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"Whiplash Effect" in a Link in the Supply Chain of Packaging for Soft Drinks - Estimated Demand Oscillation During World Cup 2014

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Abstract

This article analyzes the behavior of a link in the supply chain of PET (polyethylene terephthalate) bottles for soft drinks, from the standpoint of the packaging manufacturer, aiming to understand the so called whiplash effect (WE). The manufacturer is concerned about the impact on stocks caused by an unexpected variability on the demand during a forthcoming period. Such oscillations are likely to occur during the Soccer World Cup 2014 in Brazil, when demand levels will be significantly increased. Having this in mind, it is showed a calculation to dimension the WE applied to two levels of the studied chain, using demand data from January to December 2010. The result shows an intensity factor of 4.60 for the PET bottles demand. This parameter could be considered a warning for the next periods. In order to minimize the variability of demand caused by this effect, some management actions were proposed, all of them suggesting improving the dissemination of information in the chain. Better connection among the chain members and the integration of companies were proposed, from suppliers of raw materials to the final customer, on the assumption that the dissemination of information in the chain may reduce the WE.

Keywords: Supply Chain, Whiplash Effect, PET Bottles, World Cup 2014

1 Introduction

A manufacturer of PET (Polyethylene terephthalate) packing for soft drink in the Metropolitan Area of Salvador (MRS) is concerned about the impact on its stocks caused by unexpected variability on demand during the next Soccer World Cup 2014. It is known that demand levels of soft drink strongly increase during that kind of event. The phenomenon of unbalanced distribution due to information distortion in a supply chain remains focusing the attention of logistics practitioners and theoreticians. That phenomenon is known as whiplash effect (WE). This study is relevant as a way to contribute to solve a practical problem by measuring the present WE and using the outcome to foresee future problems.

This paper aims to study the oscillations in demand caused by information distortion on the quantities demanded in a link in the supply chain formed by the PET packing manufacturer and a soft drink company that uses that package. Such oscillations were observed between January and December 2010, and its consequences were studied in the light of the WE, having been dimensioned by the method developed by Fransoo & Wouters (1997). The outcome of the calculations is a warning sign about the expected impacts of these oscillations for the period of the Soccer World Cup 2014, when the levels of demand will strongly change.

As a way of preventing an artificial amplification of demand orders during the soccer championship it is suggested better integration between the two levels of the supply chain. To mitigate that phenomenon occurrence, is recommended to implement information technology tools for disseminating more accurate data about quantities predictions.

2 Context

In recent times, logistics processes have attracted the attention of industries, trade and service organizations due to the search for greater competitiveness. Logistics costs, which mostly are classified as variable costs, now represent an increasingly significant percentage in the composition of total production costs. Thus, greater attention and more control in the quest for significant reductions in logistics costs have become of interest to the productive activity. It is known that information about demand throughout the supply chain tends to be amplified at every link in the chain upstream and, consequently, its members take the chance to operate under unrealistic expectations of increased demand, producing the WE (Forrester 1958). Such effect causes an impact in the logistic costs as it induces the chain companies to make speculative and needless decisions that could be avoided. The appropriate determination of the WE reveals the extent to which distorted and inaccurate information could lead to forecasting errors at different stages of the chain. These errors will lead to unrealistic inferences about the behavior of demand. This dysfunction is associated with lack of information and also to its inadequate quality, generating distortions that are amplified by all the links in the supply chain.

In an entire chain, the retailer may be affected as well as the wholesaler, the distributor, the manufacturer and, finally, their suppliers, often exponentially, the amount that grows toward the factory and its suppliers.

In the face of that dysfunction, beyond the expected increase in variable costs resulting from the inventory, fixed costs proportion also tends to grow upstream the supply chain, due to the need for adding extra capacity. This means that the implications of the WE – which, as said, occur in a growing manner toward the factory and its suppliers - also include lengthening the time of recovery of fixed costs, as a consequence of additional depreciation of machinery, equipment and facilities. Thus, WE could results in "*increase in manufacturing costs, inventory costs, cost of transport, cost of manpower, as well as costs due to inventory shortages, leading to loss of sales to the supply chain, and problems in inventory management*" (Diniz, 2009).

The WE, also known as "Forrester effect" in honor of Jay Forrester, was first set in a classic article from the Harvard Business Review ("Industrial Dynamics, July/Aug. 1958").

For the present case study, in order to understand the occurrence of the WE in a link in the supply chain consisting of a producer of PET package and a company that produces soft drinks using such packages, data were collected to forecast demand in one year period (2010).

