Managing Bullwhip Effect: Two Case Studies

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Managing Bullwhip Effect: Two Case Studies

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Abstract

The purpose of this article is to present two examples based on real life experiences where the Bullwhip effect in supply chain is considerably reduced. Both examples relate to the consumer durables industry in India. The first example uses Enterprise Resource Planning and Vendor Managed Inventory as tools to reduce the Bullwhip Effect. The second example uses a modification of the classical inventory control policies to eliminate Bullwhip Effect. Based on these two empirical case studies, we argue that managing Bullwhip Effect is a strategic initiative by organization and the best approach is a combination of several tactical initiatives.

Introduction

Bullwhip Effect (BWE) is a well researched and documented topic in the area of supply chain management. At the basic level it refers to the propagation of demand variation at the upstream elements of the supply chain partners in the organization. The concept of BWE was introduced with an analytical frame in Lee et al (1977a). An article explaining the implications of BWE to managers was elaborated in Lee et al (1977b). In a subsequent review Lee et al (2004) the authors discuss various research initiatives in supply chain literature arising out of the need to understand the causes resulting to Bullwhip Effect, means to quantify the effect, responses and methodologies used by organizations in responding to BWE.

At the macro level BWE induces inefficiencies in production, scheduling (capacity utilization), sourcing, distribution, revenue generation and its realization. At the operating level, it generates more (additional) inventory and keeps it in the most inappropriate place, to meet a specified service level. At the performance level it can reduce the velocity of cash, destroy potential revenue and erode (in a significant way) by price discounts the revenue realization. It can potentially dilute a competitive (strategy) and position and therefore can be a strategy buster.

The best example for sequence of tactical errors that can happen on account of BWE to erode the competitive positioning of an organization to documented in the HBS case on Procter & Gamble. We capture the essential abstraction of this in the next few paragraphs.

- The demand forecast at the upstream of a supply chain is based on the actual demand plus a noisefactor. Thus, in reality the input available for demand forecast is not real, it is a distortion based on the perception of the channel member or a supply chain partner close to the demand.

- Based on the inflated demand, capacity enhancement decisions (or sourcing contracts have been obtained) which partially or fully contribute to the increase in the fixed cost leading to a competitive disadvantage position.

- In a competitive set up, the pressure to utilize the installed capacity to achieve economics of scale is high, leading to a rate of production and higher than the consumption rate.

- The inventory flow in the system and stock levels at various stages in the supply chain are driven by the complicated dynamics of price discounts and economics of transportation.

- Thus, even when the production is more than the projected demand, stock may not be available to service a specified demand.

- If there is a conflict of interest among various members of the supply chain, the system would accumulate finished good inventory, resulting into various price discounting schemes and consumer inducement mechanisms.

- Once the product promotion schemes are in full swing, the demand realized and reported are distinctly different from actual demand. Thus, forecasting irrespective of the sophistication of the tool used is at best an approximate and some times

dangerously unreal. Accordingly the stated competitive position of the organization is either destroyed or diluted.

In the context of P&G (HBS case - 1995) the brand position of the product (premium price) was diluted to discount based sales and hence leading to lower sales realization. As a consequence of BWE and plethora of discount sales introduced by the company, the trade started buying the product to stock rather than to sell. Trade made money by taking advantage of contradicting sales discounts and promotional schemes. This further lead to demand profile distortion and inaccurate forecasting.

According to Lee et al (1977a), the BWF is a consequence of one or a combination of the following four important aspects related to supply chain management. These are (a) demand forecast updating by supply chain partners (b) order batching to take advantage of transportation economics (c) price fluctuation (leading to distorted consumption pattern) and (d) rationing based on demand supply imbalances. It may be worthwhile to reiterate the BWE is not only caused by anyone of these aspects of the supply chain but also due to any combination of these aspects.

In the cited articles several managerial responses to stem or contain the BWE are suggested. They include use of point of sale data to forecast demand, electronic data interchange (EDI) for order information sharing, vendor managed inventory, discount for sales information sharing, lead time reduction, combining truck delivery, internet based ordering, every day low price (EDLP), activity based costing, sharing sales, capacity and inventory data (to avoid shortage gaming), allocation methodology based on past sales etc. It is useful to note, that these measures would contain one of the reasons responsible for BWE. A successful strategy to contain BWE would require combination of several such measures in a judicious way based on the context.

