

# **Bull Whip and Reverse Bullwhip Effect in After Sales Service Supply Chains**

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## **Abstract**

After sales service is a major source of competitive advantage for the firms in current business environment. The quality of the service depends on a number of factors among which availability of spare parts at the service centers is the most critical. It is very difficult to maintain the desired inventory of spare parts due to the increasing product complexity and variety. The variation in demand of spare parts causes amplification in the variation of production operations to meet the supply target. With the inclusion of refurbished parts into the spare parts inventory for repair, the variation of production operations oscillates further. The high level of variability in the supply source causes a major impact on the performance of after sales service supply chains. It is therefore required to identify the sources of supply uncertainty and factors causing the variability. The results can be useful for organizations facing the challenge to profitably maintain the after sales service supply chains.

## **Keywords**

Bull Whip Effect (BWE), Reverse Bull Whip Effect (RBWE), supply uncertainty, after sales service, spare parts, system dynamics.

## **1. Introduction**

The current business environment of consumer electronics is faced by the challenge to serve the warranty agreements due to large product variety and far away manufacturing and customer bases. The customer expects better, faster and convenient service due to high dependence on electronics for business and personal needs. Most of the customers now also consider the warranty conditions of after-sales-service for their purchase decision. The after-sales-service is emerged as the key source of competitive advantage to gain and retain customers (Alexander et al., 2002). It is one of the main differentiating factors among the competitors (Porter, 1980). The scope of after-sales-service is not limited to retain customer but it is one of the prime source of revenue generation. The after-sales-service market is up to five times of the new product market (Bundschuh and Dezvane, 2003) generating up to three times the turnover of the initial purchase (Wise and Baumgartner, 1999). It also enhances the chances of success for the new products (Goffin and New, 2001; Goffin, 1999).

After-sales-service data creates a large pool of information to understand customer demands through feedbacks that can be utilized for new product design and quality maintenance (Boyt and Harvey, 1997; Bozarth and McDermott, 1998; Brax, 2005). The after-sales-service creates a long lasting impression on the customer and they feel a constant connection with the brand (Asugman et al., 1997) that affect the customer base for the company. Traditionally, after sales services was considered as a cost overhead by the companies (Lele, 1997). With the increasing customer awareness and stringent consumer protection and environmental laws, companies are presented with an opportunity to changes the perception and convert the traditional cost outflows into revenue inflows. The organizations have taken this opportunity to reposition after-sales service as a source of differentiation and revenue generation (Armisteadand Clark, 1992). Management of an efficient after-sales-service supply chain has become a strategic decision for a large number of competitive organizations. The efficiency of such a supply chain depends on the planning, availability and delivery of the spare parts.

The current research addresses the concern for spare part planning for products such as computers or smart phones. In most of these cases, customer expects on-sight-same-day service that is performed by replacing the subassembly in the equipment. Companies have developed online tutorials to facilitate the customers understand the problem to report correctly for ordering of the replacement part. Once the customer reports about a malfunction, and their

perceived cause for the same, the organization has to schedule an onsite inspection and replacement of the part. Better the information sharing and spare part availability, better will be the service and customer experience. This requires the organization to have detailed and integrated information of customer records and to plan the spare-parts inventory taking into consideration the overhead costs. It also requires the organization to have efficient resource planning, and upstream supplier coordination. The high product variety and short life cycle enhances the complexity of the system. Organizations want to strive for better forecasting and spare-parts planning as well as compatible product designs. The overall after-sales-service needs a highly coordinated supply chain of customers, retailers, service centers, spare-parts manufacturers and repair vendors. Though the benefits seem obvious yet little attention is being paid to this area by researchers and managers.

