – Weekly or monthly meetings involve process owners and focus on tactics deliverable to review the results of initiatives and manage key exceptions amongst stakeholders. The

following items should be discussed: 1) a review of current performance metrics for both sides, 2) managing current team initiatives with clearly assigned accountabilities and milestone deliverables, 3) identifying and resolving supply constraints based upon the collaborative forecast, and 4) a review of changes to the demand forecast based upon promotional planning, assortment planning or any other change to the demand plan. (VICS 2004)

5.2. CPFR Process

Figure 10- CPFR Model (VICS 2004)

CPFR consists of 4 high level sections:

Strategy & Planning – Establish the ground rules for the collaborative relationship. Determine product mix and placement, and develop event plans for the period.

Demand & Supply Management – Project consumer (point of sale) demand, as well as order and shipment requirements over the planning horizon.

Execution – Place orders, prepare and deliver shipments, receive and stock products on retail shelves, record sales transactions, and make payments.

Analysis – Monitor planning and execution activities for exception conditions caused by unforeseen environmental or market risk events, supply chain disruptions or a performance breakdown. Aggregate results and calculate key performance metrics. Share insights and adjust plans for continuous improved results.

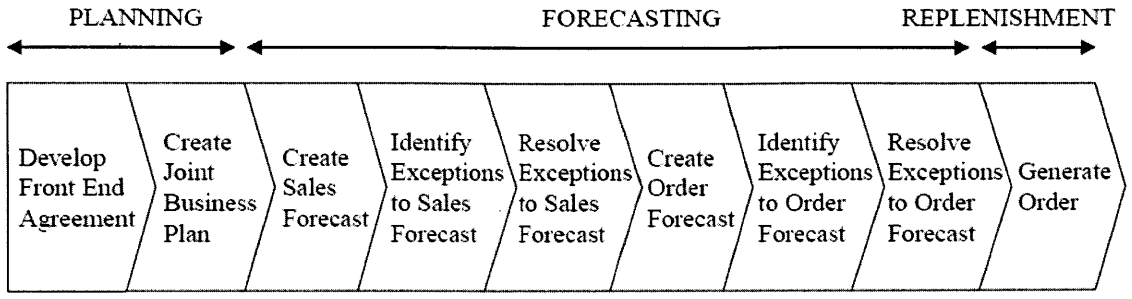

Figure 11 - Activities in the CPFR process (Danese 2007)

These four sections include 9 steps illustrated in Figure 11. First, the manufacturer and the retailers develop a joint business plan where they share their measurable targets, strategic objectives and tactics to achieve these targets. Next, a POS (Point of Sale) forecast is developed by each party, followed by identifying exceptions between the forecasts and later both parties share insight to understand what drove their forecast numbers in order to reach an agreement. The last steps focus on the forecast of purchases from the manufacturer. Again, both parties generate a purchase forecast and the collaboration results in accurate forecast of orders. Lastly, the execution of orders is monitored to ensure delivery at the right location at the right time. (Sagar 2010-2011)
The course correction stage is highly important for continues improvement within the collaborative planning process.

- Measurement – quantifying the degree of error and benchmark the error to industry or history.
- Learning – understand the root cause of the error that has been measured for future learning. First, establish a tolerance level of error and this should be used to flag any exception. The error can arise from quantitative error such as improper setting of parameters or qualitative such as missing promotional activities.

CPFR can take a number of different forms and different managements can lead implementation of different types of CPFR. Based on Danese (Denese 2007), the following factors influence CPFR collaboration:

- CPFR goals – the reasons companies drive towards CPFR implementation. If companies implement CPFR to reduce cost, the collaboration is limited to data communication (data exchange on order forecast plans, stock level, and sales plan. But if companies want to

improve the supply network response to demand changes, the collaboration is extended to plan synchronization and manage expectations.

- Product / Market characteristics - Including the characteristic of the products managed through CPFR and the market in which they are sold. Companies that have in depth knowledge of the final market, demand elasticity is high and low spatial complexity (geographical distances between companies involved in CPFR) tend to engage in full collaboration.
- Supply network's physical structure – Supply network characteristics (facility location, size, specialization, number of facilities, material pattern flows)
- Supply network's relational structure – influences the number of potential CPFR partners and the number of interacting units.
- CPFR development stage – Stage of the development of the CPFR project can affect the number of interacting units. A company can collaborate with several units when the number of potential CPFR is high and CPFR is at an advanced stage

5.3. Linking S&OP and CPFR

S&OP is a strategic business management process that aligns functions in a coordinated internal collaborative process while CPFR is a strategic business management process that aligns trading partners in a coordinated external collaborative process. (VICS 2010) Although CPFR and S&OP represent internal and external collaborative planning, respectively, the line between those two processes have grown greyer over the years (Sagar 2010-2011). Figure 12 illustrates an integrated closed loop planning between CPFR and S&OP in which a statistical forecast is enriched with qualitative feedback from various partners externally and internally. The loop is closed by comparing the forecast with actual sales and learning from the errors that may be fixed in incorporated in future planning. It is common that corporate planning functions build their future plans off historical shipments and not based on demand signals from the shelf (Baumann 2010)

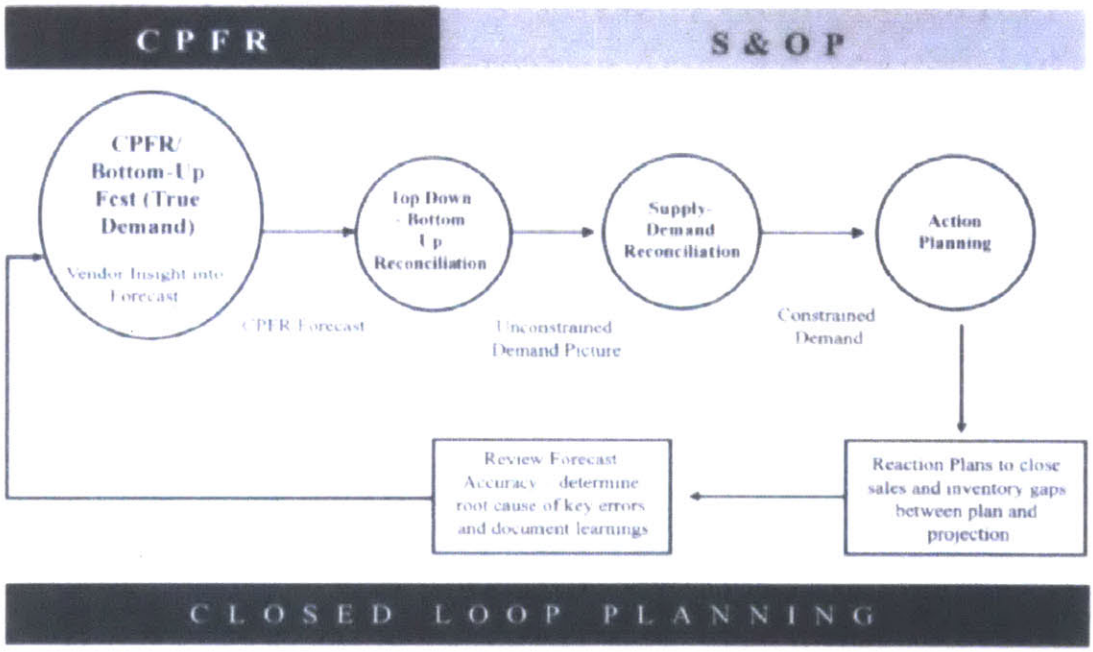

Figure 12 - Closed Loop Planning (Sagar 2010-2011)

In the VICS case study of Lowe's / Whirlpool (VICS 2010) it was noticed that collaboration exists in the Operations planning, CPFR level between the demand planning functions of the two organizations. Collaboration in higher level was sporadic and inconsistent which causes sales plans that did not include future advertising, promotions and product transitions. As a result, forecasts were not accurate and forward visibility was limited. Lowe's and Whirlpool established relationships in mid- managements level in the organization and started focusing on sales and marketing plans

collaborations, which allowed them to extend the planning horizon to 3-6 months. Figure 13 describes the linkage of S&OP and CPFR implemented in Lowe's / Whirlpool.

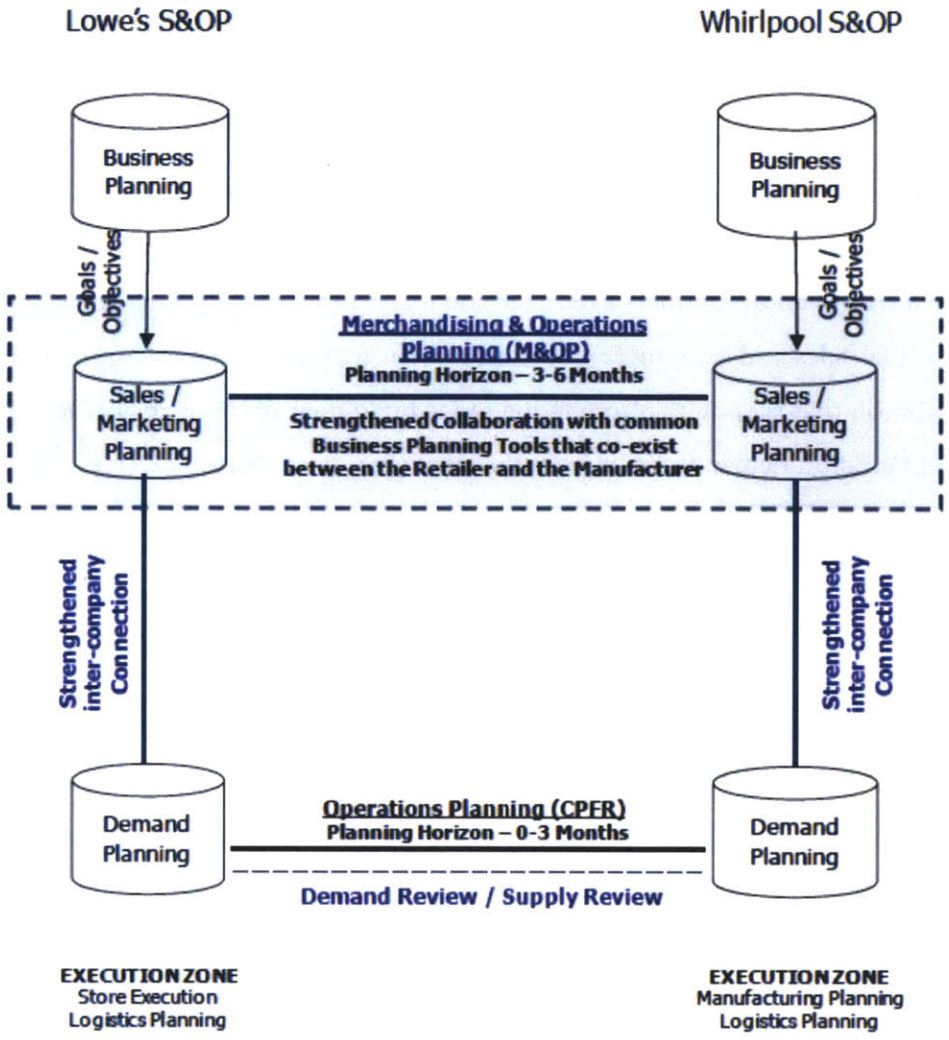

Figure 13 - Lowe's / Whirlpool linkage of S&OP and CPFR (VICS, 2010)

5.4. CPFR at Dell

At Dell, CPFR is relatively in its early stages. In March 2011, Dell started to collaborate with one of its largest retailers and share POS (point of sale) data. A weekly conversation is held with representatives from Dell and the retailer to discuss POS, future promotions and forecast for the current cycle. Dell follows the first activities of the best practice CPFR. The demand planner, with the help of an external consulting group, generates a demand forecast and compares that number with the retailer's number. In the weekly call, the demand planner discusses differences of the

forecast with the retailers and shares new information that may contribute to the gap. Both parties share access to an EDI (Electronic data interchange) that holds inventory and POS data of the retailer. Once a sales forecast is agreed upon, the conversation of replenishment begins. In most cases, the replenishment forecast that will be used will be the retailer's. After one cycle, the other two demand planners initiated a CPFR process with the other two largest retailers. Figure 14 demonstrates the current CPFR process in use at Dell.

