Factors causing reversed bullwhip effect on the supply chains of Kenyan firms

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Abstract

The study sought to determine the factors that cause supply variability along the supply chain of organisations. The study location was Kenya Pipeline Company, Kenya where from a population of 7 depots, purposive sampling was used to select a sample of 5 depots. Data was collected through the use of questionnaires with both open and closed ended questions to capture the qualitative and quantitative characteristics of the pipeline operations. Descriptive survey and a case study research design that encompasses both quantitative and qualitative methods to collect and analyse data were utilized. The findings suggested that capacity constraint was the major factor contributing to supply chain inefficiency. The conclusion was that the supply chain was inefficient because of capacity challenges and government intervention. Recommendations included capacity adjustment strategies, equipment upgrade, additional man and machine hours, reliable source of power and a non-disruptive government intervention.

Keywords*:* Reverse bullwhip, variability, supply chain, Kenya

1. Introduction

Reverse bullwhip effect refers to the variability of supply downstream the supply chain thereby depicting inadequate supply in the face of adequate demand. Reverse bullwhip effect is multifaceted and can occur between the producers and wholesalers, wholesalers and retailers and between retailers and end user customers. With regards to the supply chain elements, influence is reciprocal and behavior is erratic during periods of supply disruption which compound the problem into a chaotic chain. However with regards to the supply chain facilities, variability's are localized but the impacts are system wide. As firms successfully streamline their operations, the next opportunity for improvement is better coordination with suppliers and customers in order to receive or get their products to end users within the place, time and form of need. Budiman (2004) notes that this depends on complex tasks that require several companies working together as a supply chain or network to eliminate all supply chain inefficiencies. In attempting to effectively coordinate the supply activities, firms are faced with intermittent supplies, mutating consumer tastes and preferences, advancements in technology and a threatening competition. According to Tang (2006), as supply chains become more global, supply uncertainty becomes a more striking issue. Kumar et al. (2004) observe that while pipelines are one of the safest modes of transporting bulk energy and have failure rates much lower than rail roads or highway transportation, failures do occur and sometimes with catastrophic consequences.

Initially the problem that faced companies was the bullwhip effect which is variation in demand and goods produced for stocking in large warehouses. This might not have been a good strategy since it was prone to too much inventory against unforecasted demand. The excess inventory would easily lead to higher inventory holding costs and risks including possible obsolescence. However, today the reversed bullwhip effect seems to be the major problem facing firms. Cachon et al. (2007) confirmed that only 47% of industries studied in the US exhibited bullwhip effect while the remaining 53% the reverse bullwhip effect. The reverse bullwhip effect is a problem that needs attention since the nature of current competition has seen the emergence of a new business model where the focus of competition has shifted from between organizations within a supply chain to between the supply chains themselves (Cox, 1999; Christopher and Towilll, 2001; Lambert and Cooper, 2000).

The immediate effect of reverse bullwhip effect is seen in cost of stock out including supplier switching costs, destroyed business relationships, fluctuating product prices and panic buying. In the oil industry in Kenya, shortage of fuel has seen inflation rising and destabilizing the economy. Reverse bullwhip effect is a reversal of gains made through implementation of the philosophies of Operational Performance Management (OPM) like Just In Time, Lean production and Total Quality Management. Clearly if firms have already secured orders, discontinuity of supply should not deny them market share. Several causes of this variability have been addressed in available literature. These include supplier capacity challenges, inadequate and /or distortion of information, companies' strategy to preserve a pricing regime, disruptive regulation and business procedures and policies of companies. In the organization structure, most companies in Kenya do not have supply chain as a fully staffed department but as an extension of planning and supply. This study sought to determine the major causes of supply chain variations along the supply chain of Kenya Pipeline Company.