The complexity of the situation increases in cases where the spare parts are repaired and reused in the products such as computers. In such cases, the spare part inventory depends on the mix of new as well as refurbished products. Whereas the refurbished spare parts highly depend on the product failures and sales history. Current research analyzes the business scenario where the after-sales service providers also make use of refurbished spare parts. This is a very complex situation as the demand for a repair is highly unpredictable. Forecasting the demand is a challenge even if the part failure rate and sales history is known. The service providers have to efficiently manage the collection, repair, and, delivery lead time for a defective product to maintain the desired service level and customer satisfaction. The heterogeneity and variety of required spare parts is manifold as compared to the manufacturer as any of the products sold over a horizon of several years may require a repair. The heterogeneity and variability in demand and lead-time and repair time in supply make it critical for the service provider to carefully plan the inventory. Service provider has to determine the portfolio of new parts to be procured and the number of old parts to be repaired. The retailer has to deal with the demand uncertainty from the customers and supply uncertainty from the suppliers, whereas the customer's demand and supplier's capacity is not affected by retailers situation. BWE is generated by the variability in customer demand moving from the customer to suppliers via retailers whereas RBWE is generated by variability in supply capacity moving from supplier to customer via retailers.

This research proposes a hypothesis that a bullwhip in sales may cause a reverse bullwhip in arrivals for repair, as repair is highly dependent on the sales history and part failure rate. Bullwhip in sales will have a reverse bullwhip in the demand for spare parts for that product. The service provider will experience a compound effect of sales bullwhip due to the large number of products arriving for repair. When there is a combination of BWE and RBWE generated due to both supply and demand variability, the supply chain may cause higher variation not only upstream or downstream but also anywhere in the chain. It is required for the organizations to critically analyze their demand and supply variability and factors affecting it. The objective of this research is therefore to identify the effect of sales bullwhip on spare-parts demand.

This paper is organized as follows: Introduction is presented in section 1, followed by the review of literature in section 2. The problem description is presented in section 3 and a system dynamics model is presented in section 4. The paper is concluded in section 5.

## **2. Literature Review**

There is insignificant literature addressing after-sales service supply chains as compared to supply chain design, management and performance measurement.

Levitt (1983) first identified the sales of a product as a long-term relation between the buyer and seller which will continue for a long time and are the key to long-term profitability, therefore indicating towards after-sales function as a competitive advantage. After-sales service existed in literature with several other names like customer support, product support, technical support, and service (Goffin and New, 2001). Several authors (Cohen and Lee, 1990; Ehinlanwo and Zairi, 1996; Loomba, 1996; Asugman et al., 1997; Boyt and Harvey, 1997; Urbaniak, 2001; Johansson and Olhager, 2004) have attempted to define after-sales services. Based on the above mentioned literature, after-sales services can be broadly defined as a set of activities performed after the sales of the product to support customer usage and disposal. After-sales service also gave the opportunities to have a better feedback on the product performance and quality related issues, thus a service intelligence network to improve the customer experience. As the activities are carried out by several vendors and third parties, and it gives a chance for competitive advantage Earl and Khan (1994) classify after-sales as a business network process. With the increase in

e-commerce and other technologies, number and variety of customer touch points and service delivery channels has increased leading to a more complex supply chain structure (Hill et al., 2002). The various players in the chain play a major role in increasing the effectiveness of the total chain, thus coordination of all the players is also a difficult task.

Literature (Hull and Cox 1994, Nordin 2005) stated that there is very less attention given to after-sales services in manufacturing contexts. Most of the articles discussing the supply chain configuration for after-sales service either report results from empirical findings or propose some framework for the supply chain configuration.

Some other articles focusing in after-sales strategy or definition on product service include Levitt (1983), Lele (1986, 1997), Frambach et al. (1997), Wise and Baumgartner (1999), Mathieu (2001), and Oliva and Kallenberg (2003). There also exists ample literature on optimisation policies for inventory management but not very specific to spare parts inventory management in after-sales supply chain. Only few authors such as Schroeter and Spengler (2005) discussed the issues of spare parts management in a closed-loop supply chain. The articles mainly focusing on manufacturing organization are Hull and Cox, 1994; Zackariasson and Wilson, 2004; and Brax, 2005.

There also exists examples where researcher have applied system dynamics to address the concerns of after sales service. For example, Spengler and Schroter (2003) proposed a system dynamics model for strategic management of the spare parts. Tian and Zhao (2009) addressed the supply support of spare parts in military logistics by applying system dynamics approach. Wang (2011) presented a demand pull model based on system dynamics to understand the dynamics of spare parts supply.