Before we proceed with our examples of situations which have successfully contained BWE, it is worthwhile to summarize two important observations related to BWE in the cited references.

- BWE is not an external phenomena. The industry is governed and influenced by the external environment. BWE is an internal (firm level) response to the environmental phenomena.

- BWE is a consequence of rational behaviour of the supply chain partners. It usually reflects when partners operate in isolation and optimize their individual objective function. Accordingly, there is no coordination among the supply chain partners or if it exists it is weak.

In the remaining part of this article, we present two Indian case studies where an appropriate managerial response to BWE was implemented. We conclude this article with a broad framework and a methodology to contain BWE in a wide range of supply chain environments.

Case Study 1 – Hindustan Oil Company[*]

HOC Profile: This case study pertains to an FMCG company called Hindustan Oil Company (HOC), which is in the business of branded hair oils, edible oils, fabric care, skin care and processed food. It recorded a turnover of Rs. 8 billon in the year 2003. ROC was larger than 30%. Sales has registered (during 1999-2003), a combined annual growth rate of 6% and the corresponding profit figure of 16%. HOC reached nearly 100 million people through 1.7 million retail outlets. In addition, it sold 46 million consumer packs every month, reached 18 million households and employed 1000 people.

Growth Strategy: The primary focus of the business strategy is to aim market leadership, by building brand, strengthening the distribution system, controlling cost and use innovative management practices to support the business activities. HOC has significant presence in the global market. HOC wanted to support its growth plan by increasing use of technology, value added products, repositioning hair oil (a commodity) as a personal care product and converting edible oils as a nutrient based product.

Managerial impediments: However, there are number of issues which did not allow HOC to grow rapidly. They included inaccurate forecast (non sophisticated mathematical models resulted this), sales opportunities lost as a result of mal-distribution, non availability of stock and low delivery performance reflected in unacceptable service level. There were issues related to shrinkages, damages and product sold in the market after the

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[*] While the discussion presented in this section is based on real life experience, the name of the company is changed to protect the business interest of the organization.

useful life time. Information availability on stock was sparse. Departmental silos and myopic approach to business lead to sub optimal solutions. As a consequence of inter departmental transfer of stock, and high inventory at various locations contributed to the increased cost of delivery.

Supply Chain Structure: The supply chain consisted of a network of plants, depots, distributors and retailers. HOC managed 12 brands in 100 stock keeping units (SKUs). The distribution network was complex. 98% was unorganized. HOC owned 6 factories and had long term arrangements with 15 contract manufacturers. 32 Stock locations, 1000 distributors and 1.2 million retailers enabled HOC to reach the relevant customer segment. The manufacturing activity was relatively simple. No major capacity constraints were anticipated. Part of the capacity cushioning was facilitated by contract manufacturing. Sourcing was restricted to commodity buying. A handful of items were purchased based on commodity auction.

Sales Fluctuation: The sales widely fluctuated. The ratio between peak and minimum sales for popular brands over a period of a year was 3:1 (See Figure 1). Sales within a month were extremely skewed. On an equal period of 10 days (3 consecutive 10 days), the company recorded 10%, 28% and 62% sales. This meant roughly two thirds of the sales happened in the last 10 days of any month.

Planning Cycle: The planning cycle was 15 days. The planning was frozen 3 months before. Quarterly targets led to the sales push in the last month. The inevitable consequence was inventory build up, mal-distribution. Customer dissatisfaction, reduced sales, eroded profitability are the add on factors.

Information Systems: The information systems were primitive. Most of the planning systems were excel spreadsheet based. There was no system related to distribution planning. Many islands of information systems designed and developed on various platforms contributed confusion, data inaccuracy and inconsistency. There was no common database across HOC.

ERP Selection: Based on a detailed internal study, HOC implemented an ERP solution. The (ERP) selection was based on the data and process integration that can be provided

by the ERP package, rich functionality and features of the ERP product, product support services, Indian presence of the ERP vendor, recommendations by leading management consultants, track a record of the ERP vendor, ability to scale up the system and FMCG experience of the vendor company in India and abroad.

ERP Implementation: The implementation was completed with a strong commitment and support of the management. Appropriate resources were made available. Training and Education preceded ERP implementation. Counseling was available on change management initiatives. The major modules which facilitated the supply chain efficiency included demand planning (forecasting accuracy), data warehouse (reduce mal-distribution and lost sales), vendor management inventory (to improve response time).