2. Theoretical Background

Different firms have different causes of inefficiencies within their supply chain which cause supply variability along the supply chain described by Svenson, (2003) as reverse bullwhip effect. In order to maintain smooth flow of products from production points to end sale points, firms need sustainable, efficient, agile and networked supply chains. To further enhance this network of interdependence companies have adopted the business philosophy that "my supplier should also use my products or services." This business regime is adversarial but is well designed to enhance mutual dependence. Viewed in this context the supplier of a company is an extension of that company and the impact of reverse bullwhip effect are therefore double edged. Lummus et al. (2001) defines supply chain as the systematic and strategic coordination of the traditional business functions and the tactics across businesses within the supply chain, for purposes of improving the long term performance of the individual companies and the supply chain as a whole. Stocking level variability is affected by up and down stream business operations in the value system. These business operations are driven broadly by capacity, information, pricing strategy, business procedures and regulation.

Information sharing refers to activities that distribute useful information among multiple entities (people, systems or organizational units) in an open environment. According to Sun and Yen (2005) the following questions are considered in information sharing: What to share? Whom to share with? How to share? and when to share? Lalonde (1985) contends that information friction causes distortions where information is needed in a timely fashion which cause supply variability along the supply chain. The theoretical underpinning is that the furthest a client is from the supplier the more distorted version they have about stocks and reasons of unavailability. Advances in information technology have changed modern business practice making collaborative supply chain management possible. Information's competitive value is widely heralded as it substitutes for inventory, speeds new product design, shortens order fulfillment cycles, drives process re-engineering and coordinates supply chain activities (Cachon and Fisher, 2000; Lee et al.1997, Lee and Whang, 2001; Kurt Salmon Associates, 1993). The power of information as a business tool is realized when wrong intelligence is gathered and wrong strategy employed. Bradley (2002) reports that the supply chain structure determines the extent of information distortions which further support reverse bullwhip effect. To be helpful to supply chains firms should be able to filter sources of information and make it adulteration free.

Supply chain structure can be conceived of as a conglomeration of firms, the spatial or geographical attributes of firms, distributors and how this network is governed (Stock et al. 2000). The geographical expanse will influence task allocation, decision making authority, coordination and the location of production facilities. The higher the level of geographical expanse the fewer the supply chain units and vice versa. These supply chain units support the Sharman (1984) notion that customers' orders are allocated to the product supply at the order penetration point. In a supply chain goods flow through a complex series of plants, intermediaries, warehouses and distribution centers and the flow can involve multiple modes of transport (Bradley, 2002). Supply chain units have unique characteristics of which Fisher (1997) proposed two types, the physically efficient chain which stresses least cost and the responsive chains which focus on effective and rapid response to actual customer demands. For these chains, accurate forecasting and consideration of market mediation costs are the keys to competitiveness. Christopher (2000) postulates that agile chains provide extremely rapid response to

highly variable demand while Naylor et al. (1999) defines a 'leagile' supply chain as a supply chain having a lean up stream and an agile down stream component. A lean supply chain structure is organized to maximize operational efficiency and minimize overall cost. Typically lean organizational arrangements in a supply chain are used for higher volume product lines that have stable demands and standardized technologies.

Cox (2004) explains that companies which are able to manage their long term business relationship by crafting mutually beneficial supply chains normally have high global volume, regular and standardized (predictable) demand, supply requirements and low switching costs. This reinforces long term business relationship and brand building. The primary objective of supply chain management is to fulfil customer demands through the most efficient use of resources, including distribution capacity, inventory, labour and by companies carefully selecting among all the options (rapid response, capacity adjustments, least cost approach and a combination of all these), a supply chain can be tailored to 'fit' the physical and market needs of the specific products it moves and prevent supply disruptions. Companies can easily choose the location of their facilities but they cannot choose the location of their customers.

Collins et al. (2009) indentifies the imperatives that currently guide the design of supply chain as primarily cost reduction and fast delivery, recipes rooted in the realm of operations management. If companies can effectively and efficiently contest other supply chains, the cost reduction arising from such a process is passed on to the customers in low product prices as another competitive edge. Without any specific effort to coordinate the overall supply chain, each firm in the supply chain has its own agenda and operates independently from the others (functional silos), such an unmanaged network results in inefficiencies (David, 2000). However Fisher (1997) notes that supply chain cannot cope with everything and therefore companies need a framework for designing supply chains according to different product characteristics. A stable supply chain results in rational price fluctuations and revenues are predictable.