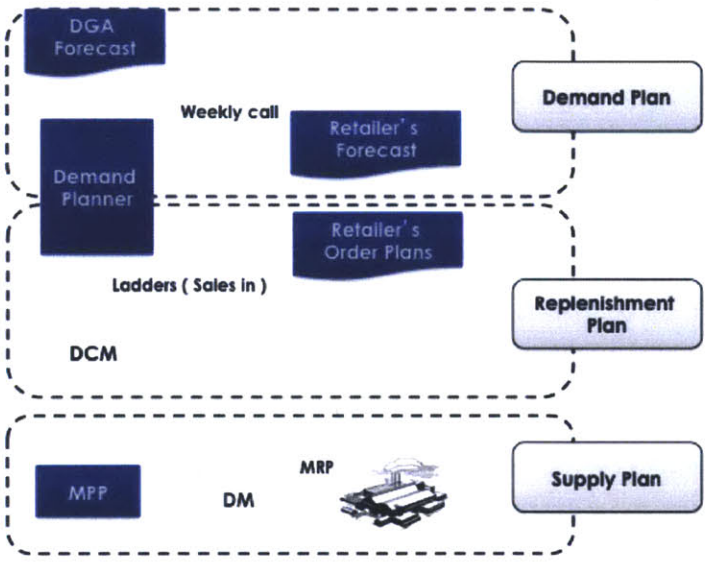

Figure 14 - Current CPFR at Dell

Course Correction – The major barrier in the current CPFR process is the technology tool that restricts learning and tracking forecast errors and issues. The external consultant sends the demand planner a Power point with the forecasted numbers per week per SKU. These numbers are at no point kept on a Dell database. Once the forecasted number is agreed, the numbers are kept on the 3rd party tools and the only number transferred to Dell's data systems are the forecasted orders. The current tool used does not keep past history but only presents snapshots of the forecasted orders. Therefore anytime replenishment is updated, the demand planner overwrites the past forecast. This challenges the ability to measure the baseline forecast error and bias that will be discussed in detail later. Furthermore, the learning process is not executed well because the future forecast does not take into account assumptions and errors that were discovered in past cycles and there is no formal feedback process back to the sales and merchandizing teams.

Dell's CPFR process should be reexamined to align the process with the Collaboration strategy. Initially, Dell needs to define what is the goal of its CPFR process. Interviews at Dell showed that increasing forecast accuracy is the major goal of this process. Top managements should decide if the

goal is cost reduction or strengthening the supply chain network. The current collaboration is mostly data communication, which fits the cost reduction objective. Based on product and market characteristics, it may be more appropriate for Dell to engage in full collaboration. Dell has in depth knowledge of the final market due to years of experience in the PC market along with its direct channel data. In addition, as PC's have become a commodity, promotions have high effect on sales so demand elasticity is high. Before expanding its current CPFR to other retailers, it may be better to wait until the CPFR is at a more advanced stage of collaboration.

Conclusion

Dell is at an early stage of S&OP and CPFR. These two are tied together and are key components in improving forecast accuracy and reducing the bullwhip effect. Both processes already have roots in the organization but have to be driven from a top management with linkages to the different processes. To improve collaboration internally and implement, responsibilities must be defined, aligned and communicated across the channel. The linkage between S&OP and CPFR is key when implementing S&OP to enhance feedback from CPFR to the integrated supply chain.

6. Dell's Demand Planning

Demand planning goal is to predict future customer demand for a set of items to help the supply chain meet the customer demand and ensure the delivery of the right quantity of the right product in the right time. . It's a key activity in supply chain and in S &OP.

Demand planning should consist of the following (Stadtler and Kilger 2008):

- Collection of past forecast data, historic customer orders, shipments and correction of historic data
- Statistical forecast
- Judgmental human forecasting
- Consensus forecasting
- Planning of dependent demand
- Release of forecast to further planning and execution functions

If there were one customer and one product and no external market factors, forecasting future demand would not be as hard as it seems using statistical method. However, in today's reality companies are engaged with multiple products, channels and markets resulting in complex processes and organizations.

6.1. Organizational Structure

Demand Planning can be the most challenging of all steps in S&OP (Wallace and Stahl 2008). When it comes to future demand, different groups within the business view it differently. Dell's planning lies in multiple functions across the organization. This section will try to describe the current planning process within Dell. Figure 15 demonstrates the three main organizations that are involved with Dell consumer planning: Global Operation Planning, Product Group and Sales and Marketing.

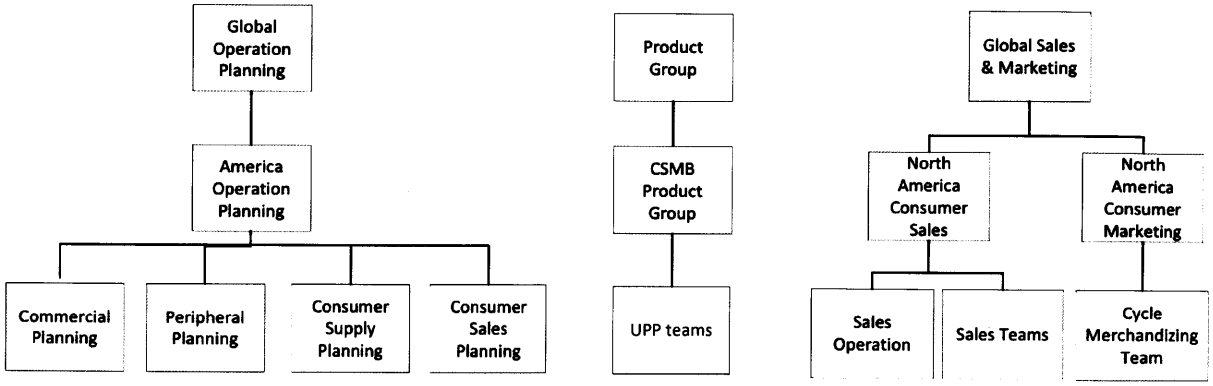

Figure 15 - Dell's planning functions

These views must be reconciled into one single sales forecast and plan, which is reviewed and authorized by senior executives.

Figure 16 demonstrates the relationship and the function within America Operation Planning group

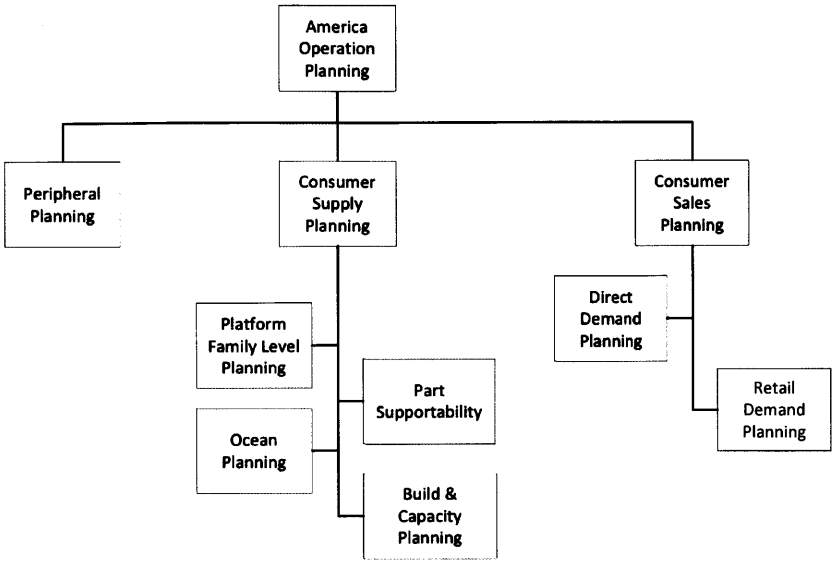

Figure 16 -America Operation Planning

Current planning functions:

- Finance: Provides a P&L every quarter with revenue, units and margins (RUM) goal, approves different concessions and rebates based on profitability.
- Merchandising: Provides future cycle roadmap and burst opportunities with complete configurations and volume. The Roadmap is by retailer, by configuration and is an overall lifecycle volume. The plans are updated when a retailer changes its requests up until the retailer locks its configurations
- UPP (Unit Production Plan) – On a monthly base, UPP plans volumes on an overall platform level for the next 3 months. This plan is on a financial quarterly base. The UPP is part of Product Group Organization. UPP is basing its plan on previous year sales in, market product mix (Desktop vs. Laptops), Roadmap configurations and eventually reduce the risk of the Merchandizing roadmap by approx. 20%. The UPP organization used to be within the supply chain and in September 2011, it was moved to the Product Group organization
- Demand Planners – Demand Planners are part of the global operations planning organization. In case of the three major retailers (Wal-mart, Best-Buy, Staples) there is a specific demand planner responsible for the account. The Demand Planner's role is mostly to phase the overall demand on a weekly bucket. The input to the rest of the supply chain is ladders. The ladders are orders planned for the future cycle. The ladders are changed based on the retailer's request but have a 4-week lock window where no changes can be made.

- Platform Family Level Planning (PFLP): Responsibility of FHC (Fixed Hardware Configuration) and FGA (Finished Good Assembled) review, ocean offset and supportability.
- Peripheral Planning (PP): Responsibility off peripheral mix load and confirmation of supportability on change within lead-time.

Table 5 - Planning Function's Horizons

• Function	Output	Horizon	Bucket	Frequency	Detail level
Finance	P&L	Quarter	Monthly	Quarterly	Platform
Merchandizing	Road Map	One retail cycle	None	Less than once a week	SKU
UPP	UPP	Quarter	Monthly	Monthly	Platform
Demand Plan	Ladders	One retail cycle	Weekly	Weekly	SKU

6.2. Current Lifecycle Planning Process

The retail selling cycle consists of three seasons: Spring, Back to school and Holiday. The planning process at Dell starts six months prior to the start of the selling season i.e. Back to school cycle begins in June thus planning begins in December the prior year. Figure 17 describes the time line of the retail buying cycle. A Buying cycle consists of planning and execution phase. The planning phase consists of several internal discussions as well as with the retailer in order to determine what products Dell will offer in stores the following cycle in terms of configuration and timing. The planning phase ends with the retailer confirming (locking) the product configuration and volumes. Sales, marketing, product group, finance and global operations planning are all involved with the planning phase. The execution is the build schedule, delivery of initial orders and actual sales. Supply Chain has a stronger presence in the execution phase along with demand planners and sales representatives verifying with the retailers the orders received. The replenishment period is composed of replenishment orders for the product configurations offered during initial fill and new orders for "Burst" configurations.

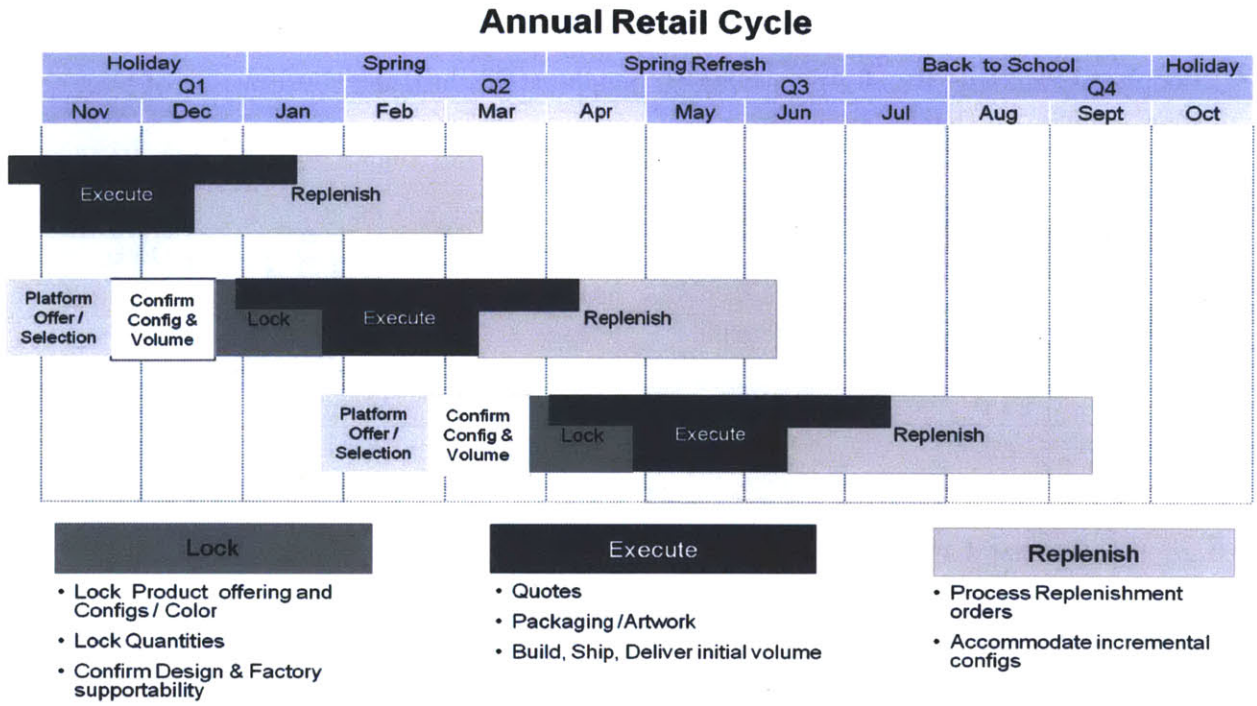

Figure 17 - Dell's Retail Planning cycle (Gupte, 2009)

Before Cycle

At first, Finance sets the Revenue, units and margins goals (RUM). Product Group designs the configuration options that fit a given platform while Merchandizing teams begin the process of configuring the different SKU to pitch to the retailers. The merchandizing teams ask Sales what they predict is the right configuration that will fit a retailer and the quantity for each SKU. Road Maps are updated once sales have new information from the retailer and it can be updated on any given day but officially they are updated weekly. Simultaneously, UPP teams form the Unit Production plan. The UPP is released every month and has a quarter horizons and a monthly bucket. The UPP is aggregated on a platform base. The peripherals planning and material planning start signaling the ODM as early as 16 weeks before the cycle begins since some of the commodities have a lead-time of that length.