The packaging producer receives demand forecasts in liters, classified by type of package, final customers and the company that makes soft drinks. This information is converted into a Master Production Plan. Over the periods, initial forecasts will be finally manufactured (or modified as orders are placed) and then billed and delivered becoming "actual sales" for the packing producer and "effective procurement" for the soft drinks company. The WE is configured by the quantitative differences found between the "demand forecasts" reported monthly, then fortnightly, and the actual sales consolidated. These differences result in the increases in inventory costs and those other costs directly related to overestimated or underestimated production process, whatever the case may be. In this context, attempts to measure the consequences of that effect on logistics costs are justified. This study pays especial attention to the costs of raw materials inventories, since such costs are of significant importance to the efficiency of management, from the PET bottles manufacturer standpoint.

Furthermore, if it is considered that in normal market conditions the WE has already been installed, i.e., it occurs systematically even though to a lesser extent, the increased demand for PET bottles during the World Cup 2014 may enhance this dysfunction. The companies of the chain will be in charge of managing the business order to prevent themselves from that phenomenon during the mentioned event. The suitable measures depend mainly on the application of appropriate information processes between the supply chain levels (bottle manufacturer and soft drink producer), seeking integration and dissemination of more accurate information on demand.

Based on the arguments presented here, this work has its problem-question defined as follows:

> "*What are the current impacts of the WE in the production of PET bottles and how to prevent these impacts from growing during the World Cup 2014?*"

3 Theoretical Fundaments

Ballou, (2001) sets out the logistics business studies, so that management can provide better level of profitability in distribution services to customers and consumers. This can be done by planning and organizing effective control for handling and storage activities aimed to improve the product flow. Regarding the logistics industry Ballou, (2001) presented (Table 1) where the logistic function relates to the company areas of production and marketing.

Table 1: The function of the Logistics Industrial Company. Adapted from Ballou (1999).

LOGISTICS FUNCTION IN INDUSTRIAL COMPANY				
PRODUCTION	**PRODUCTION INTERFACE AND LOGISTICS**	**LOGISTICS**	***MARKETING INTERFACE AND* LOGISTICS**	**MARKETING**
Production Planning	Production Planning	Inventory management	Service levels	Promotion
Material Handling	Location of Facilities	Order Processing	Pricing	Market Research
Maintenance of Equipment	Purchases	Storage and Handling	Package	Management of sales teams
Quality management		Transportation of finished product	Location of facilities	

According to Silva & Colenci (2009), demand and forecast errors are always associated in a given system. These errors are spread and amplified when transmitted from company to company within the value chain from customer towards supplier. The products demand variability to final consumers is considered a common phenomenon. This can be explained by a number of factors, such as special dates that encourage consumption, such as Christmas, Mother's Day, Father's Day, Valentine's Day, Children's Day, ie.., allowances, bonuses and extra salary; cultural events that stimulate the consumption of certain products, marketing campaigns, early academic periods, sold out season, and other factors.
It can be stated that the WE is the result of the discrepancy between planned and actual demand, leading the companies to poor decision making in their intention to align supply with demand. Thus, companies, for not having the correct information of their clients, seek to protect and secure the stock to a possible change in demand.

Distortions in information demand may occur and do occur, as we move away from the final customer along the supply chain. In a simple linear supply chain - a series of companies whose claims come only from the next member - the final consumers create the demand for the last company of the chain. Both the seasonality of demand and the forecast errors can increase the distortion, as we approach the beginning of the supply chain.

Lee, Padmanabhan and Whang (1997) listed the difficulties resulting from WE:

- lost sales due to stock-outs generated by extreme variations in demand;
- Increase safety stocks, aiming the recovery of service levels to ensure the competitiveness of the structure;
- Increase the number of rescheduling production to cover emergencies;
- Inefficient management of local resources such as personnel, equipment and capital.

The substantial consequences for organizations are:

- Rising costs related to inventories in the supply chain, due to the increase of local stocks in each stage of the system;
- Fall in return on capital invested in chain operations;
- Decreased productivity of employees who work in production processes developed in the system;
- Reactive decision making process, mainly due to the demand peaks, causing disruption of planning;
- Inefficient management of resources in the supply chain as a whole, as a result of local inefficiencies and difficulty of integration of performed operations.

3.1 Methods applied to the dimensioning of Whiplash Effect

There are interesting works applying simulation methods to measure the WE, (DOMANSKI, R. et al., 2009). Nevertheless, the case calls for a practical algorithm to be used on the shop floor, among practitioners.

Silva (2008) presented their work in some research about the methods of calculating the WE, used in various industries, in order to make assessments of the level of amplification and fluctuation in existing supply chains. Table 2 shows these research and areas in which it was applied.