Tactical measures: The forecasting was improved by using data on primary, secondary and off-takes in the market. The sales and marketing schemes were made uniform and robust to reduce seasonality. Target based planning was deemphasized. The last three months sales average was used to benchmark the forecast.

To reduce the skewed sales, no dumping of stocks was resorted to. Targets were based on secondary sales (between depots to distributors) rather than primary sales (between plants to depots). Excess inventory was reduced at the distributors' level based on the new stock norms proposed. Vendor managed inventory was used as a policy to refill the stock at the distributors.

Metrics: Several performance metrics related to inventory levels, skewness of sales, percentage of distributor stock out, percentage of depot stock out, excess stocks and forecasting accuracy enabled HOC to control and manage inventory flow.

Results: As a consequence of ERP implementation, changes in the inventory policy, and vendor managed inventory, the ratio of peak to minimum sales, dropped from 3 to 1.3 for the same average sale (See Figure 2). The other benefits as a consequence of taming BWE are listed in Table 1.

Areas of improvement: As a consequence of the ERP implementation, HOC can now focus on lost sales, damaged items and shrinkages. It has time and managerial energy to

concentrate on improved sales of small brands. Further, the marketing managers would be able to spend more time on sales rather than chasing stocks. The next set of improvement would come from automatic billing process, reduced skewness of sales leading to better availability of products and service levels and efforts to reduce mal-distribution.

Case Study 2 – Skittles India Limited

Profile: Skittles India Limited (SIL) was an organisation which sold a wide range of products known as skittles ex-stock. The four manufacturing facilities of SIL were located in South India. The finished products from various manufacturing locations were brought to a central warehouse in a southern metro for further distribution (through 20 branch sales offices) to customers all over the country. Every branch administered a local warehouse to receive, store and sell skittles. The twenty sales branches of SIL were grouped under five geographical regions, for sales and marketing administration.

Product(s): Skittle as a product was characterised by three basic attributes, the raw material used, final colour of presentation and the pack size in which it was offered. Different market segments would require independent products in terms of composition, colour and size. From the marketing point of view, skittles appeared in different brands, characterised by several colours within a brand and a final stock keeping unit based on its presentation in terms of size. SIL manufactured and sold 170 types of skittles under 300 brands.

Production: The production process from raw material to finished product consisted of four broad processing stages designated as A, B, C and D. These sequential processes in turn generated various sub-processes based on the end product specifications. Not all skittles needed to go through all the four manufacturing processes.

Distribution: The national distribution network of skittles resulted material flow from manufacturing locations to central warehouse, branch offices, dealers and retailers. Often skittles were sold directly to industrial customers. The fluctuation in demand (quantity) for skittles sold in the domestic market was large. Exhibit 2 is a brief description of seven representative brands. Table 2 shows actual sales and forecasts for these brands.

Competition: SIL had two national level competitors both enjoyed relatively a smaller market share. Skittles were also produced by a host of (unorganised sector) local manufacturers. Presence of a large unorganised sector producing and selling skittles at very low price characterised by dubious quality and non-uniform sizes complicated the market dynamics.

Planning: The fundamental input to logistics operations was from the marketing in terms of (where, what, when, and how much) itemwise sales plan. This was translated by logistics in consultation with production as a manufacturing plan (what, how much, when, and where to produce). After completing production, issues related to allocation (which branch would get how much of what item) was decided. The finished goods inventory distribution to branches took place according to the integrated business plan and the consequential sales plan, manufacturing plan, allocation plan and the despatch plan.

Replenishment Policy: Since SIL operated on a sale based replenishment system, reorder points and reorder quantities were calculated based on the lead time for replenishment, and its variations, combined with demand fluctuations. When stocks at the branch warehouses fell to the reorder point (ROP) level an order for reorder quantity (ROQ) was placed on CWH for replenishment. For certain class of items, a flexible reorder quantity was followed (see the note on circulation level for additional details).

Logistics Function: The logistic function was charged with the responsibility at SIL, to ensure safe custody of finished goods, stock accounting of the material received from the manufacturing locations, and accurate despatch of finished goods to various branches. On an average four trucks (approximately 10 MT each) of material arrived in a day at the central warehouse and an equal quantity of material was despatched daily from the central warehouse. Each truck contained about 300 cartons of finished goods.