Approximately 12 weeks before product launch date, sales and mechanizing approach the different retailers and present the potential SKU's for the relevant cycle. At that stage negotiation between Dell and the retailers occur regarding price, quantities, different rebates and agreement on which SKU's they will commit to ordering. The negotiation time period varies depending on the retailer. Once the retailers confirm the desired SKU's, the configurations are locked and the demand planners' role begins. They start by phasing the demand on a weekly base to set off the relevant

orders called ladders. At this point, demand planners phase each SKU on a weekly basis and rely on retailers order requests and previous cycle run-rate. Production capacity and material capacity are verified. Peripheral Planning, PFLP, ocean planning and build planning aggregate the ladders with other channels and break down to individual components. These aggregated orders are loaded into the system and sent to suppliers. Two weeks prior to the MABD (Must Arrive by Date), retailers must commit to orders by submitting an official purchase order.

In cycle planning

Once the cycle begins, the demand planners' role is actively communicating with the retailers, sales teams and supply chain to assess the orders status and the sales through data. As sales though data is received, the demand planner retrieves information on what promotions are planned to see if the plans needs to be updated.

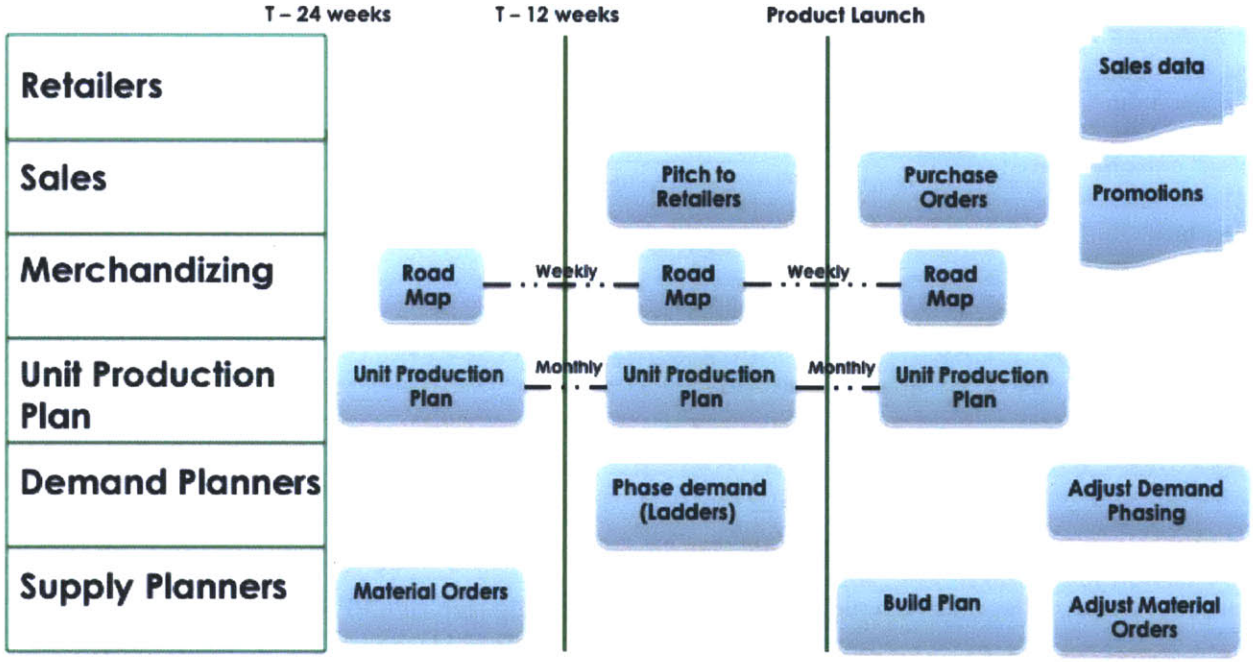

Figure 18 - a macro overview of lifecycle planning process

6.3. Current Forecast at Dell

As part of Dell's initiative to improve demand sensing, an external company, was hired to produce a forecasting technique. The company is working with the demand planners to produce a weekly forecast that is also updated on a weekly basis based on sales through data and promotions. The company is using time series based on previous years performance. On a weekly base, sales along

with the buyer from the retailer and the demand planner discuss the forecast for the next few weeks, challenges, and possible promotions or discounts that may influence sales through. The retailers along with the demand planner agree on required orders. The demand planner loads the DCM (Dell Channel Manager) with the updated ladders. The ladders are approved in the DCM in terms of material capacity and production capacity. If a certain SKU is out of stock, the demand planner does not have prior visibility and has to communicate back to the retailer. At this point, there are different functions that try to change SKU between retailers so that all requirements can be met. Once ordered the Supply planners receive a specific order, they aggregate it with other channels orders.

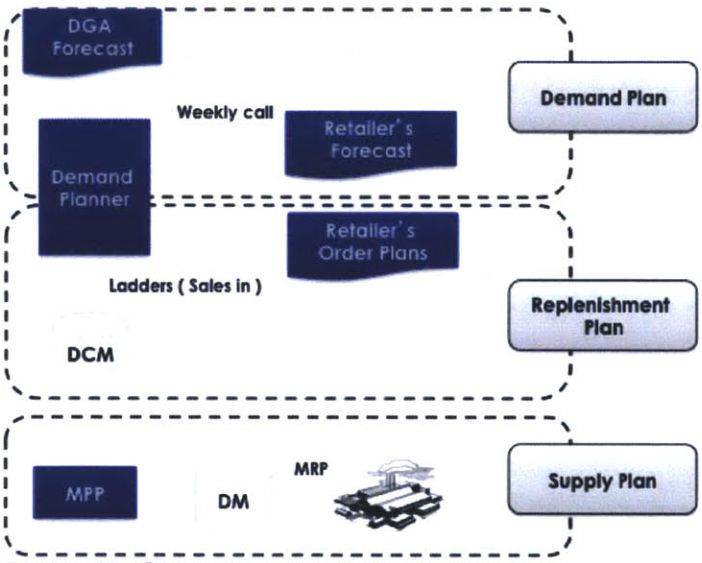

Figure 19- CPFR process at Dell

The basic CPFR elements exist at Dell the retailers mostly drive the replenishment process. It is common that a collaborative replenishment is the challenging step of CPFR since it is difficult to refuse your customers orders. Currently, at Dell there is a high churn of orders as retailers are frequently updating their orders until the last commitment deadline. The demand planner should bring a recommendation for replenishment to reduce risk in the supply chain. Figure 20 illustrates the different replenishment plans that were sent upstream during the cycle. Demand Planner changed the ladders several times during the cycle.

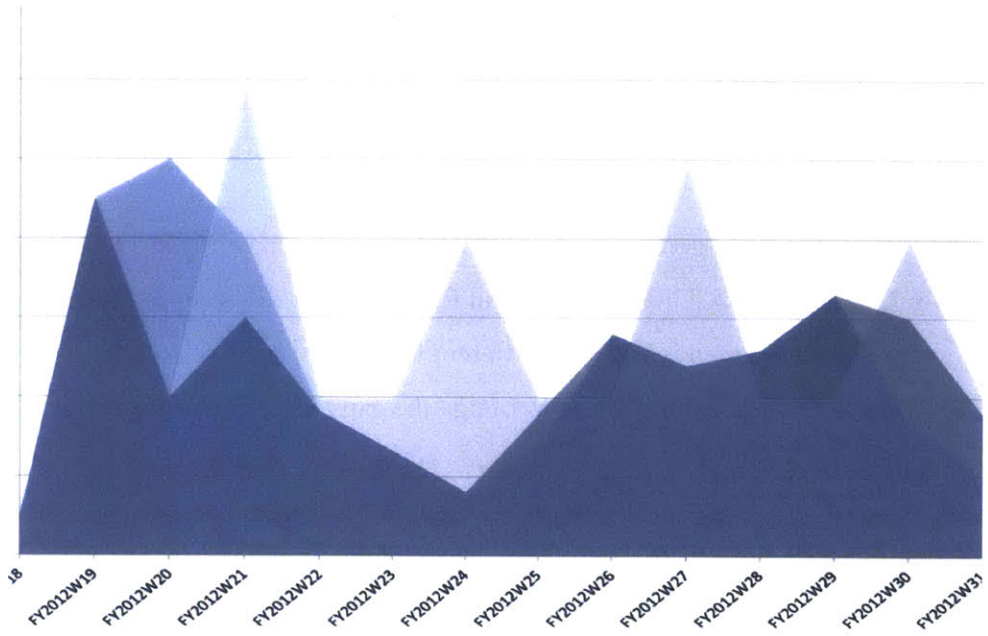

Figure 20 - Replenishment updates

In a best practice CPFR, while engaging in the conversation with the retailer, the demand planner should recommend replenishment forecast as well. To measure the performance of the forecast, one should measure what is loaded to the system. Currently Dell only updates the system with ladders and not forecast.

6.4. Challenges at Dell Planning Process

Information Systems

Dell's retail planning's IT tools are not highly evolved. Road Maps are generated on Excel spreadsheets and loaded to a SharePoint drive every time there is an update. UPP is sent via email to different stakeholders. The external consultants' forecast is generated and sent to demand planners in Power Point slides and although Ladders are uploaded to a database, every change that is made is overwriting the previous signals thus no tracking of past signals is available.

Demand is different from actual sales since actual sales include promotion data. In order to generate the baseline forecast, promotions needed to be taken out of past sales and added back on when signaling the forecast upstream. Currently, past promotions data are not available and are not planned and not taken into consideration when determining the baseline forecast.

In addition, there is not one common identifier for a SKU. Each function in the organization uses a different key for a SKU such as purchase order, PRN, Model ID, Lot ID therefore conducting a

root-cause analysis requires excessive resources. Furthermore, many employees spend a significant amount of time translating each forecast to their relevant product/ SKU / Order identifier with basic Excels spreadsheets.

Multiple signals

The guideline for a clear S&OP process is to generate a one number forecast. Currently at Dell there are forecasted numbers from Merchandizing, UPP and Demand Planners with different quantities. Each forecast is updated in a different frequency and on a different aggregated level so supply planners upstream have to make their personal judgment to bridge the gap between the numbers. Figure 21- demonstrates the difference of forecast each unit made at the same timeframe. It can be observed that the Road Map quantities are higher than the UPP signals. The Ladders quantities vary in relationship to UPP and Road map since retailers drive them.

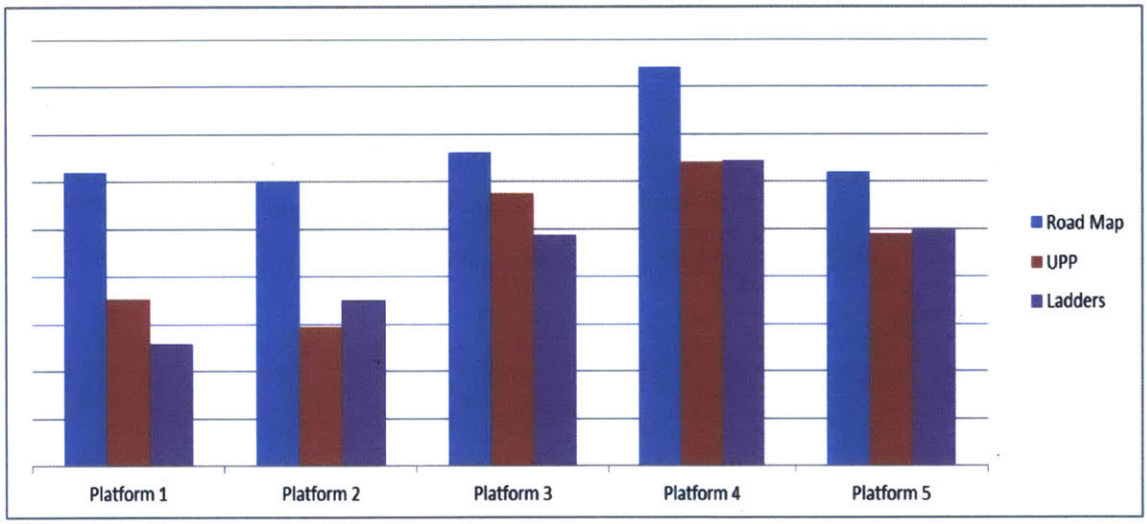

Figure 21 - Back to School Different forecasts

The supply planners need to follow the UPP platform level number to send the signal to the ODM. The UPP is released once a month while the ladders that break down the configurations, are released weekly. When the supply planners observe a gap like observed in the figure in platform 3, they will increase the amount to order from the ODM to match the UPP number while using personal judgment to split that quantity between the configurations.