Table 2: Examples of research for the measurement of whiplash effect. Adapted from Silva (2008)

REFERENCES	**AIM OF THE RESEARCH**
Blackburn (1991)	Automotive industry
Avery *et al* (1993)	Automotive industry in an MRP environment
Hammond (1994)	Automotive industry in an MRP environment
Lee *et al* (1995)	Food Industry (USA)
Lee *et al* (1997)	Personal care industry
Holmstrom (1997)	Supermarket industry (Europe)
Gill e Abend (1997)	Retail industry (USA)
Taylor (1999)	Automotive industry (UK)
Fransoo & Wouters (2000)	Food Industry (Europe)
McCullen & Towill (2001)	Mechanical Industry (Europe)
El-Beheiry *et al* (2004)	Toy Industry (Europe and USA)
Hejazi & Hilmola (2004)	Electronics and furniture industry (Europe)

In the present study, the methodology used to measure the WE was the one developed by Fransoo & Wouters (1997). According to these authors the effect on a chain level (ω) is obtained by the ratio between the level of dispersion in sales of a supplier to his customer (Cout) and the level of dispersion of demands of the customer to the supplier (Cin) of the link studied. The level of dispersion (C) is obtained by dividing the standard deviation (σ) by the arithmetic average (μ) for each distribution (Table 3). The demands (Din) are quantitative data informed by a posterior level of the chain (customer) to the previous level (supplier). Sales (Dout) are the quantitative data corresponding to the previous level of the chain (supplier) in response to demands. That is, Din is the order of a chain customer to a supplier and Dout is the value of the requests addressed by this vendor, as shown in Figure 1 below:

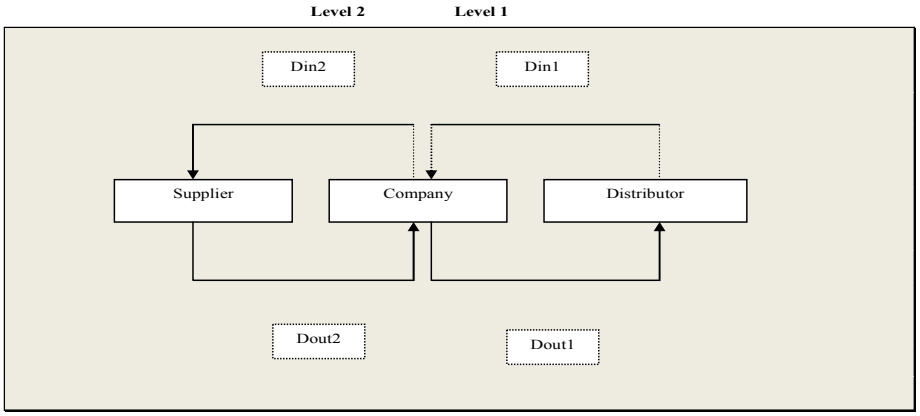

Figure 1: logistical Flows link in a two-level supply chain. Adapted from Vieira, Barbosa and Conceição (2003).

According to the methodology, the " whiplash effect" is calculated using the formula in Table 3 below:

Table 3: Calculation of the WE. Adapted from Fransoo & Wouters.

(1) ω = Cout / Cin	the effect on a chain level
(2) Cout = σ (Dout (t, t + T)) / μ (Dout (t, t +T))	level of dispersion in each link on sales
(3) Cin = σ (Din (t, t + T)) / μ (Din (t, t + T))	level of dispersion in each link on the demands
(4) Dout (t, t + T)	value of orders served by the supplier to the customer (sales)
(5) Din (t, t + T)	value of orders for a customer to a supplier chain (demands)
(6) ωT = ω1 x ω2	whiplash effect in a total of two levels of the chain

4 The firm and the World Cup 2014

The research firm is one of the largest units of the Brazilian market to produce PET bottles for soft drinks. This factory, located in the City of Simões Filho, Bahia, offers packaging solutions for customers of different needs - especially the soft drinks market. The company is a major supplier of packaging for leading soft drink market in Brazil, having pioneered the production of PET in Brazil since 1987. (Available in http://www.engepack.com.br accessed on 24 September 2011.) FIFA World Cup 2014 (International Federation of Association Football) will be held in Brazil for the second time. Investments about $ 4.5 billion only in stadiums are provided, and $ 500 million of this amount is budgeted for Salvador. The general infrastructure projects are ongoing and an investment of over $ 8.5 billion is estimated nationwide.