Budiman (2004) found that supply fluctuation was due to capacity adjustment lead time, production lead time, order processing delay and order wait time. Svenson (2005) observes that the reversed bullwhip effect is caused by factors such as deficient information sharing, insufficient market data, deficient forecasts and capacity issues. Facilities with mass production are responsive to supply variability while customization platforms are prone to longer production lead times. Business processes sub optimization by design or default can lead to a butterfly effect where a small variation can lead to system wide variation. Companies need an optimal balance between the possibility of idle capacity and having adjustable capacity facilities. Most companies are no longer simply contented with price as a determinant in procurement services but also sustainability of the supply and ability to meet unpredictable and short notice supply instructions. Ability and expertise override costs where the cost curve minimization is already achieved.

According to Rong et al. (2009), when customers react not only to price itself but changes in the price, some pricing strategies implemented by the supplier may lead to reversed bullwhip effect. Where there is a central pricing authority like in price controls, price change anticipations can result in supply shocks as every supply chain element seeks to maximize on the price differentials. Under imperfect market conditions like in the oligopolistic markets, collusions by the market players can set supply quotas that are preservative of desired price levels. However price variations under perfect market conditions are a reflection of market forces of demand and supply and reverse bull whip effect plays the causal role on pressure on price.

David (2000) conducted a project involving three companies done by and found strong pressure from senior management to minimize inventory for financial reasons rather than setting stocks to a calculated buffer against quantified demand and supply variability. Senior management had the view that in today's Just In Time (JIT) and customer service environment, it is up to the supplier to meet our demand no matter how variable it is. Unfortunately this approach fails to understand that in order for stockless/ JIT systems to operate properly supply and production systems that are both capable and reliable are necessary. The company mission and vision embodies its core values with strategies designed to achieve the visions. These values have a bearing on the manner of reaction to market

opportunities and challenges. Accounting practices like lean financial year stocks trigger reverse bullwhip effect which amplifies along the supply chain and becomes repetitive.

Regulation has different dimensions including production quotas, quality thresholds, environmental compliance, product price and payment modes, service delivery times and transit routes and modes among others. Regulation has positive values with regards to affordable price against quality, health safety, environmental compliance and minimum quantity to supply. The quantity threshold has a double impact on supply and can encourage or discourage reverse bullwhip effect. Supply chain is a flow concept and any non value adding restrictions in quantity, time, space and personnel aggravate supply variability as a result of the long queues thereby creating another level within the supply chain. Missed transportation connection in the middle of a supply chain may cause a customer outage or a supplier shutdown. Where travel restrictions take the form of hours of travel, truck utilization is reduced and supply stability may not be guaranteed.

3. Methodology

The study location was Kenya Pipeline Company (K.P.C.), Kenya where from a population of 7 depots, purposive sampling was used to select a sample of 5 depots. Since these depots operate on standardized procedures the choice of a depot was based on its location along the supply chain. Mombasa, was selected because it is located at the source while Nakuru, Eldoret, Kisumu and JKIA are located in the middle of the supply chain. Since the study excluded inter-organization interactions i.e. between the pipeline and oil marketers, variability was assessed between the source and the middle of the supply chain. Data was collected through questionnaires with both open and closed ended questions to capture the qualitative and quantitative characteristics of the pipeline operations. The data collection also involved gathering statistical information so that the database represents both quantitative and qualitative information (Creswell 2003). Those interviewed included target operations staff, the branch operations managers and head office staff. A mixed methods research design that used both qualitative and quantitative approaches in a single project was employed to gather and analyse data (Cameroon 2009). Data was analysed through descriptive statistics and presented through percentages, mean and standard deviations

Capacity as a cause of reverse bull whip effect was examined at two levels, the down and upstream. Within these levels capacity was investigated in terms of storage and utilization. Essentially the two levels and two approaches assessed the ability of the source to supply and the middle to dispense. Regulation was assessed on its intrusion in the supply space, whether regulation added value in the supply chain. Information was considered as its ability to flow freely, its speed, how it was relayed, its reliability and consistency. Supply chain structure was observed in terms of the facility location, order movement patterns, depot locations, and chain support structures was investigated in terms of boosters, pipeline network and their locations. Business procedures as a cause of supply disruption was questioned in terms of the nature and speed of approach to market opportunities and challenges such as the stipulated lead time for order delivery and whether business procedures of customers had any impact on supply deliveries.