Despatch Plan: This despatch plan was arrived at by considering (a) the stock available in the central warehouse (b) the immediate projected inflow from manufacturing (c) the prevailing market condition at the branch location (d) the peculiarities of the branch, item and item branch combination, (e) truck despatch plan and (f) truck availability to the branch.

Elaborate computer communication network had been set up between the central warehouse and branches so that at the end of the business day, the branches transmitted the exact quantity that had been invoiced during the day, which was converted as order pending on Central Warehouse (CWH). Based on the pending order, it took less than half a day to identify the availability of stock at the central warehouse.

At the CWH, cumulative requirement of a stock item across branches, and the stock available was compared to plan for any rationing on demand-supply. Deviations were considered on special circumstances and merits.

The CWH computer kept track of how much quantity was in circulation for a skittle, including the stock in branch, stock on transit, stock in the warehouse allocated for a branch, orders on central warehouse from branches. Normally, the physical stock in branch and the orders pending from the branch on CWH would constitute the safety stock that was to be kept at the branch for a specific item.

The replenishment system was triggered by a sale in the branch. As and when sales were invoiced, an order was placed in the central warehouse for refilling. If stock was available, it was refilled and order was responded to by a despatch. If stock was not available at the central warehouse, refill order was converted as an order on manufacturing where it joined a queue for further processing (See Figure 3).

The level of stocks maintained at CWH for a skittle was based on estimates of manufacturing cycle time and demand fluctuations on the daily forecast of all India sales (i.e. annual forecast divided by 365). Production planning at manufacturing locations aimed to maintain CWH stocks at predetermined levels based on:

- ABC classification of the item at the national level
- The stock position at CWH
- Days of stock cover (Stock at CWH divided by the average daily forecasted sales)

Constraints in production relate to lot size constraints (skittles necessarily have to be made in certain lot sizes), production line balancing constraints (balancing between whites and

colours), total capacity constraints, constraints on total quantity of specials and constraints on material availability for each stage of manufacturing.

The replenishment policy at SIL was a assortment of periodic replenishment system, classical ROP, ROQ model and a variation of ROP, ROQ model called circulation level. All items at the CWH were classified in the three district groups.

Group	Volume of sales	Demand fluctuation	Inventory Control Policy
I	Low	Low	ROP, ROQ model
II	Moderate	High	Circulation level
III	High	Low	Periodic replenishment system

The ROP was influenced by the following factors:

- Daily demand estimate (obtained by dividing the all India sales forecast by 365)
- Fluctuation factor (determined on a case to case basis for item branch combinations)
- Replenishment lead time (includes all time delays due to order communication, order processing, allocation and load building time and transit time)

ROQ was fixed at 30 days of requirement. The all India annual sales estimate was used to compute this requirement.

When ROP + ROQ was larger than a carton content, it was termed as circulation level.

When an item is under ROP, EOQ policy a refill request was generated only when the physical inventory is lower than or equal ROP. When an item is under periodic review policy, at specified intervals refill request for a variable quantity is generated.

When a item is under circulation level, the order fill quantity is increased on every occasion when there has been a real demand at the branch level. As a consequence, the amount of inventory (both virtual and physical) would remain a constant. For example, the physical stock at the branch, the quantity requested for an order fill, stock allocated for the branch at

the CWH and the goods intransit would add up to the circulation level. As and when there is a consumption at the branch, this demand is translated to a despatch (or reduction in CWH stock) which in turn places an order with the processing plants.

The concept of circulation level was extended between the CWH and manufacturing locations. The ROQ in this case was determined by the manufacturing constraints. The fluctuation factor is determined for an individual skittle at an all India level. The replenishment lead time includes order communication time, time an order waits before manufacturing begins, manufacturing throughput time, transit time to the CWH.

Reflections

We have briefly summarized the managerial approaches to tame BWE in two different contexts. The two examples have some similarities, differences and offer a unique insights related to managing BWE. The following observations are in order.