One of the most important world sporting events today, the World Cup 2014 will mobilize the savings of the 12 (twelve) host cities in the social, infrastructure and movement of productive resources. In such, the productive organizations will be challenged to respond proactively by planning for the supply of raw materials to manufacture its products, the adjustment of their production capacity, and adequacy of its distribution network, aiming at the efficient and effective service demands. Considering that the period of the event is relatively short, the programmed actions should be planned well in advance and accurately, so that products and services are available to consumers at the right time, right place, and the desired quality.

One of the problems facing supply chains for some is the possibility of occurrence of the WE, due to the sharp increase in demand for products and services. Thus, the study of the implications of that phenomenon as a possible solution can contribute to preventive negative effects caused by changes in demand for specific products and services, during the World Cup 2014.

The firm of this case study has a strong belief that a practical measurement of the WE will be helpful to overcome difficulties related to demand oscillation during the sport event.

5 Results of the WE during the period from January/2010 to December/2010

The methodology developed by Fransoo & Wouters (1997), described in section 3 of this work was applied to the case study. Samples for the soft drink sales forecasts and production volumes of PET bottles (Level 1), as well as, the intended purchase of PET resin from the suppliers and the actual quantities sold by them (Level 2) are shown in Table 4, from January to December 2010. The calculation of the WE is shown in Table 5.

Table 4: Production and Sales Plan. Source: Company studied.

		PERIOD												
		jan/10	feb/10	mar/10	apr/10	may/10	jun/10	jul/10	ago/10	sep/10	oct/10	nov/10	dec/10	Total
Level 1	Sales Forecasting *Din* 1	668.380	486.538	614.618	513.248	492.022	554.271	577.993	466.463	643.722	700.897	726.938	750.958	7.196.049
	Production Volume *Dout* 1	802.056	608.173	799.004	590.235	590.426	731.638	809.190	587.744	759.592	939.202	763.285	1.126.437	9.106.982
Level 2	Forecast Purchases *Din* 2	600.000	600.000	600.000	800.000	600.000	600.000	800.000	600.000	800.000	800.000	900.000	900.000	8.600.000
	Sales Volume *Dout* 2	585.000	585.000	585.000	0	650.000	700.000	750.000	0	825.000	0	905.000	880.000	6.465.000

By observing Table 5 it is noted that at Level 1, by comparison between the forecast of sales and the production of PET bottles, there was an amplification of 1.28. In turn, at Level 2, the comparison between the forecast of purchased PET resin and its sales volume by the same supplier, it is noted that there was an amplification of 3.60. As a result of its impact on two levels, the overall effect investigated to the chain stood at 4.60, which is the multiplication factor of the upstream supply chain of PET bottles for soft drinks.

Table 5: Calculation of the WE in two levels of the chain studied. Source: Designed by the author

PRODUCTION OF PET BOTTLES							
Levels		**Monthly Average**	**Standard Deviation**	**Cin**	**Cout**	**ω**	**ωTotal**
Level 1	Sales Forecast Din 1	599.671	99.246	0,1655	0,2114	1,28	4,60
	Production Volume Dout 1	758.915	160.454				
Level 2	Purchase Forecast Din 2	716.667	126.730	0,1768	0,6363	3,60	
	Sales Volume Dout 2	538.750	342.810				

6 Results of the WE estimated for the World Cup 2014

According to data reported by the Ministry of Sport in 2010 (based on studies of the Brazilian Institute IBGE), in 2014 the Gross Domestic Product (GDP) of Salvador will have increased by 4.23%. This percentage refers to the overall increase of GDP in the local economy, and there is no evidence that it can be regarded as the same percentage of increase that will occur in the production of PET, or even the production of soft drinks. This is because the impact of GDP increase in the production of such products

should also be identified by the time the event date is approaching and the share of GDP be predicted for the area of food and beverages.

The impact of the WE calculated were obtained considering the forecasts and actual sales reported by the producer of PET, which occurred during the year 2010, which followed the behavior of consumption patterns in terms of normal variation, considered all events provided for that year.

The fact that the company recognizes the current existence of the WE evidenced by an amplification of the order of almost five times according the Fransoo & Wouters model is positive to the management . In fact, based on the forecasts of demand growth that will occur in the World Cup 2014, the two levels (supplier and customer) of the chain tend to manage more efficiently their relationship. Then, impacts should be minimized, so that the factor found (4.60) in the calculation performed in year 2010 will not occur during the sport event in 2014. It was recommended to the management the implementation of specific IT tools that should be used seeking to share information on demands in the chain, which aims to reduce the impacts generated by the WE.