### 3. Problem Description

This research addresses the concern arising out of supply side uncertainty in the after-sales supply chains. The system under study considers a situation where a product is introduced into the market for which the company has to provide after-sales service for a number of years after the sales. The organization in consideration is an assembler that coordinates with several OEMs for manufacturing the equipment. It also facilitates the sales through a network of wholesalers and retailers. The details of the supply chain in consideration are presented in figure 1.

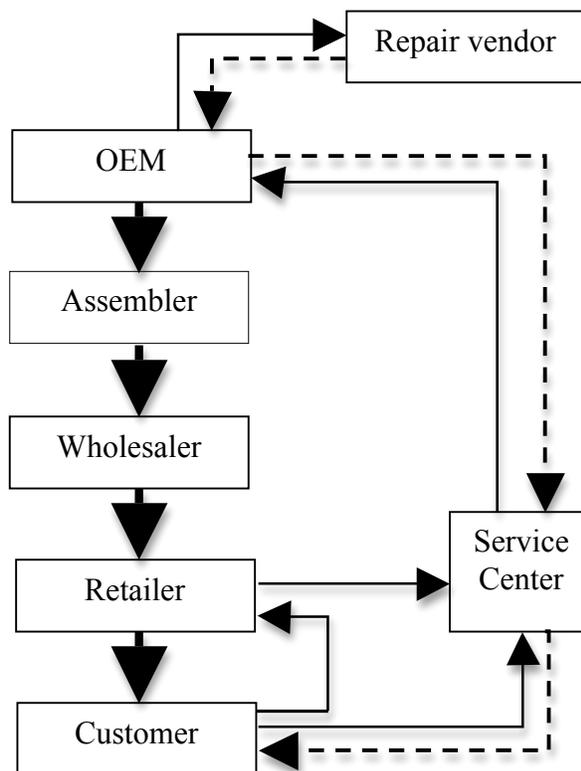


Figure 1: After-Sales Supply Chain for High Value Products

In case of any failure, the customer will either approach the service center or the retailer for possible repair. There can be business commitments to provide on-spot service where the service has to be provided at the customer location by replacing the defective subassembly. In either case, the product or the defective subassembly will return to the service center from where it will be send to the OEMs. The OEMs further send these subassemblies to the repair vendors. The service quality and customer satisfaction is highly dependent on the quality and speed of service, both of which are dependent on spare part availability at the service centers.

Any new entrant in the market generally follows the product maturation curve. Sales of the product in the initial phase will be low and may pick up later. One the sales volume starts falling or new technology/ variants being introduced; the organization decides to prune this variant. But, the organization has to support the after-sales service for the existing customers even after stopping the sales of the product. Details of the product sales and service request are presented in figure 2.