Sale through data

Throughout the lifecycle planning, actual sales through data is not measured and is not a factor in planning future SKU or quantities. When spring cycle was analyzed, it appeared that the common

reason for retailers to change the configuration later is the inability to sell inventory currently on their shelves. If sales through is tracked and analyzed, changes like these can be avoided.

Definition of Responsibilities and Roles

Dell's organizational culture strives for constant change and as such there have been many re-organizations in the past few years. As a result some planning functions switched business units or restructured based on channel, cycle or product. However, these changes have caused confusion in the objective of each business unit and distinction. Some employees remained doing the same tasks as before thus causing multiple entities addressing the same issues. When interviewed, many employees did not know what other functions responsibilities were and one supply planner mentioned when asked about his role: "we are now checking the checker who is checking the checker".

Standard processes

Currently, as there is no one defined planning process and limited analytical tools, within the different teams, there are multiple methods to plan the quantity. Each merchandizing team for each cycle takes into account different parameters to plan. The demand planners phase the ladders differently from one another. Some use seasonality index, some use the weekly run rate and some use the retailers' direct input. Since there is no IT tool, Excel spreadsheets are different across the globe. Some track sales through data, promotions and inventory level while some don't.

7. Forecast Methodology

7.1. Forecast methods

There are two different forecasting approaches- time series analysis and causal models. Time series analysis assumes that demand follows a specific pattern and that task of forecasting is based in observations of past demand.

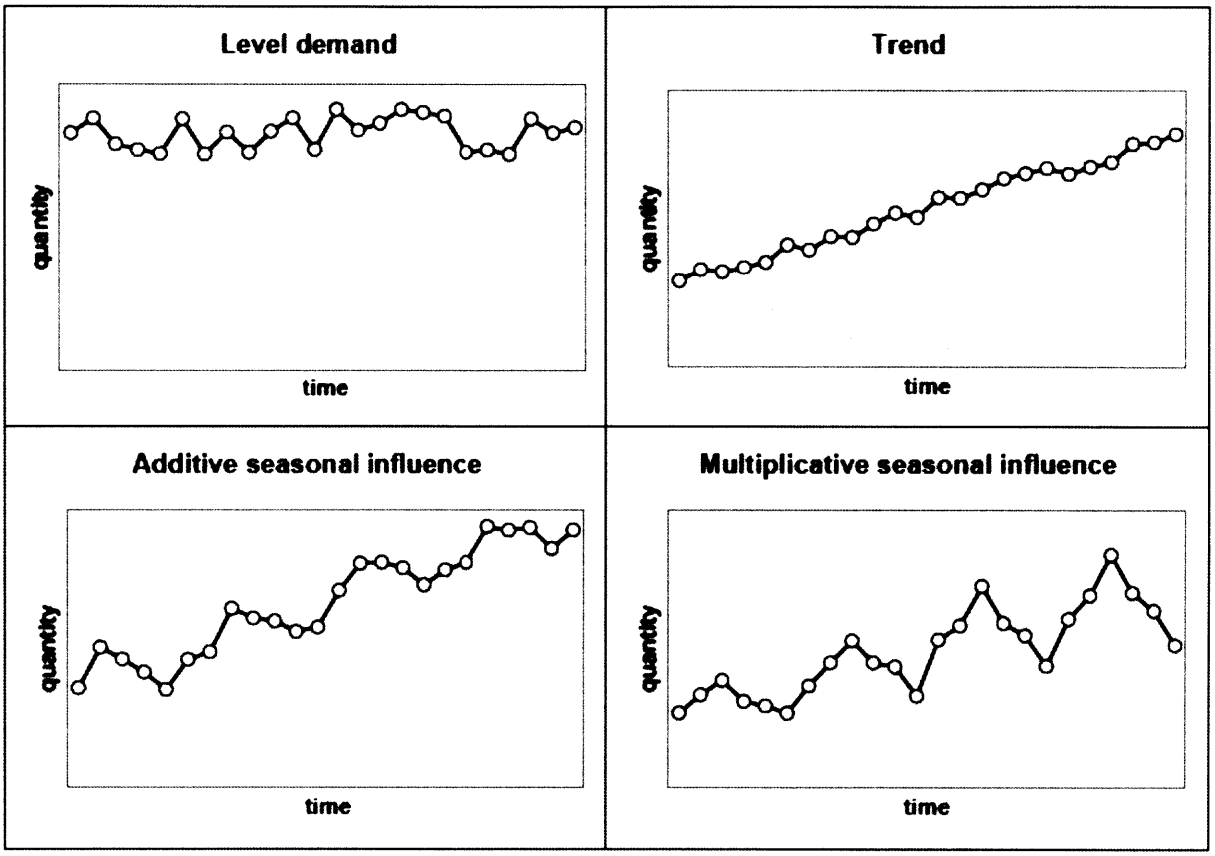

Figure 22 - Demand Patterns (Kilger and Wagner)

Time series has the following basic component:

- Level (a) – value where demand hovers around.
- Trend (b) – Persistent movement in one direction
- Seasonal Variations (F) - Movement that is periodic to the calendar hourly, daily, weekly, monthly, quarterly, etc.
- Random Fluctuations (ε) - Irregular and unpredictable variations, noise

A causal model assumes one known factor determines demand for example; ice cream demand may depend on temperature on a specific day. If there are enough observations, a linear regression can be used for estimation.

Time series techniques are chosen based on the level, trend and seasonality of past data.

1. Simple Moving Average is used when demand is level with random noise

$$X_t = a + \varepsilon_t$$

The moving average is the mean of the N most recent observations. Historical data of the N periods must be stored and more importantly equal weight is given to the N periods with no data prior to that.

2. Simple Exponential Smoothing – mostly common used for short-term forecasting.

Smoothing constant (α) will dictate the tradeoff between past and recent data.

$$\hat{X}_{t,t+1} = \alpha\, x_t + (1-\alpha) * \hat{X}_{t-1,t}$$

The weight of the observations is exponentially decreasing with the latest demand getting the highest weight.

3. Holt's Method – smoothing constant for level (a) and trend (b).

Forecast Model:

$$\hat{X}_{t,t+1} = \hat{a}_t + T * \hat{b}_t\text{l:}$$

Where:

$$\hat{a}_t = \alpha\, x_t + (1-\alpha) * (\hat{a}_{t-1} + \hat{b}_{t-1})$$
$$\hat{b}_t = \beta * (\hat{a}_t + \hat{a}_{t-1}) + (1-\beta) * \hat{b}_{t-1}$$

4. Holt- Winter's Method – used when demand has a significant seasonality pattern. Seasonality in multiplicative. This is more useful in aggregate, medium range forecast. This method is efficient to forecast seasonal pattern because it smoothes the estimates for the three parameters. This method requires the most data since it requires at least two cycles of demand history. (Silver, Pyke and Peterson 1998)

Forecast Model: $$\hat{X}_{t,t+\tau} = \left(\hat{a}_t + T * \hat{b}_t\right) * \hat{F}_{t+T-P}$$

Where:

$$\hat{a}_t = \alpha\, (x_t/\hat{F}_{t-P} + (1-\alpha) * (\hat{a}_{t-1} + \hat{b}_{t-1})$$
$$\hat{b}_t = \beta * (\hat{a}_t + \hat{a}_{t-1}) + (1-\beta) * \hat{b}_{t-1}$$
$$\hat{F}_t = \gamma * (\hat{x}_t/\hat{a}_t) + (1-\gamma) * \hat{F}_{t-P}$$

7.2. Recommended Forecast Techniques at Dell

Data collected at Dell retail channel over the past three years showed that using time series on a SKU level is not effective for prediction. Each Cycle there are various different SKUs. Figure 23 illustrates the lack of seasonality for each SKU in a given cycle, mostly due to promotions, which are not reordered at Dell. Each line represents a different SKU actual sales volume. It can be seen that most SKU suffer from high variations and those are not always timed with other SKU.

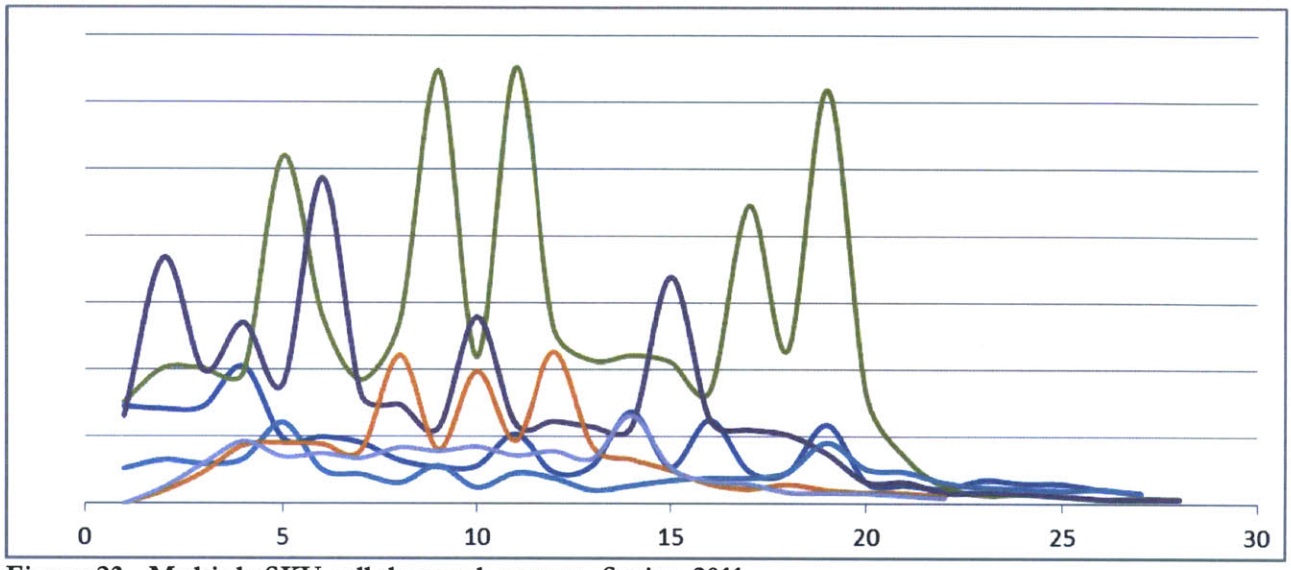

Figure 23 - Multiple SKU sell thorough pattern, Spring 2011

These SKU were not sold in the previous cycle, so the previous demand pattern is not available. Each SKU is defined by a number of attributes; therefore there are a finite number of combinations possible. Product Group ranks the different possible parameters to assign each SKU has a sequence number. That way, a given sequence demand's seasonality will behave the same in any given period. In the case that there are more than 120 SKUs, this prediction may not be accurate since there are multiple SKU that fit a customer segment. In the retail channel, promotions have a significant impact on the sales through data therefore when there are multiple SKU, the promotions can cannibalize other configurations. Based on the assumption that aggregated forecast is more accurate, a further analysis was done to observe the overall Notebooks sales thorough at a retailer since 2008.

Due to the product variability discussed in chapter 8, the seasonality in each price band at the retailer was analyzed. The findings are demonstrated Figure 24 below.

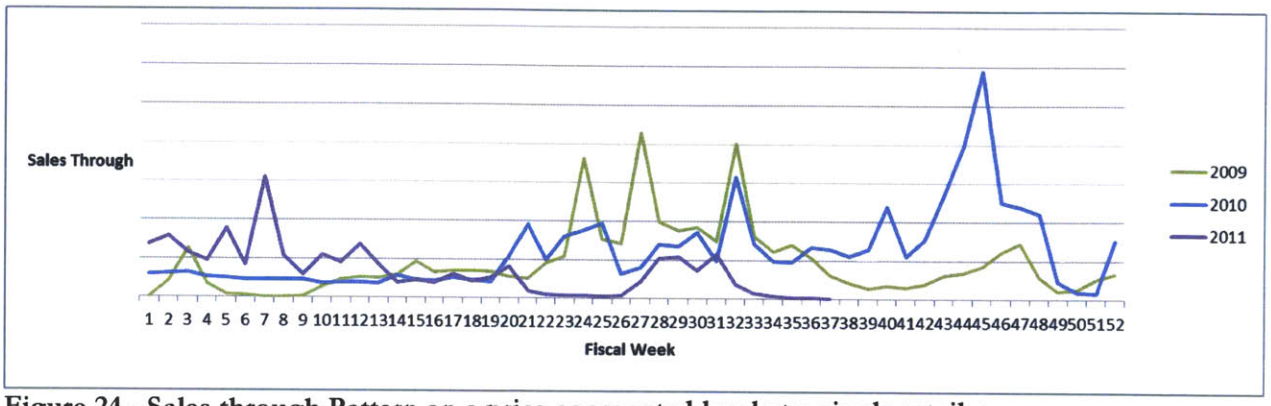

Figure 24 - Sales through Pattern on a price aggregated level at a single retailer

The data shows that there is Level, trend and seasonality so Winter-Holt's model was tested. Since promotions are not recorded in the retail channel, the seasonality index was taken from the direct channel where promotions data are stored. Figure 25 represents the winter-Holt's model that was tested. The Winter-Holt's model estimates the future demand for SKU less than $549. Winter Holt's motel smooth the seasonality therefor personal judgment needs to be applied when using this method.