6.1 Anticipated costs of the WE in World Cup 2014

According to data from the Brazilian Association of Soft Drinks - ABIR in the period 2004-2012 (actual data and projections) soft drink consumption grows by an average of 3% per year. Thus, projecting the same growth in the years 2013-2014 on the company's data, we infer that the production of PET bottles would reach 7,465,222 million liters in 2014 (Table 6). The cumulative percentage of growth will be about 13%, without considering the implementation of the World Cup.

Knowing that there will be significant increase in the consumption of soft drinks, and, assuming hypothetically that there may be a 40% increase in consumption, due to domestic and foreign tourism movements during the course of the sporting event of 2014, sales could be about 10.4 million liters (Table 6). It should be explained here that the increase of 40% is just a prediction for the area of food and beverages in 2014.

Table 6: Projections of consumption (sales) of PET bottles. (in liters). Source: Designed by the Authors.

CONSUMPTION OF SOFT DRINKS, liters				
Year	**Actual Consumption**	**Predicted Consumption**	**% Accumulated**	**% Year**
2010	6.632.753		100	3
2011		6.831.736	103	3
2012		7.036.688	106	3
2013		7.247.788	109	3
2014		7.465.222	113	3
Cup 2014		10.451.311	158	40

Considering that the prices of raw materials will not change significantly in coming years, because beverages are commodities, projected purchases of PET bottles would be in the order of $ 42 million, and its consumption would reach R$ 52,7 million, which would demonstrate the impact of the WE in logistics costs of raw materials (Table 8).

Table 8: Projections for World Cup 2014. Source: Designed by the authors

PET BOTTLES – Projection for 2014			
Purchases		**Consumption**	
Volume	**Value**	**Volume**	**Value**
10.214.700	41.979.573	14.349.984	52.710.030

7 CONCLUSION

This article aims to discuss the impact of the WE in the manufacture of PET bottles by a company of the package sector in the State of Bahia and to present a method for sizing effect. It was recommended to the management some information technology tools capable of mitigating the WE on the variability of demand information. Details of the mentioned recommendation are not part of this work.

The results obtained by the application of the methodology developed by Fransoo & Wouters for sizing the WE highlighted the lack of synchronism in the programming activities of the production of PET bottles with regard to the acquisition of raw materials, due to amplification of demand information.

The case study pointed out the same kind of implications from the WE which was mentioned by Lee, Padmanaban and Whang, 1997. In fact, the producer of PET packaging carried out some tasks to keep up with demand variation especially the "to increase safety stocks, with a view to recover from low service levels". One of the conclusions of this phenomenon is that its effects lead to reduced profitability, since organizations tend to build up stocks of raw materials and thus immobilize capital that will only be paid in longer terms, i.e., from the moment those stocks are being used. Additionally, this reduces the profitability of other links in the chain, because of rising costs imposed on them. In such a situation, if the final prices of the products are inflexible, chain companies will bear those costs and, consequently, their profit margins will be reduced.

Indeed, in its management strategy, the company studied will have to protect itself against the harmful effects caused by the considerable variability in demand informed by the client. If the company uses appropriate information tools to monitor and control their inventories more effectively, the total cost of the chain would be reduced and the return on capital employed in logistics operations and production of PET bottles would be kept.

The dimension of the WE as calculated in this research resulted in obtaining amplification of the order of 1.28 for the first level of the chain - producer of PET packaging and producer of soft drinks - and 3.60 for the second level - producer of PET packaging and raw material supplier. Thus, it was noted that from the first to the second level of the supply chain, there has been an increase of almost three times. Considering the complete supply chain with the two levels lead to an amplification factor of 4.60, indicating that this is the extent of WE in the observed relationship between the companies studied.

The mentioned degree of amplification derived from purchases of raw materials that should be corresponding to 6.4 million liters, while the actual demand by the producer of soft drinks was around 9.1 million liters. This scenario means that the producer of packaging suffers the effects of misinformation between demand and consumption. The implication is that if its production schedule considers as valid the correct quantity demanded, there will not be enough stocks to manufacture the product, and its customer will not be addressed in adequate level of service.

Thus, due to fluctuations in the actual quantities of consumption, the package producer is obligated to maintain stocks at excessive levels of demand forecasts, absorbing costs of maintaining inventories, in order not to incur the costs of inventory shortages.

Due to the grandiosity of the World Cup 2014 - and therefore the predictions of significant increases in consumption - it would seem that the companies studied will get prepared to respond effectively to situations that could lead them to compromise their operations as a result of the WE. That signifies implementing management programs that reduce the uncertainty and variability by means of information technology tools.

This work entails the conduct of future research on the chain studied, particularly with regard to the adoption of information technology tools that minimize the consequences of whiplash in the production of PET bottles for soft drinks.

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