Both the situations correspond to

- Multiple products and several SKUs
- Operate under significant competitive pressure
- The elements of the supply chain are owned by the organization
- The supply chain is complex network and is spread wide geographically
- Demonstrated an ability to contain BWE

The differences are

- HOC has made a small beginning towards a pull system. It need to evolve.
- SIL has perfected a pull based system. Additional generation of non-moving inventory is not feasible in SIL.
- Non-moving inventory need to be managed carefully in the context of HOC. Constant vigil is needed. The system is still driven by forecast, dispatch and production components.
- The improvement in HOC is a combination of managerial and other tactical measures.
- In SIL, the improvement is primarily based on the pull system implemented.

- HOC is a comprehensive managerial initiative. SIL is a simple but a significant response to minimize the effect of BWE.

- SIL uses a combination of inventory control measures to reduce non-moving inventory in the system.

- Every demand in the system is eventually translated to, inventory transfer or a production unit (in the context of SIL).

Unique Features of HOC Implementation

- HOC, has used ERP as a basis to streamline inventory flow, increase service level and improve the distribution cost.

- There are three major initiatives undertaken by HOC which lead to its performance improvement on supply chain efficiencies. They are improved forecasting based on secondary sales, vendor managed inventory and uniform (on time) and standard (across products) product promotion scheme.

- The BWE was managed by reduced skewness in sales, more uniform off-take from the factory, warehouses and distribution centres.

- Several management initiatives like redefining inventory norms, moving from target based dispatch to sales based dispatch acted as facilitators.

- The taming of BWE is not yet complete in HOC. But the organization is able to get a handle on the issues responsible for it.

- The basic sources of inefficiencies in supply chain like information silos, inadequate stocks, mal-distribution, inaccurate forecasting are minimized.

Unique Features of SIL Implementation

- SIL has a well coordinated logistics department which minimizes the inter departmental conflicts.

- SIL basic strategy is convert the inventory flow to a pull based system

- Supporting infrastructure (information system), prioritization of service level, close monitoring systems, batch production, judicious combination of dispatch schedule all contribute to the operational efficiency of the logistics system.

Step to tame BWE

- Managing BWE is predominately a strategy initiative, not a tactical one.

- BWE would surface only when the manufacturing set up is organized as made to stock

- BWE would be minimum if the operations can be reorganized as made to order

- Taming BWE is a journey to transform the operations from manufacturing to stock to manufacturing to order. This journey is different, not easy and is context depended.

- The first tactical move is to convert the plan, produce, dispatch service sequence to a pull system driven by demand.

- BWE taming needs a set of comprehensive initiatives and systems. Single isolated efforts however big or significant they are, may have a limited effect.

- It is far more easier to tame BWE when the elements of the supply chain are under the control of a single management (The documented experience of Barilla supports this).

- As pointed out by the original authors, the BWE is a consequence of rational response by the member of the supply chain. In a way the optimal response of the individual elements is leading the reduced efficiency of the overall chain. This is in a way brings back the control and co-ordination issues in a supply chain to a sharp focus.

- It is also useful to note that BWE can one of the indicators of lack of co-ordination in the supply chain. Actually, when the co-ordination is well managed the ill-effects of Bull Whip would also diminish.

Conclusion

In this article, we have documented the experiences to contain BWE based on two case studies. We have also analyzed the similarities and differences in these two case studies. Based on this empirical analysis, we have evolved a frame of reference to contain BWE. We believe the work presented in this paper is complementary to the original contribution on BWE. The implementation frame work needs to be strengthened by additional case studies from a variety of situations. In this sense, this contribution initiates research in an area, which would help the supply chain researchers and managers to understand why some companies are able to contain BWE and others are not.

Table 1: Improvement in Metrics in HOC after ERP Implementation

Metrics	Before	After	Remarks
Distributor Stockouts	30	15	Average Distributor Stock. Out in %
Excess Inventory at Distributors	430	220	Excess over month plus norm in Rupees lakhs
Stockouts	21	9	Average Depot Stock Out in %
Inventory	29	22	Average Inventory in number of days (Depot + Plant + Intransit)
Forecast Accuracy	76	82	Accuracy at Depot level for a 15% band
Freshness Index	98.20%	99.40%	
Skew ness within months (blockwise)	10 : 28 : 62	24 : 34 : 42	Percentage sales per block of 10 days