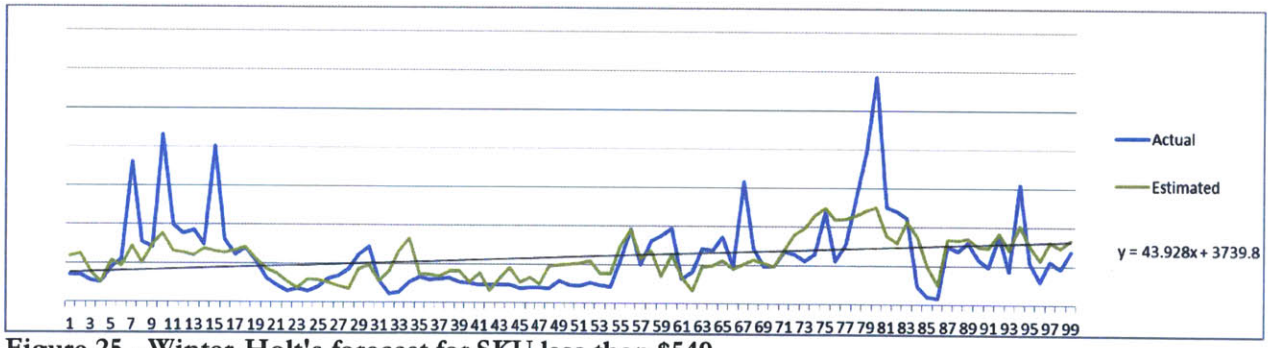

Figure 25 - Winter-Holt's forecast for SKU less than $549

7.3. Forecast Accuracy

Each forecast will always have some degree of error (Silver, Pyke and Peterson 1998). To improve forecast, one needs to start by measuring its forecast accuracy. Currently Dell is in the transformation of tracking the forecast history and measuring its accuracy. Due to the current work methods the demand planners' practice, tracking the retail channel forecast, in a later stage in the

process. Dell decided to track accuracy as opposed to error. The forecast accuracy metrics that were agreed upon at Dell are the following:

Mean Absolute Percent Error (MAPE)

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\frac{|Actual\ Sales_t - Forecast_t|}{Actual\ Sales_t}$$

Forecast Accuracy = 1-MAPE

MAPE is less sensitive to the magnitude in demand due to the fact that it is expressed as a percentage so it is valuable when comparing products with different volumes. (Silver, Pyke and Peterson 1998).

At Dell, it measures the ability to sell what was forecasted during 8 weeks span.

n=8 since the lead time is 8 weeks. The process is that a snapshot of each configuration 8 weeks forecast is stored every weekend. At the end of such period a comparison against actual sales is done.

$$Net\ Bias = \sum_{t=1}^{n} Forecast - \sum_{t=1}^{n} Actual\ Sales$$

$$Forecast\ Bias = 1 - \frac{Net\ Bias}{\sum_{t=1}^{n} Actual\ Sales}$$

The term bias means that on average, the forecast are substantially below or above the actual demands (Silver, Pyke and Peterson 1998). A high Bias error means that there is either the parameters of the demand model are incorrect or the model itself is wrong. It is difficult to detect a bias since the noise in a demand model tends to disguise it. A graph of the forecast error can indicate whether there is a positive or negative bias.

7.4. Forecast Measurements at Dell

Currently Dell treats ladders as the forecast. However, comparing Actual sales data to ladders results in a high forecasting error as seen in Figure 26.

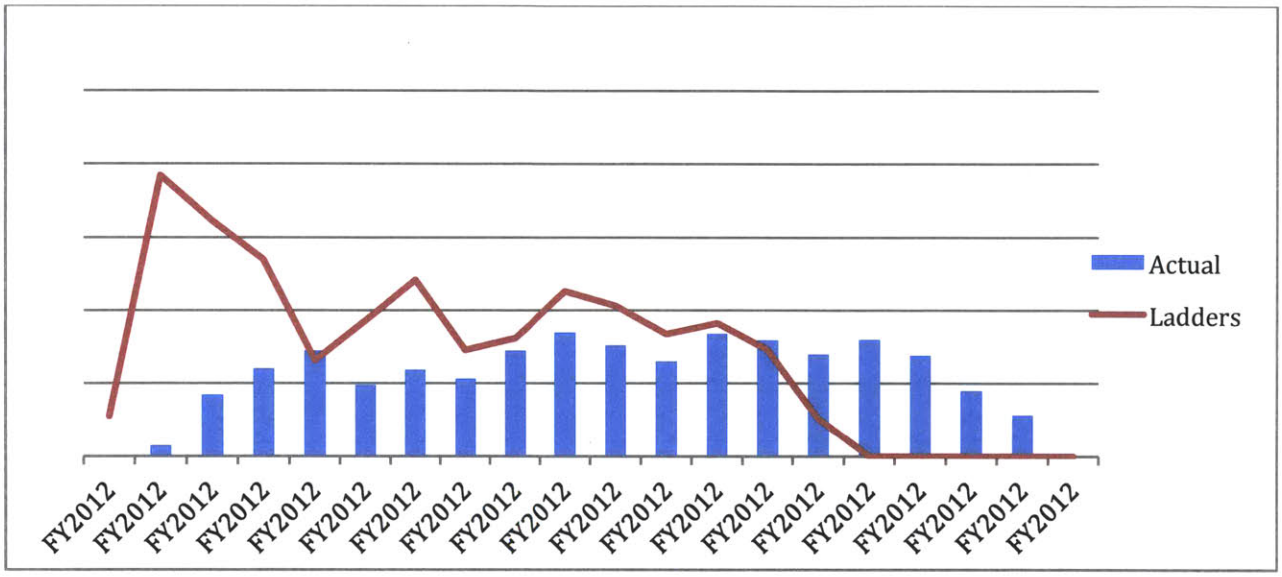

Figure 26 - Actual sales in comparison to Ladders for total laptops for a given retailer

The forecasting process that is described in Chapter 6 brings challenges to measuring the forecast accuracy. To reduce the bullwhip effect and engage in collaboration with the retailer, the actual sales and the forecast needs to be tracked and compared. To better explain the challenges, an illustrative example presented in Table 6. In the CPFR conversation, the demand planner and the retailer, each present their forecast for the actual dales and agree on a forecast. In the example, the demand planner with the help of the external consulting group forecasted 500, 700, 900, 1000, 800 for the first five weeks. The retailer forecasted 700, 900, 1100, 800,600 for the same weeks. They agreed on the following forecast 600, 900, 1100, 900, 700. Dell usually prefers to sell to the retailers earlier in the cycle and the retailer prefers to have enough safety stock to guarantee supply. The ladders are the orders made be the retailers and in most times does not correlate directly with actual sales. In the example, the ladders that were made are 1500, 1200, and 1400. The demand planner sends this forecast as the signal for the build plans. Actual sales for that time period are 650, 700, 950, 850 and 750.

Table 6 - Forecast example

	W-4	W-3	W-2	W -1	W1	W2	W3	W4	W5
Dell Forecast					500	700	900	1000	800
Retail Forecast					700	900	1100	800	600
Agreed Forecast					600	900	1100	900	700
Ladders					1500	1200	1400		
Build Plan	1500	1200	1400						
Actual Demand					650	700	950	850	750
Dell Error					150	0	50	-150	-50
Retailer Error					-50	-200	-150	50	150
Agreed Error					50	-200	-150	-50	50
Ladders Error					-850	-500	-450	850	750

When calculating the accuracy of these different measurements it is clear why ladders are not the signal to measure. The accuracy based on MAPE is shown in Table 7. The forecast accuracy made by dell and the retailers are high at above 80%. However the ladders accuracy since they are not forecasting actual sales is very low.

Table 7 - MAPE results

Plan	MAPE	Forecast Accuracy
Dell	11%	89%
Retailer	16%	84%
Agreed forecast	13%	87%
Ladders	90%	10%

Bias accuracy can reduce this effect. In the example presented the Bias accuracy for ladders will result in 95%. When comparing the different aggregated forecasts that occur at Dell based on Bias accuracy, it is seen that the ladders are a better indicator of the overall sales than the roadmap and UPP. Figure 27 - Bias accuracy demonstrates the differences

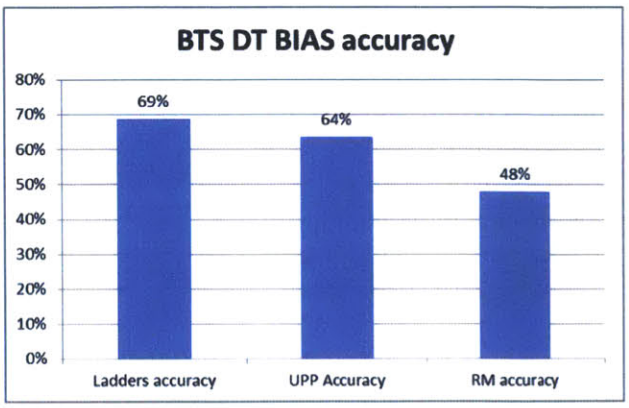

Figure 27 - Bias accuracy

It is likely that the ladders bias is higher due to more certainty and information from the retailer exists when they are initially calculated.

Assuming that the ladders are an indicator of the actual market dynamics is incorrect, so keeping track of that accuracy is redundant. To understand the forecasting trends, the demand planning organization needs to track the forecast and actual sales. Store the different forecasts on a regular base and measure the retailer, Dell and the agreed forecast in comparison to actual demand. With time, if Dell's internal forecast is tracked, Dell can present the findings to the retailers and slowly gain more credibility and power when recommending a forecast and a replenishment plan.

7.5. Forecasting and Replenishment Improvements

The Overall forecasting process relies on the execution of an S&OP process but it can begin with the demand planner's roles. A forecasting and replenishment tool was implemented for the demand planner's use to give a forecast recommendation for the retailer and a replenishment recommendation based on weeks of supply targets.

Inputs

Seasonality Index – seasonality index needs to be calculated annually based on sales through data

Selling dates – Launch date and planned end of life date

Display units – Units physically displayed in retailer stores. This number will not be taken into account during replenishment

Lifecycle Target – Overall planned lifecycle volume

Promotions - Percentage lift that promotion would achieve for a given week

Move Factor – Activity or event known to reduce/ increase demand permanently.

Weeks of Supply – Retailer target safety stock

Planned Order Receipt – Planned Shipments

Ending Inventory – The amount of inventory Dell has left in it's supply

Product						Last week completed			Alfa (# wks)		Ours:1, Dealer:2 SellThru - Sell in		Display units	Lot size	Cycle Target
SKU ABC						30-Jan-11			29%	6	1	1	25	1	8,000
	Wk	Seas. Index	Start date	Net Sales	Promo %	promo	Move Factor %	Baseline Fct	Our ST Fcst	Dealer ST forecast	Planned order receipt	Our sell In	Ending inventory	Weeks of Supply WOS
Jan	1	0.65	1/2/11					-	-				-	
	2	0.65	1/9/11			-		-	-		558	558	558	4.0
	3	0.65	1/16/11			-		-	-		627	627	1,185	4.0
	4	0.65	1/23/11			-		-	-		573	573	1,758	4.0
	5	0.65	1/30/11			-		-	-		836	836	2,594	4.0
Feb	6	0.89	2/6/11			-		600	532		513	513	2,575	4.0
	7	1.04	2/13/11			-		600	627		594	594	2,542	4.0
	8	0.96	2/20/11			-		600	573		554	554	2,523	4.0
	9	1.39	2/27/11			-		600	836		669	669	2,355	4.0
Mar	10	0.85	3/6/11			-		600	513		598	598	2,441	4.0
	11	0.99	3/13/11			-		600	594		779	779	2,625	4.0
	12	0.92	3/20/11			-		600	554		713	713	2,785	4.0
	13	1.12	3/27/11			-		600	669		596	596	2,711	4.0
	14	1.00	4/3/11			-		600	598		456	456	2,570	4.0
Apr	15	1.30	4/10/11			-		600	779		-	-	1,791	4.0
	16	1.19	4/17/11			-		600	713		-	-	1,077	4.0
	17	0.99	4/24/11			-		600	596		-	-	481	4.0
	18	0.76	5/1/11			-		600	456		-	-	25	
May	19	0.88	5/8/11			-	-100%	-	-		-	-	25	

Figure 28 – Replenishment tool initialization

As Sale through data comes through, the demand planners must update this data and the tool will update the forecast based on an exponential smoothing forecast of the past six weeks. The demand planner now has ability to view how different promotions will affect the forecast, how delaying shipments will affect retailer's inventory as well as Dell.