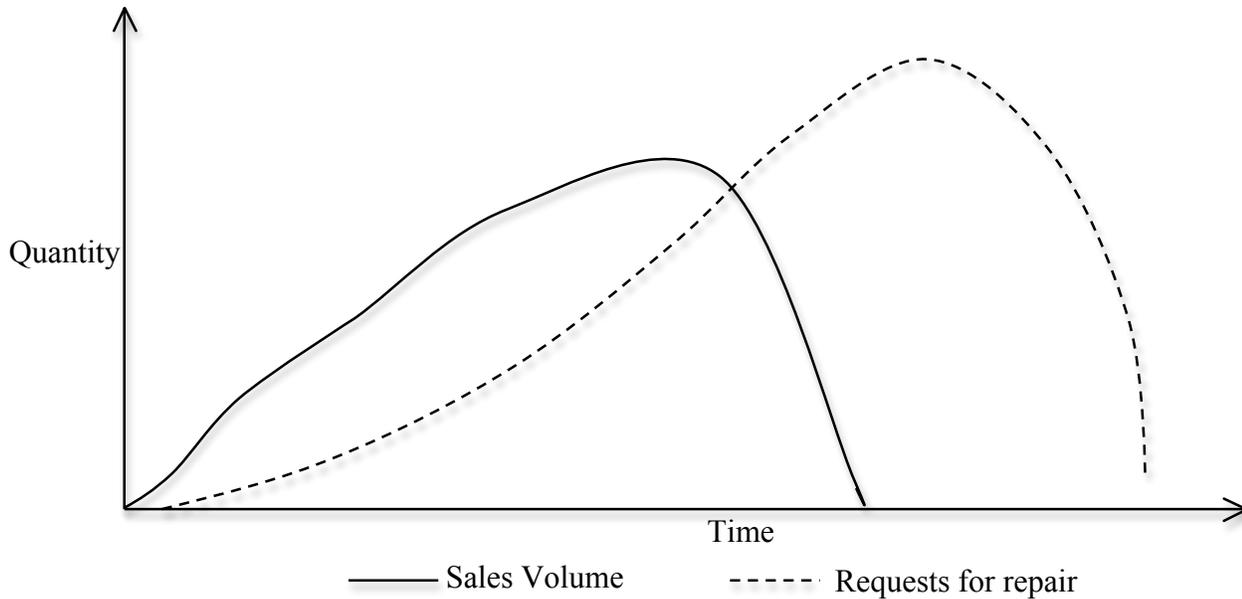


Figure 2: Sales and request for repair volumes across time

The spare part availability depends on the stock of spare parts at the OEMs that is dependent on the production volumes of the new parts and incoming refurbished parts from the repair vendors. The volume of refurbished parts depends on the refurbishing rate and the arrival of defected parts. Considering the variability in the sales volumes of the equipment, there will be variability in the service request. This will create a huge variation in the arrival and stock of refurbished parts. Assuming that the demand for the equipment is normally distributed with a mean  $Dm$  and variance  $Dv$ , and considering a bullwhip in the forward chain from OEM, assembler to customer we can assume that the production volumes will have a mean  $Pm$  and a variance  $Pv$ , where  $Pm$  and  $Pv$  will be a function of  $Dm$  and  $Dv$  given that  $Pv > Dv$  due to bullwhip effect across the chain.  $Dm$  and  $Dv$  will also have an effect on the service requests mean  $Sm$  and variance  $Sv$  and the mean  $Rm$  and variance  $Rv$  of availability of refurbished parts. The variability in the production volumes as well as the availability of refurbished parts will further enhance the complexity and increase the variability of the supply of spare parts.

To further understand the issue, we applied system dynamics methodology to identify the sources of variability in the after sales service supply chain.

## 4. System Dynamics Model

This section presents the system dynamics model to understand the after sales service supply chains. Figure 3 presents the system dynamics model for the problem at hand. The variables used to model the problem are defined as follows:

**Product Age:** Age of the product since it was manufactured

**Sales Volume:** Number of products sold

**Failure Rate:** Number of products in need of service per unit time

**Products in Operation:** Number of operational products at any instance

**Demand for Spare Parts:** Number of spare parts required at the service center to meet the required service levels

**Repair and Replace:** Number of products repaired by replacing the subassemblies

**No of Defective Subassemblies:** Volume of defective subassemblies generated

**Spare Parts Supply:** Number of spare parts supplied by the OEM

**Volume of New Spare Parts:** Number of new spare parts manufactured by the OEM

**Repaired Products:** Number of spare parts delivered by repair vendor to OEM

**Rate of Refurbishment:** The lead-time required by the repair vendor to refurbish any subassembly

It is evident that with the increase in sales volume over time, the number of products in operation will increase. The increase of the operational products will be adversely affected by its age and with the increase in age, more products will become obsolete. With high number of operational products and increasing age, the failure rate will increase creating more demand for spare parts at the service centers. Service centers will address the failures by replacing the subassembly. The higher the number of replacements, higher will be the number of defective subassemblies that can be sent for refurbishment to the OEM which will send it to the repair vendors. The repair vendor once done with repairing of the subassemblies will send it back to the OEMs depending on the rate of refurbishment.