Source: References 4 & 9

Table 2: Estimated vs Actual Sales of Select SKUs of SIL

All India Sales Units '000												
SKU	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	123	118	144	146	131	131	134	123	112	135	131	237
B	110	126	130	139	152	143	99	96	118	134	120	215
C	39	42	48	60	51	39	39	40	44	54	48	66
D	159	164	215	247	244	214	164	179	177	206	157	288
E	200	221	293	319	326	229	181	216	265	240	244	354
F	88	103	113	93	96	115	95	99	94	85	125	143
G	67	68	105	108	128	111	95	116	100	81	125	172
All India Estimate Units '000												
SKU	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	86	119	170	127	179	175	105	118	136	152	155	172
B	103	134	186	144	199	184	103	118	150	143	147	187
C	36	47	65	51	70	66	32	38	44	62	66	74
D	128	171	273	217	279	268	154	163	224	243	228	266
E	154	191	341	229	323	287	180	198	282	297	240	301
F	76	90	120	91	105	128	85	95	109	109	112	124
G	84	98	138	88	127	147	104	117	140	120	143	177
Sales/Estimate in % age (all India)												
SKU	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
A	143	99	85	115	73	75	128	104	82	89	85	138
B	107	94	70	97	76	78	96	81	79	94	82	115
C	108	89	74	118	73	59	122	105	100	87	73	89
D	124	96	79	114	87	80	106	110	79	85	69	108
E	130	116	86	139	101	80	101	109	94	81	102	118
F	116	114	94	102	91	90	115	104	86	78	112	119
G	80	69	76	123	101	76	91	99	71	68	87	97

Source: Reference 8

Exhibit 1: Representative Product Profile of SIL

Product A: Quality: Very good, pricing premium. 400 gm pack (10 packs in each unit) targeted for industrial and domestic users. Distribution both direct to industries and through dealer. Wide shade range includes 162 stock and sell shades and several on specials. Brand image good. Seasonality is not very strong though variations in shade demand is high. Competition - average. Future looks bright with anticipated growth.

Product B: Quality: good. Pricing premium 200 gm packs with 20 packs in each unit. Target segment purely domestic. Distribution mainly through dealers. Though wide shade range include 183 stock and sell shades but not many on specials. Product in decline stage of brand life cycle. Seasonality present. Competition high both from other companies as well as from other brands of Success. Brand image still good in many areas.

Product C: Old product, Quality: good, Pricing high. 300 gm special packs for purely domestic use. Product support abandoned but refuses to die. Brand loyalty still high in certain pockets. Seasonality present. Competition high from cheaper alternatives. Forecast bleak.

Product D: Bulk product of average quality and low priced. 300 gm packs in units of 20. Mainly for domestic use. Small manufactures looking for cheaper alternatives, also buy. Very strong brand image, established for long. Competition strong both from other companies and the unorganised sector, though some markets exhibit strong preference for SIL product. Shade range includes 116 stock and sell shade(s) plus many specials.

Product E: Low priced, non-uniform pack mainly for presence in cheap end of domestic segment. Product quality fair. Non uniform size is a consequence (managerial) of reduction in size to offer the product at lower price. Competition mainly from unorganised sector. Brand familiarity high but image average. Range wide though very few specials. Specials generally discouraged for this product. Forecast stable. Distribution mainly through dealer. Seasonality high.

Product F: Exclusively for manufactures. Product quality good. 5 kg pack. Very popular among manufacturer - exporters. Seasonality subdued, pricing is high. Competition average. Brand in growth stage of Brand Life Cycle. Growth anticipated. Non uniform sales across the regions, yet brand image good.

Product G: Standard product, price average, medium quality. Sold in 5 kg packs for manufactures. Distribution as with F, mainly direct supported by industrial jobber network. Good growth prospects. Seasonality average. Brand image good.

Source: Reference 8

Exhibit 2: Inventory Replenishment Procedures

Replenishment Time: Solids (single item) - 12 days; Loose (Mixed items) - 20 days
ROQ = 30 days of estimated demand

Item	Forecast Qty.	Item classifi-cation	Fluctuation Factor	Carton content	ROP	ROQ	CL	30 days requirement*
1	2345	B	2.5	166	-	-	2	200
2	932	C	1.7	210	88	78	-	77
3	26156	A	1.5	120	-	-	11	2150
4	5556	A	1.5	168	-	-	2	457
5	270	C	1.7	84	26	22	-	22

* Units: Common unit of measurement equivalent to 10,000 meters. Fluctuation factor determined by logistics on a case to case basis. Circulation level is measured in number of cartons.