Product				Last week completed			Alfa (# wks)		Ours:1, Dealer:2 SellThru - Sell in		Display units	Lot size	Cycle Target
SKU ABC				13-Feb-11			29%	6	1	1	25	1	8,000
	Wk	Seas. Index	Start date	Net Sales	Promo %	Move Factor promo %	Baseline Fct	Our ST Fcst	Dealer ST forecast	Planned order receipt	Our sell in	Ending inventory	Weeks of Supply WOS
Jan	1	0.65	1/2/11				-	-				-	
	2	0.65	1/9/11			-	-	-		558	558	558	4.0
	3	0.65	1/16/11			-	-	-			-	558	1.9
	4	0.65	1/23/11			-	-	-		1,056	1,056	1,614	4.0
	5	0.65	1/30/11			-	-	-		1,084	1,084	2,698	4.0
Feb	6	0.89	2/6/11	450		-	600	532			-	2,248	3.5
	7	1.04	2/13/11	250		-	574	599		800	800	2,798	4.6
	8	0.96	2/20/11			-	478	457		91	91	2,432	4.0
	9	1.39	2/27/11			300	478	1,084		267	267	1,615	4.0
Mar	10	0.85	3/6/11			-	478	408		238	238	1,445	4.0
	11	0.99	3/13/11			-	478	473		310	310	1,281	4.0
	12	0.92	3/20/11			-	478	441		285	285	1,125	4.0
	13	1.12	3/27/11			-	239	267		237	237	1,095	4.0
	14	1.00	4/3/11			-	239	238		182	182	1,039	4.0
Apr	15	1.30	4/10/11			-	239	310		-	-	729	4.0
	16	1.19	4/17/11			-	239	284		-	-	445	4.0
	17	0.99	4/24/11			-	239	237		-	-	207	4.0
	18	0.76	5/1/11			-	239	182		-	-	26	
May	19	0.88	5/8/11			-	-	-		-	-	26	

Figure 29 - Replenishment tool update

The next step is to replicate a tool like this in the current supply chain IT tools, track the forecast and allow clear visibility to different stakeholder of the data.

8. Dell Supply Chain Model

8.1. Background

Dell has historically employed a Build-to-Order supply chain strategy to directly serve customers. .Changes in the, customer preferences, have required Dell to modify its direct model. There has been a shift in product demand away from desktop computers to mobile devices (such as notebooks, tablets, and phones) and most recently to virtual solutions through the utilization of cloud computing. The PC market as mentioned in section 2.2 has become a commodity due to decrease in price and price pressure from suppliers that decreased margins.

Two of many strategies that Dell decided on had a significant effect on the supply chain: Adapting its manufacturing strategy through the use of third-parties and entering the retail channel.

The use of manufacturing partners enables Dell to build products in a cost-competitive manner with potential trade offs in long lead times.

In 2007, Dell entered the retail Channel and realized a need for a different structure as retailers now ordered in bulk and according to the retail cycle. In the historical Dell, an order of 10,000 would be treated as 10,000 different orders. Realizing these changes, require a different strategy, Dell formed a new strategy named Build to Plan (BTP)

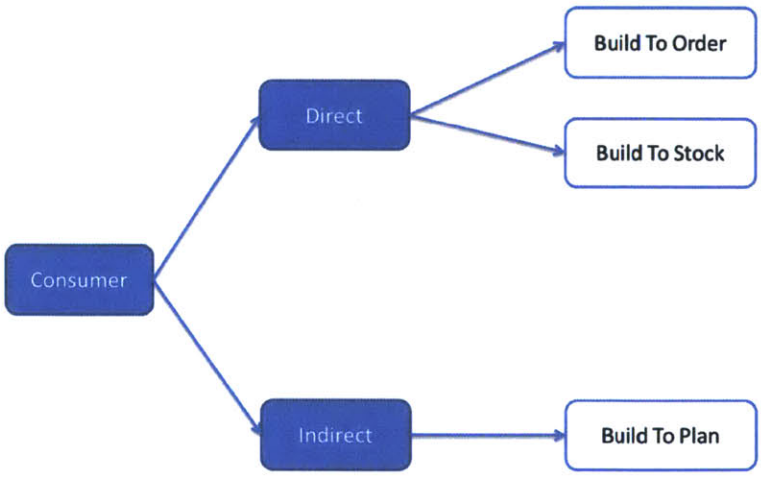

Figure 30 - Consumer segment supply chain strategies

Currently Dell has three different fulfillment methods that have different planning processes, transportation methods and inventory policies.

Segment	BTP (Build to Plan)	BTS (Build to Stock)	CTO (Configure to Order)
Segment Description	Build to forecast based on customer order plan.	Select configs built to forecast and held in region as FGI	Customer selected configs built/ shipped to order.
Target Customer	Large accounts with planned orders for standard/locked congifs	Any customer desiring next day ship of a pre build configurable platform	Any customer looking for fully configurable order.
Forecast Approach	• Unit Purchase Plan at Family Level • Production/Resource Planning down through Options Level		
Transportation Method	• Primarily ocean • Air as needed		Air
Personalization & Customization	Locked configurations	Limited: services, S&P, accessories	Unlimited

Figure 31 – Segment Definitions Summary

Figure 31 describes the difference in strategies within Dell. Build to Order is the historical Dell strategy where customers configure the product and the product is made once the customer order is made. This method does not have any inventory and is shipped via air. The BTS method is currently used for selected configuration with high volumes that can be used for special promotions or as configurable products to respond to customer needs. These products will be shipped via ocean and held in region as FGI in the US to allow shipment to customers with 48 hours. Currently approximately 50% of the Consumer Direct channel is using BTS. Build to Plan is a new term introduced by Dell and is made for customers mostly in the retail channel where they have large accounts and locked configurations. Configurations are built based on the forecasts and shipped based on customer PO (purchase order). This method requires collaboration planning and will be shipped by ocean directly to customers under the assumption that no customization is made. The Large enterprise and public segments supply chain operate under CTO.

Literature recommends using a Push strategy (Build to Stock) when uncertainty is low, long lead times, few product lines, few schedule changes and costs are reduced due to economies of scale (Simchi-Levi, Kaminsky and Simhi- Levi 2008)

A Pull- Based system (Build to Order) is harder to implement when lead time are long. It is more suitable when demand is uncertain and there is a need to customize products and there is a short lifecycle time. The goal of Build to Order is mostly to reduce inventory and reduce capital costs.

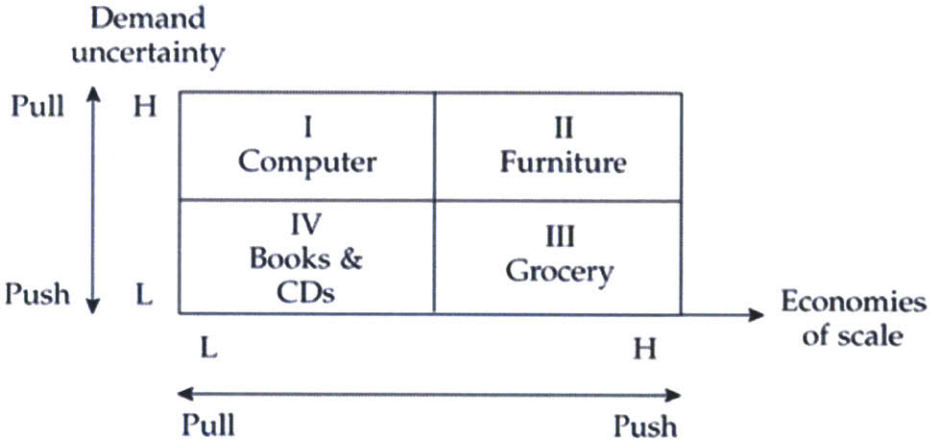

Figure 32- Matching supply chain strategies with products (Simchi- Levi, 2008)

Build to Plan is a term that symbioses BTS and BTO. The retail channel demand is derived from the different lifecycles and is not as stable as the grocery market. Retailers are changing their retail orders and configuration up until the two-week time frame allowed by contract. This is in contradiction to the assumption that configurations are based on retailer orders and are stable. Ocean shipments are challenging since retailers are changing their orders while products are on the ocean and there are still air shipments for promotions or last minute change in configurations.

In the past, companies would agree on one supply chain design and apply it to all different channels and products. As complexity increases, this assumption is not necessarily true. Fischer argues that the root cause of many supply chains is a mismatch between the type of product and the type of supply chain. (Fisher 1997). Fine noted that the speed of which technology change in a particular industry affects operations strategy (Fine 1998). The distinction between functional products and innovative products where innovative products are characterized by fast technology innovation speed, short life cycle, high product variety and relatively high margins can explain the need for a different supply chain in the PC industry. It is possible to segment the supply chain based on volatility and volume as described in Figure 33. There is room to suggest that a mix of Build to

Stock vs. Build to Order based on product would be less costly and more efficient. Managing Products in Quadrant 1 with BTS fulfillment method and those in Quadrant 3 with BTO fulfillment method.

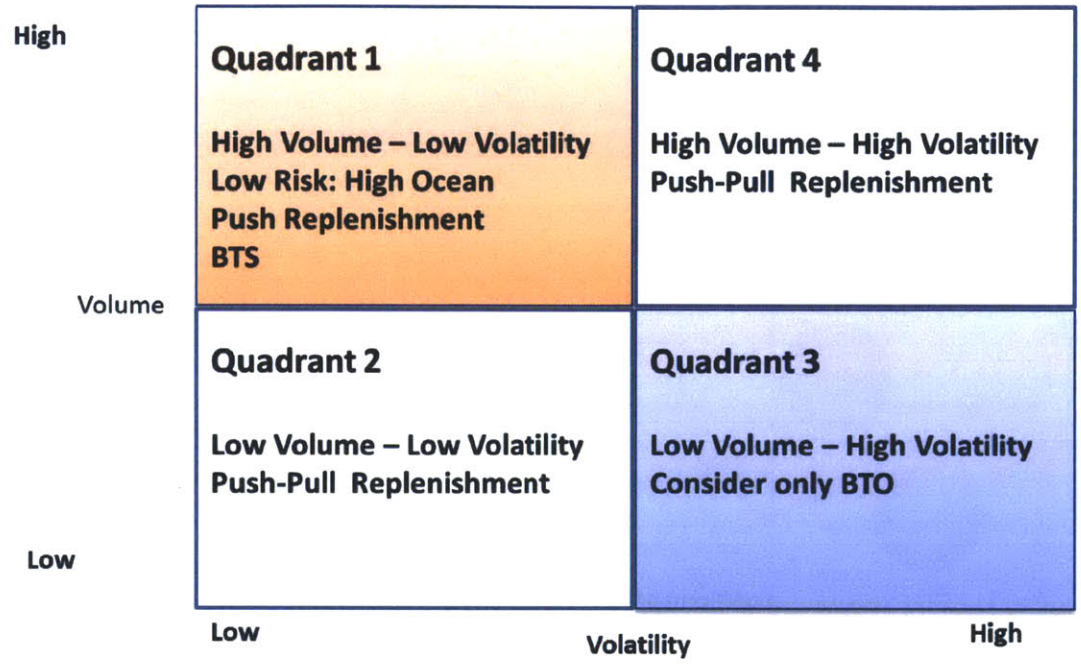

Figure 33 - Supply Chain Segmentation

8.2. Coefficient of Variance

A method to segment the different products is by Coefficient of Variance, which is defined as the ratio of the standard deviation σ to the mean μ. This measure can help assess the volatility in demand each product is experiencing.

$$c_v = \frac{\sigma}{|\mu|}$$

Figure 34 illustrates the coefficient of the products sold to the same retailer as a function of volume sold. The size of each bubble demonstrates the margins of each product. The products can be divided into high-volume and (1) low coefficient of variance, (2) low- volume and low coefficient of variance and (3) low volume and high coefficient of variance. It is recommended to avoid the 4th quadrant – high volume and high coefficient of variance since it's costly to support. Products in 1st quadrant can benefit the BTS model, as demand is relatively stable while products in the 2nd quadrant may need some postponement strategy for the products in lower demand. The 3rd quadrant products are the ones that cause Dell's supply chain most uncertainty. These products weekly sales rate vary each week causing the supply chain predicting the weekly run rate, causing replenishment

to vary and retailers are constantly short or in excess of these products. The margins of each product were also calculated, verifying that the products with low or negative margins suffered from high coefficient of variance. These products are prone for more promotion activities and discount causing this high coefficient of variance.