4. Research Results

All the five respondents acknowledged that line extension would reduce the capacity challenges since storage capacity was a major challenge at the downstream level due to inadequate pipelines supplying the upstream storage facilities. The combined storage down stream was 703,533 metric tones against the upstream utilization of the seven depots of 323,293 metric tonnes, representing 45.97%. This implied that whereas the down stream storage always had product, the flow of this product to end sale points was less than half often causing supply variation at the upstream end sale points even after schedule instruction from customers.

There were three lines 1, 2 and 3 with a pumping capacity of $880m^3$, $220m^3$ and $140m^3$ per hour respectively. On overage the pumping rate was $500m^3$/hr. with a maximum pumpable volume of $12000m^3$/hr. It took an average of 3 days to pump products to Nairobi, Kisumu and Eldoret while the lead time of servicing customer orders received by KPC was 2 days. The implication was that in addressing reversed bullwhip effect immediately after a stock out would require a lead time of 5 days

assuming no further disruptive influences of equipment failure. The longer the lead time of delivery, the more likely the disruptive influence on the supply chain. Another capacity challenge analysis was conducted between the upstream storage and utilization which assessed the loading ability at the respective depots if the storage tanks were full. The storage was compared with the average daily throughput of the corresponding gantries and standard deviations were calculated for the difference.

Insert Table 1- here

The differences between the standard deviation from the mean were broad, meaning that the differences between the storage capacities and dispensing units (loading gantries) were wide spread. The impact of the storage not holding any stocks at any particular time would trigger far reaching stocks variability.

This indicated that the loading gantries did not have sufficient capacity to push out the entire product at the end sale point (upstream storage) were the tanks to be always full. While the respondents agreed that additional gantries may not be the solution due to lack of expansion space, they indicated that the current gantries need speed adjustment to improve on the daily throughput. The last capacity comparison was conducted for the annual orders compared to the annual loadings for all the loadings in the selected depots.

Insert Table 2- here

The standard variation from the unmet orders is widespread implying variability between orders received and orders processed. Equally over 20% of the orders were not supplied due to lack of capacity. In efficient conditions the service rate of orders is supposed to be 100% so that there are no unmet orders so as to exceed the expectations of customers. The results of the facility performance as measured by order processing was an average of 80% which translated into lost sales of 20%. Given that new orders enter into the system on a daily basis, the annual cumulative lost sales in new and unmet orders was substantial.

The study found that government presence through the Kenya Revenue Authority (KRA) delayed order processing as it took time to book orders into and out of the Enterprise Resource Planning (ERP) Simba system. Trucks loaded could not leave the system without clearance from the customs officers. The ERP Simba system was prone to system failure and even in desperate situations loaded trucks could not be cleared in time thereby confounding the supply disruption. Respondents indicated that it took on average each local truck 20 minutes to be cleared from the KRA and an average of 1hour for exports transit trucks.

The study established that information was communicated through two way radio calls and IP Phones. For external customers email and mobile phone usage were the means of relaying information with occasional letter writing to customers which took less than one hour to deliver. K.P.C. also uses the German ERP software of Systems Analysis and Programme development (SAP) which uses real time to access customer trading accounts to monitor the transactions. 3 depots indicated having monthly operational meetings with customers for briefings on operational issues, the other two depots indicated meetings are not diarized but held as and when need arises since email and notice boards relayed the operational issues to the customers most of whom are housed within the premises of K.P.C. The results showed that oil marketers, (the K.P.C. customers) did not share sales data with their supplier K.P.C. Kenya Pipeline Company therefore relied on scheduling instruction from their customers and all the respondents indicated that there were no delays in receiving scheduling instruction. All the respondents pointed out that no complaints had been received from customers because of non communication. Information was therefore not a major factor causing the reverse bullwhip effect in the supply chain of KPC.