The replenishment system is expected to work as follows:

Item	ROP/CL	ROQ	Comments on ROQ
1	2 cartons	2 cartons - current stock [@]	Variable
2	88 units	78 units	Fixed
3	11 cartons	11 cartons - current stock [@]	Variable
4	2 cartons	2 cartons - current stock [@]	Variable
5	26 units	22 units	Fixed

[@] Current stock is defined as stock at branch + onway from CWH + stock at CWH allocated for the branch waiting despatch.

Branch replenishment cycle:

Day 0   - Order generated when branch stock hits ROP
Day 1   - Order received (electronically) and processed at CWH
Day 4   - Stock allocation at CWH (average response time 3 days)
Day 9   - Stock quantity waiting for despatch (average time 5 days)
Day 15 - Stock arrives at the branch (average transit time 5 days)

Production cycle:

Day 0 - Replenishment order (generated by CWH based on ROP) on manufacturing location
Day 1 - Order received (electronically) by the manufacturing location
Day 16 - Order released for processing (average wait of 15 days)
Day 33 - Process completed (Average manufacturing throughput time 17)
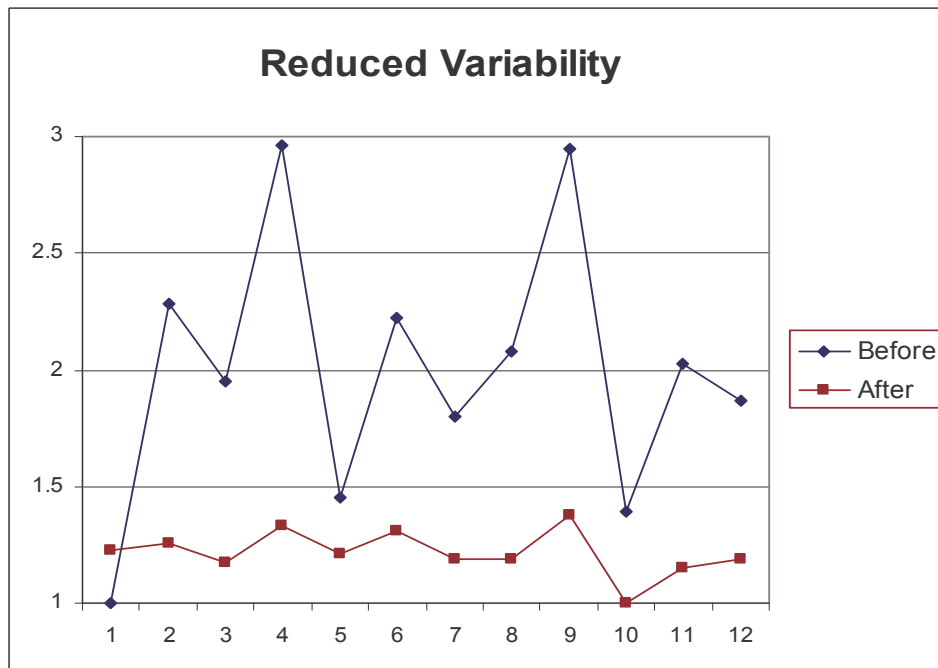Day 35 - Stock arrives at CWH (Transit time 2 days)