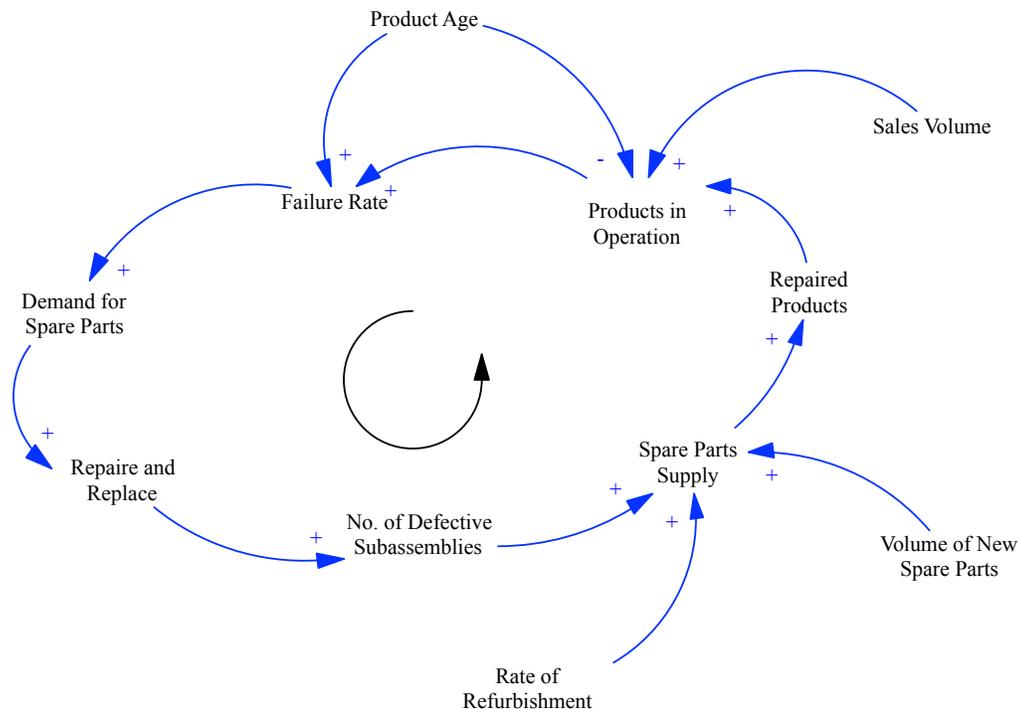


Figure 3: System Dynamics model to understand the bullwhip and reverse bullwhip in after sales service supply chains

The spare parts available at the OEMs will depend on these refurbished subassemblies as well as newly produced subassemblies at the OEMs. More the availability of spare parts more will be the number of operational products. This is a reinforcement loop that shows that higher the number of operational products higher will be defective subassemblies and vice versa. This is an interesting phenomenon, as the variability in the initial sales volume will create variability in the number of operational products. This variability will create a bullwhip effect causing variability in the number of new subassemblies required for new products at the OEMs. This variability will also add variance in the number of defective subassemblies resulting in variability in the spare parts supply. The overall variability in the production at OEM will be a function of these two factors making it very complex. This will result in a huge variability in the supply volumes creating lack of supply in a high demand scenario.

The organization will have to suffer huge losses due to loss of sales and service commitments. It is highly important for the researchers and managers to address the supply side uncertainty for sustainable and profitable operations. Considering the several factors creating this supply side uncertainty, one of the key factors is the variability in the initial sales volumes. It was not very evident till the companies were not concerned about using the refurbished subassemblies in the after sales service supply chains. The production managers were more concerned about matching the market demand without even thinking of the long-term effect of the variability faced at the supply side. This research motivates the managers and researchers to look at the various sources of variability and reduce it at the very beginning to have a better supply chains.

## 5. Conclusion

This paper presented a problem of after sales service supply chain considering the use of refurbished subassemblies as a potential source of spare parts. Here the research effort was to understand the variability in the supply of spare parts caused by a number of endogenous and exogenous factors. A system dynamics models is present to understand the cause and effect of various factors creating the variability in the whole system. It is found that the variability in the forward flow of new products is a major source of variability in the supply of spare parts. Thus the managers need to address the variability of the supply chain taking into consideration the after sales service as well. In future, the researcher may further develop the presented model into stock and flow diagram to be tested on real life industrial settings.

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