As regards the supply chain structure, the study found that downstream storage tanks were located in Kipevu, Refinery and Moi International Airport. The booster pumps were located at Mombasa, Samburu, Maungu, Mtito Andei, Makindu, Konza and Nairobi. All the respondents indicated that the location of these boosters were convenient based on the distance to which the product was to be pumped. The challenge was lack of reliable power backup during periods of electricity outage.

However, all the respondents indicated that there was need for additional pipelines to further improve efficiency of the pipeline.

The study sought to assess how orders move within the chain that is, how the loading vessels (trucks, trains) move within the loading gantries. The results showed that there was a standard procedure of order movements. The orders from the customers were received by the Pipeline Oil Industry Coordinator (Pipecor), and then introduced into K.P.C. system. Orders were then received at fuel fax where fan tickets were generated against the products on order; verification of order capture was done before the order was forwarded to the loading gantry and assigned truck called in. Reverse logistics at this level was complex as the customer could not access their purchase order except through Pipecor. For truck movements, the study established that each gantry had three product islands with varying numbers of loading arms. The number and location of loading gantries were not a challenge on speed of order processing since there were isolated islands for special loadings for trucks with foot valves. Business procedures of customers had minor effects on the supply chain and it was determined that multiple product orders were particularly a challenge because a truck had to move from one gantry to the other as per the gantry having that product. This lengthened the queue as the truck had to be lined up at the gantry with the product. Loading time for a multiple product order was longer than single product order by 50 minutes for a combination of 2000lts each of Kerosene, Regular, Super petrol and Diesel.

5. Conclusion

The study sought to determine factors that cause reverse bullwhip effect on the supply chain of an organisation. Capacity constraints that slowed down supply included less pipeline network, lack of sufficient back up for emergencies and slower equipment were the main cause of supply variability in the supply chain of K.P.C. Increasing pipeline network, equipment, speed and extending loading time would reduce supply variability. While available literature indicates that lack of information among the supply chain elements causes reverse bullwhip effect, where functional connectivity in information networks is already achieve, information usefulness is limited to sharing and speed. Business procedures of customers affected supply speed to the extent of product mix while regulation added another level within the supply chain and pricing had no effect on the supply chain. While government regulation was always deemed to be non-threatening, the intervention had disruptive influence and could be a simple procedure that is only machine controlled. In and out booking of orders could be done by a punching machine that records the document identification to minimize human involvement. Oil pipeline installation has massive capital requirement, however due to growing demand K.P.C. needs to adopt capacity improvement strategies like equipment upgrade, emergency back-up structures, and additional network of pipeline, longer man and machine hours.

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Table 1: Storage capacities and gantry daily throughputs

Upstream		Loading gantry	Difference
Storage	Capacity in m^3	Daily through put in m^3	
Mombasa	99109	3.7	99105.3
JKIA	100580	5	100575
Nakuru	30553	2.5	30550.5
Kisumu	45068	3	45065
Eldoret	47766	3	47763
Mean	53846	2.867	53843.13
Standard deviation	28546	0.95	30928.73

Table 2: Variations in annual loadings per depot

DEPOT	ANNUAL ORDERS (M^3)	ANNUAL LOADINGS(M^3)	UNMET ORDERS(M^3)	%UNMET ORDERS(M^3)
Mombasa	923,467	734,567.00	188,900.00	20.46
JKIA	112,3789	898,890.00	224,899.00	20.01
Nakuru	699,898	497,456.00	202,442.00	28.92
Eldoret	789,768	567,305.00	222,463.00	28.17
Kisumu	901,567	603,504.00	238,063.00	26.41
TOTAL	4,438,489	3,361,722	1,076,767.00	123.97
MEAN	739,748.20	560,287	179,461.20	20.7
STD. DEV.	187,756.60	163,134.00	36,435.19	5.1