Source: Reference 8

Figure - 1
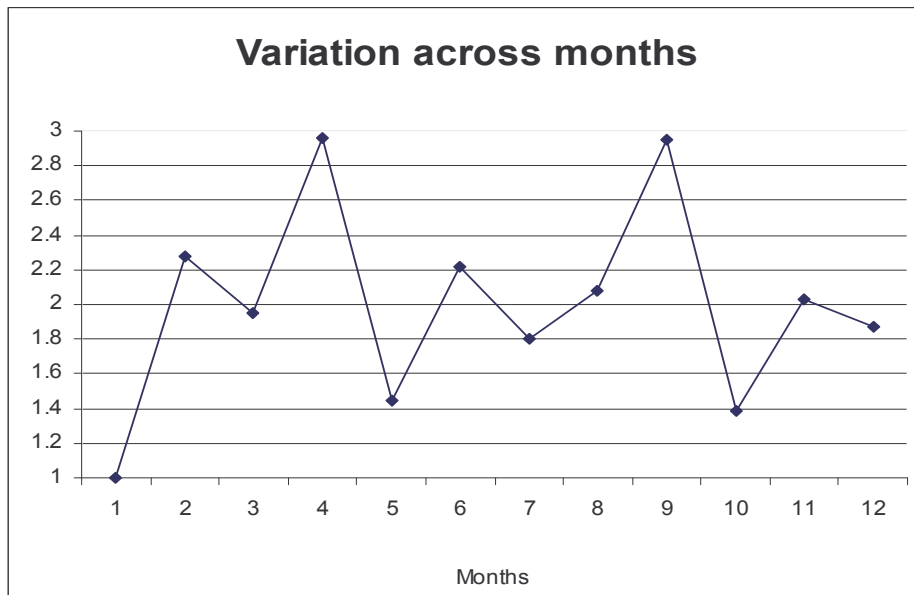
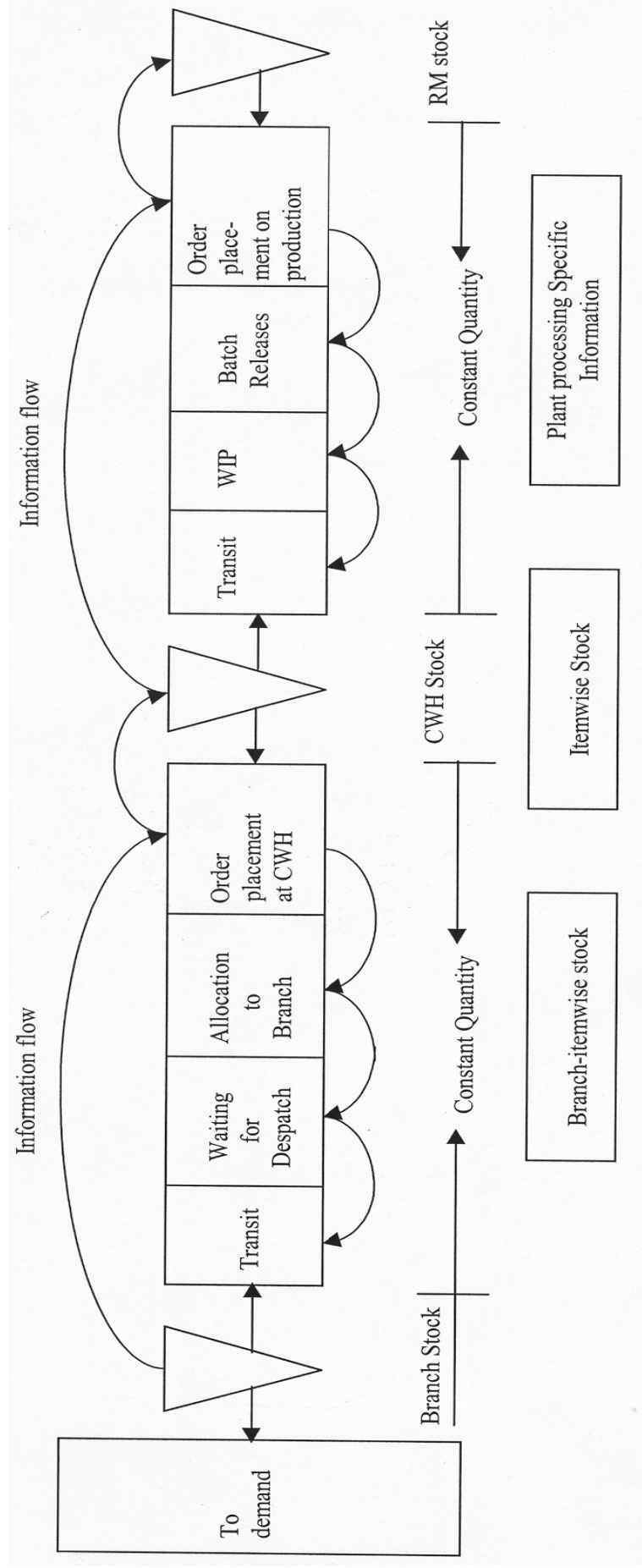**Peak / Minimum Sales ration Variation across the year
as high as 3:1 (Key Brand)**

Figure 2

**Peak to Minimum ration down from 3 to 1.3
Average sales is same**

Source: Reference 4 & 9

Figure 3
The Concept of Circulation Level

Source: Reference 8

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