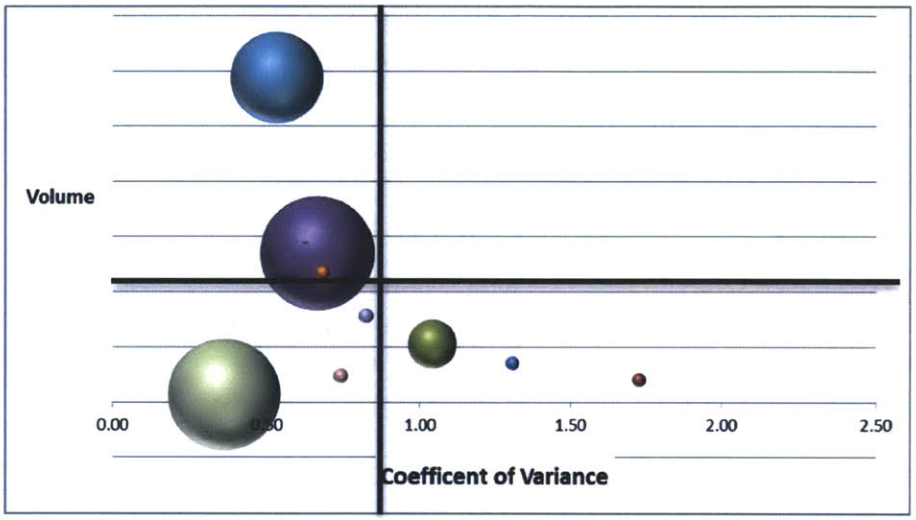

Figure 34 - Coefficient of variance for different products for retailer X

Due to the law of large numbers, coefficient of variance decreases as demand increases. This implies that aggregated forecasting is more accurate than the forecast of its components (Rosenfield 2005). Organizations often develop an aggregated forecast for all products or channels and then disaggregated this forecast to its complements. Data aggregation is a key assumption in the top down forecast. (L. Lapide summer 2006)

As explained earlier, the PC market in the retail channel has become a commodity thus price has a high impact on the sales. In the consumer electronic, products are already segmented into the price band. To verify the assumption above, Figure 35 demonstrates the coefficient of variance when products are aggregated by price. This aggregation proves that the low-end price range products have lower margins and have the higher volatility.

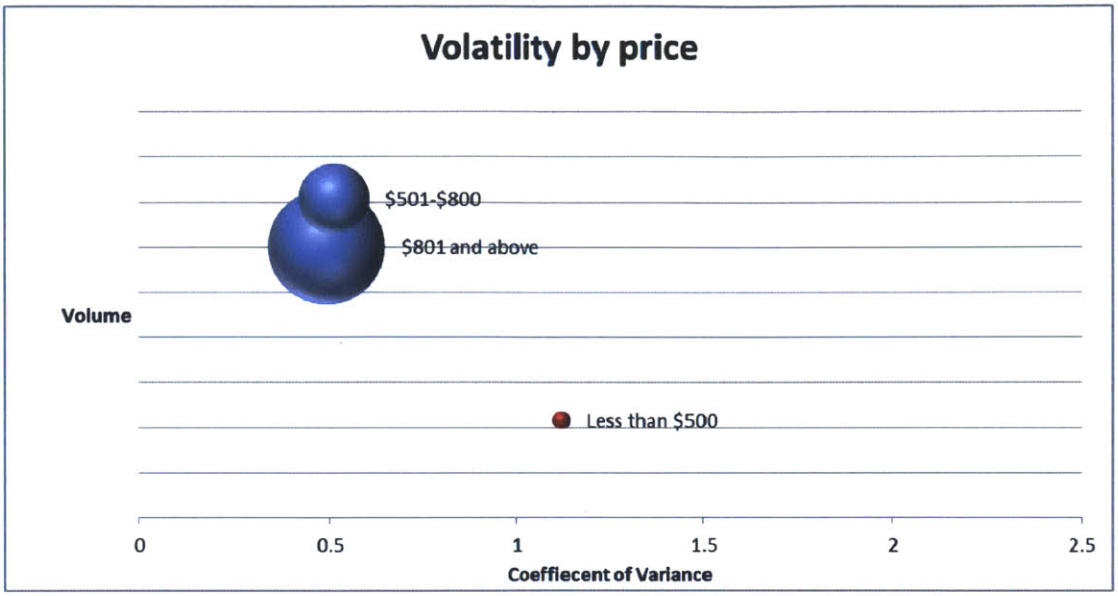

Figure 35 - Coefficient of variance aggregated by price

This breakdown of products implies 2 conclusions:

1. Aggregate based on price band
2. One size does not fit all - Different Products require different supply chain. The low end products (Less than $500 price band) have low margins and high variability. Using Build to Stock for these products will not be profitable and will risk Dell to have high cost of inventory and scrap.

As shown in Figure 36, the analysis for all notebooks sold throughout 2011, shows that although the trend is slightly less visible, the low margin products are the ones driving the high volatility.

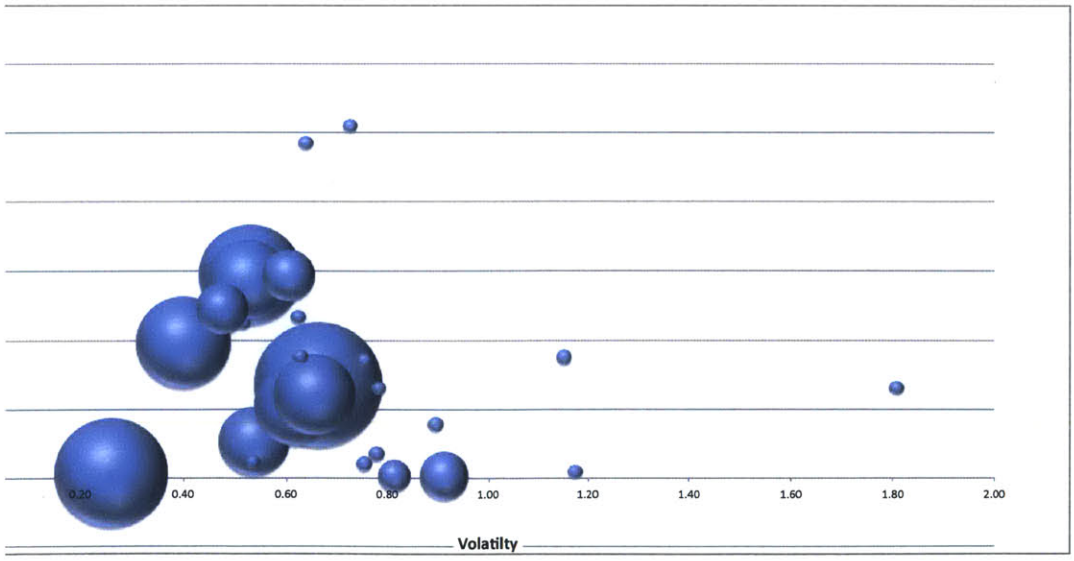

Figure 36 - Coefficient of Variance, Notebook 2011

8.3. ABC Segmentation

The"80 20 rule" represents the fact that for most business a small fraction of the products account for a large portion of the value. ABC segmentation refers to the segmentation of the product line into three segments based on product sales where A items are the high sellers, B are the medium sellers and C are the low sellers. Each segment is recommended to be managed in a different way to help make the forecasting more efficient (L. Lapide winter 2005-06). The retail channel at Dell in 2011 had more than 140 SKU planned for the back to school cycle. Figure 37 demonstrates how 17% SKU count for 80% of the sales volume.

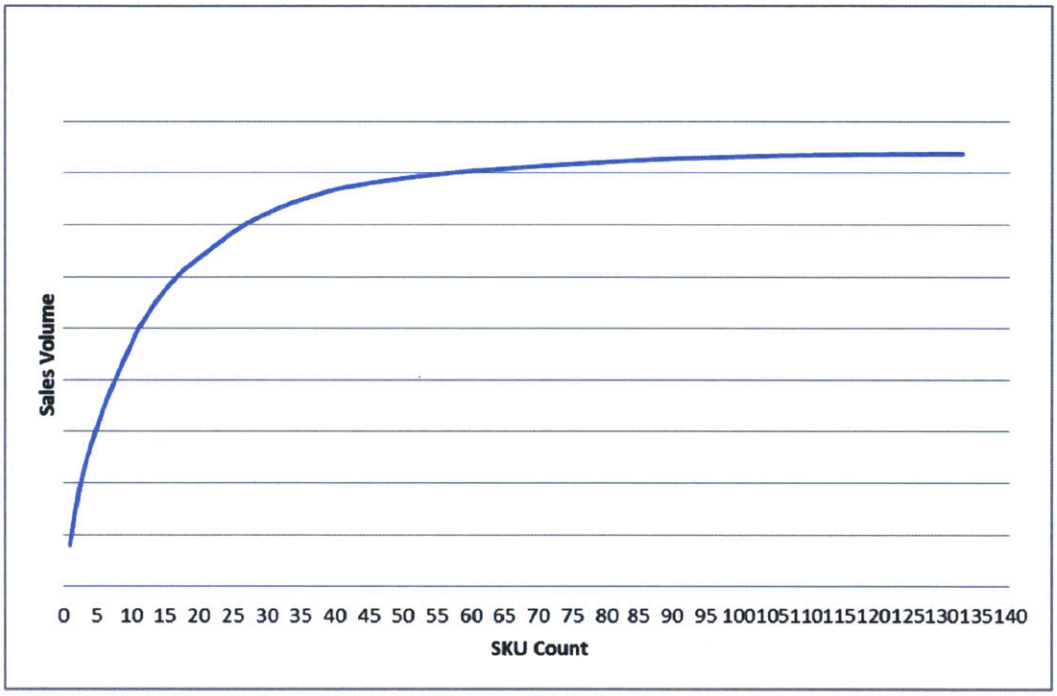

Figure 37 - 80-20 Rule at Dell retail channel

The breakdown of the SKU poses the question of the necessity of all these different SKU, when variability is high and the average SKU has low volumes. This segmentation does not take into account the demand variability so forecasting based on ABC segmentation alone is not enough to achieve the aggregated decrease in variability.

The long Tail Phenomenon

The term Long Tail has gained popularity in recent times as describing the retailing strategy of selling a large number of unique items with relatively small quantities sold of each – usually in

addition to selling fewer popular items in large quantities.[1] As Anderson noted many online retailers such as Amazon and Netflix focus on the long tail **(Anderson 2006)**.

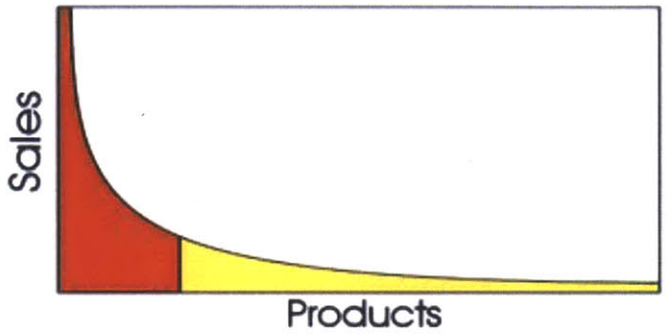

Figure 38 - The Long Tail

Simchi – Levi argues that inventory costs for low selling items are high as forecast accuracy is low, resulting high safety stock. **(D. Simchi-Levi 2010)** So when observing the long tail, one must take into account the profit margins. Even for online retailers such as Amazon, delivery lead time for some of the low selling products are longer but the business needs to define its supply chain with its business strategy.

Figure 39 illustrates Dell's Notebook sales during 2010. It is clear to see that Dell's product mix has a high number of products that are on the long tail. However, over 50% of these SKU's have low margins (Lower than 1%). According to Simchi-Levi, pricing strategy needs to be aligned to supply chain strategy. If a firm competes based on price, a different supply chain is needed – a firm that that has low profit margins due to low-pricing strategy, must focus on reducing operating costs. **(D. Simchi-Levi 2010)**. Dell's PC are currently competing on price in the retail channel so to reduce operating costs, one must consider a different supply chain strategy.

[1] Wikipedia – Long Tail

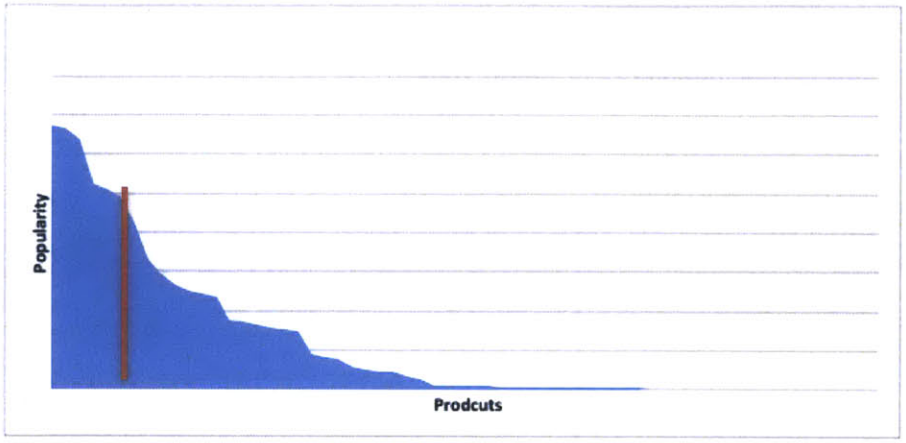

Figure 39 - Dell's sales Distribution

9. Recommendations

9.1. Planning Process

As discussed before, multiple SKUs can meet customer demand, and promotions will largely impact the consumer's final purchase. Since Dell does not control the final price and promotions, they cannot directly shape demand. In addition, since each cycle may contain entirely new SKUs due to rapidly updated product lines, it becomes difficult to base future forecasts on past SKU performance. Based on the premises that an aggregated forecast is less prone to variation and price is the most important consumer driver, demand planners should forecast on an aggregated level based on price band. To prove this assumption, further data gathering is required that currently is not collected at Dell (see future work opportunities). Additional data, such as past promotions, retailers' sales through data and final selling prices could contribute to a more in depth analysis.

Currently, demand planners do not have input into the overall lifecycle volume quantities that drive the upstream supply chain. Prior to a planning cycle, demand planners should make a recommendation for the overall lifecycle volume based on sales through data.

Merchandizing should release the roadmap once a week, and based on the platform and recommended retail price, forecast on an aggregated level using time series. For a price band level, past performance is available so time series is applicable. To decide the quantities of the different peripherals, the demand planner should use attachment rates (Good, Better, Best), which is a common term in the industry. These attachment rates can be assigned based on past data. Based on the S&OP process, sales and marketing, supply chain and finance should meet on a regular basis (optimally weekly) to discuss the updates of the retailer's feedback and different trends in the market. Once they agree on a baseline forecast, one signal should be sent upstream. Once the SKUs are locked, the aggregated forecast can be divided according to the agreements with retailers.

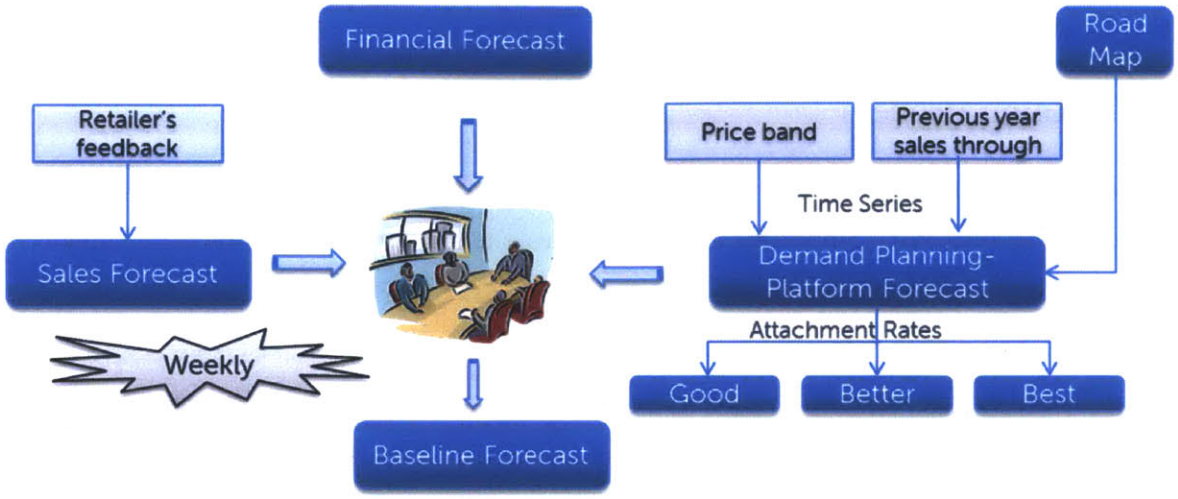

Figure 40 - Recommended planning process

Figure 41 gives an overview of the revised planning steps. Promotions should be planned far in advance, once the final SKU and volumes are known. Demand Planners should use the seasonality index and the planned promotions to build an initial weekly forecast. Based on weeks of inventory wanted at the retailers, along with lead-time, a replenishment recommendation should be discussed with Supply Planners concerning the build plan and confirming supportability. Given these demand and shipping constraints, demand planners must create an optimized replenishment plan. When the cycle begins and sales through data are received, forecasts should be recalculated based on exponential smoothing, and replenishment should be updated. The current DCM should support this process, so that each forecast can be stored, tracked and measured for forecast accuracy.

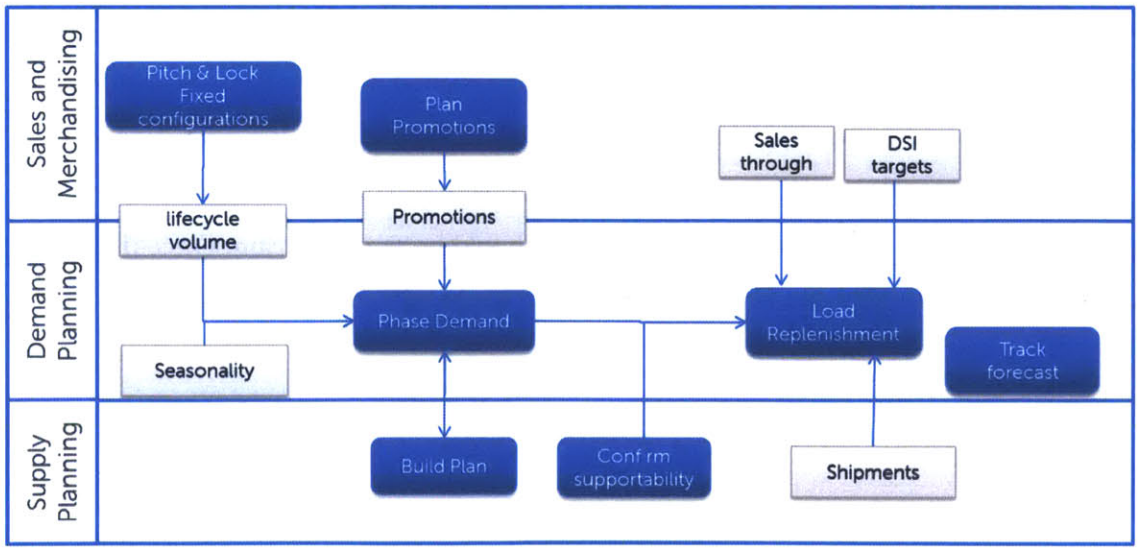

Figure 41 - Recommended Process during the execution phase

9.2. SKU Complexity

Dell has been shifting away from manufacturing all of its products for some time now. In order to achieve maximum value from this shift, Dell needs to reduce the number of SKU's offered to the retailers. The analysis has showed that there are a large number of configurations that add limited dollar value but add complexity to the supply chain. The benefit of the additional volume may be reduced due to carrying costs of extra inventory, and scrapping obsolete inventory, and concessions made to the retailer to sell off old inventory. Competitors such as Apple already proved that consumers are willing to accept limited variety in return for high quality products. With the given SKU complexity, forecasting on a SKU level is close to impossible. If SKU reductions are not feasible, the goal should be to align the planning process and minimize uncertainty throughout the chain.

9.3. S&OP Implementation

S&OP is a complex process to implement so it is vital that a top executive lead S&OP. For successful implementation, the S&OP process should be aligned with the consumer strategy and Dell's overall business strategy. Currently, sales executive management approves the forecast, but all management executives including supply chain should also approve. Based on best practices, demand planners need to have ownership of the planning process from start to finish, which may imply reorganization of the demand planners. A clear definition is needed of what forecast each business unit is responsible for, what numbers are they allowed to change, and what numbers drive actual production. The process needs to be communicated to all stakeholders to avoid churn of information.

9.4. Information Technology

To have a successful planning process, all stakeholders need access to the same information. Master Data Management (MDM) has the objective of providing processes for collecting, aggregating, matching, consolidating, quality-assuring, and distributing data throughout an organization to ensure consistency and control in the ongoing maintenance and application use of this information (cite source). In the course of transformation and normalization, standards for product IDs and other formats are first needed in order to ensure data consistency. The start of such a process in the retail channel can begin with a common unique identifier for each product.

Such processes generally result in central data repository, from which all data requests can originate so that all parts of the organization are working with the same data.

The IT toolset must also be capable of tracking forecast accuracy, but only as a means to better meet customer demand. A standardized method to measure and judge forecast accuracy is the first step, but measuring accuracy in an of itself is not the end goal. With the given complexities, demand should be planned on a aggregated level as described above. In addition, true demand must be tracked by storing actual sales data and promotions. IT tools should be designed to allow easy storage of that data and access throughout the channel.

9.5. Retail Channel

Current incentives to sales teams are based on 'sales-in' performance, thus increasing the bullwhip effect. These incentives could be restructured in order to soften the impact to the upstream supply chain. Also, retailers have the ability to back out on their order commitment up to two weeks before the MABD while products are already in shipment. This causes excess inventory, and many planners across the channel hedge their forecasts to avoid it. To reduce uncertainty, Dell needs to renegotiate the current contracts that give them flexibility in configurations and quantities. These agreements were made when Dell was first entering the retail channel; abut now they should reconsider these terms.

In addition, the push towards achieving 100% ocean shipments causes extra costs of inventory and retailer concessions. As the analysis suggests, there are a number of low volume SKUs that have a high coefficient of variation. As seen in Chapter 8, the products in the fourth quadrant have high uncertainty and Dell should consider a postponement method of either shipping these products by air after the retailer fully commits to these orders, or to do final assembly of these products in the US to reduce the costs of scrap and concessions.

9.6. Future Work Opportunities

The following areas may be of interest for further study in relation to this work:

- Transportation Optimization – As manufacturing has moved outside of the United States, transportation has become a focus for reducing costs. However, due to high oil prices, shipping by air has become far more expensive and there is a trend to ship by ocean. Shipping by ocean causes long lead-times and increases uncertainties when forecasting. There are additional costs besides transportation that should be taken into account such as

costs of stock out or excess inventory (promotions, scrap, transshipments) to find the appropriate allocation for ocean shipments. An analysis could be performed to study how to optimally ship orders given the different costs involved.

- Postponement Strategies – In order to reduce uncertainty in the supply chain there may be room to consider a postponement strategy in which final customization is done in a location physically closer to the retailer. Currently, retailers have specific requests for packaging or custom SKU. If Dell chooses to allow these options, postponement is a method that can reduce uncertainty and the bullwhip effect but requires further planning and capital investment that needs further investigation.
- Contracts with Retailers – The current contracts with retailers allows the retailers flexibility with purchase orders, lock dates, configuration changes and more. An investigation can be done to determine if these contracts can be renegotiated. Given the short life cycle of the PC, there is an opportunity for revenue sharing and profit maximization for the retailers and for Dell do reduce overage and underage costs.
- Optimal Number of configurations – With the different initiatives to reduce SKU complexity, a more analytical approach is needed to determine the optimal number for configurations that will provide maximum profits while maintaining the current retail partners.

10. Summary

As businesses goal is to generate profits, forecast accuracy is merely a metric to view alignment with market dynamics. However, improving that metric has large implications for inventory costs, transportation costs, cost of stocking out and more therefore can reduce operating costs.

The initial step for improvement would be to identify the current performance and gaps in current process. Consequently, a key component for Dell is to begin measuring forecast and actual demand instead of short-term sales metrics. The foundation for good planning lies in the organization processes, knowledge sharing and collaboration. S&OP and CPFR are initial steps towards collaboration but the key for success is executive engagement. Forecasting is art and science-quantitative analysis integrated with qualitative personal judgment based on experience. Following best practices that are described in this research can help Dell, with its experience, to integrate the two.

It is essential that Dell continues to invest in improving the current IT tool capabilities. Visibility of actual demand data and the forecast to all stakeholders in a clear consistent method can reduce overlaps in responsibilities and improve work processes. Forecasts, promotions and prices needed to be saved in one database to allow measurements, forecasts improvements and better statistical analysis.

To improve the effectiveness and profitability of the retail channel, Dell needs to continue to adjust its build to plan supply chain and match it with the products offering, order variability and lead-time and understand the tradeoff between those.

After demand-planning processes are mastered, then there is an opportunity for more advanced collaboration schemes such as demand sensing which are more relevant to immediate responses to market changes.

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Appendix A. Dell Terminology

Build-to-order (BTO): building a product once a customer has made a purchase

Build-to-plan (BTP): Build to Plan: building products according to a life cycle schedule or predetermined agreement

Build-to-stock (BTS): building products according to forecasts and holding the product in a finished goods inventory position

CTO: Configure to Order

CPFR: Collaboration, Planning, Forecasting and Replenishment

DCM: Dell Channel Management

EDI: Electronic Data Interchange

FGI: Finished Goods Inventory

Lead-time: the amount of time from when an item is ordered to when it arrives.

MABD: Must arrive by Date

MPP: Master Production Plan – Production Forecast by LOB and Platform

MRP: Material Resource Planning

ODM: original design manufacturer

OE: This is the data when the customer places the order

PC: Personal Computer

PFLP: Platform Family Level Planning

POR: Plan of Record

SKU: stock keeping unit that is a number or code used to identify each individual product that a company has for sale

S&OP: Sales and Operations

UPP: Unit Production Plan