Behavioral obstacles in a metal mechanical industry
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ABSTRACT

One consequence of poor coordination is the variability of the demand at the next upstream level in the supply chain, known as bullwhip effect. The experiment is focused on a business game known as the beer game, which was applied into a metal mechanical industry. The main difference of this experiment, with other studies, is the choice of participants (company staff performing similar roles). The experimental results confirm the value of the information, its effect on profitability and business efficiency, avoiding unnecessary costs and inadequate management of resources.

This experiment shows the behavioral obstacles, because all the participants know how the other participants react in similar situation and try to use this knowledge to win the game. According to these results, they incorporate sustainability in their supplying chain, thus management practices need time and trust to become a driver for bringing positive changes in the society.

KEYWORDS

Experiment, Coordination, Information, Supply Chain.

INTRODUCTION

The experiment environment was a dynamic, non-linear system with various controls established by the times, delays and dynamic flows (information, products, materials and others). The cases show the variability of orders, increased levels of inventory, reducing the efficiency of the processes, excessive use of capital and its effect on the client [7] [8].

This experiment based on previous researches about two categories of the bullwhip effect: operational [8] and behavioral [6] [11]; and the experimental models based on competitive and cooperative in the supply chain [1] [3] [4].

The experiment consists on four treatments in which the participants have different level of collaboration and visibility of information to improve the satisfaction of customers, to avoid uncertainty, mitigate variability and range of production orders.

The difference among the previous experimental models [3] [11] [12] is the choice of participants in the experiment, these are employees (workers) of a metal working company. The experimental part and the practical part are related one each other.

The participants should focus the results on reducing costs and meet the expectations of customers [2]; or bound human rationality produces systematic errors in judgment and choice [10].

The aim is to prove that the coordination between participants will reduce significantly the variability and amplification of orders [3] [11].

The participants work in a metal furniture company. Its features include:

- The market segment is focused on low-cost products.
- The company maintains a balance between the quality of the products and process, according to the requirements of customers.
- The structure of production is flexible, in order to offer a wide variety of products to the clients.
- The introduction of new products is done relatively quickly.
- The production plant is flexible to changes in demand, increase or decrease, due to its cellular structure.
- The main processes involve cut, wash, weld, paint and assembly.

The company had a problem; the retailer sales in many products were considerably lower than production orders. The warehouse had products returned and discontinued. These products are sold in the plant, but in many cases below the cost.

EXPERIMENTAL DESIGN

The experimental tool is a computer game based on the traditional Beer Game [5] [6]. The participants have four roles (factory, distributor, wholesales and retailer).

The rules and mechanism of the game are documented in detail in various publications [9] [10]. In each period, the participants try to meet its customer demand, through the inventory, orders in process and future orders.

The objective is minimizing the cost of the whole team.

The experimental development was done with Microsoft Visual Studio to take control of the model. The platform is built on the Microsoft Windows XP and architecture of communication supported under TCP/IP, with Microsoft Access database. The client-server application is divided in three layers:

- User application
- Sever application
- Database

According previous researches, we prepared four scenarios or experiments. The aim was obtain information for implement a supply chain sustainability plan in the production process.

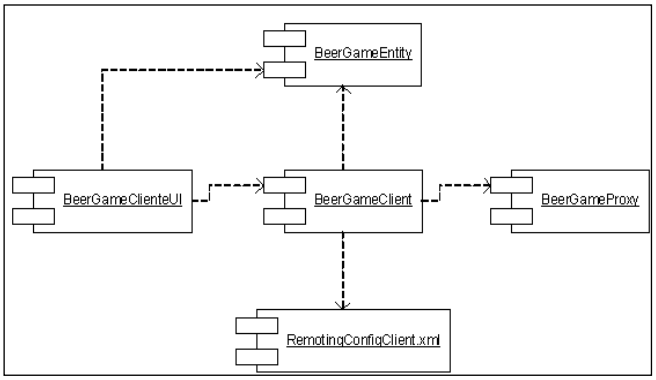

Fig. 1. User application components, allows the experiment interaction, server connection and save the records.

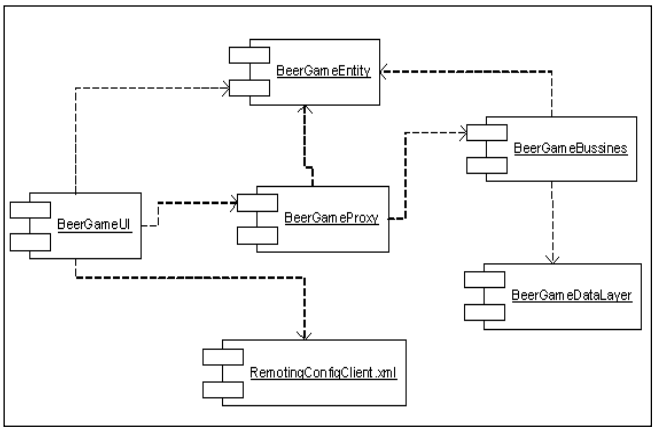

Fig. 2. Server application components, generates flows and records in the database with options of administrator, setup demand and monitor

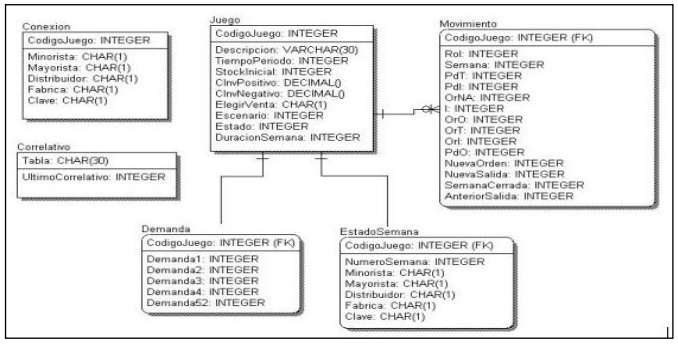

Fig. 3. Database, relational tables for query, record and change data were developed with Microsoft Access

EXPERIMENTAL RESULTS

According previous researches, we prepared four scenarios or experiments [3] [4] [11] [12]. The aim was obtain information for implement a supply chain sustainability plan in the production process.

The experiment without information shows an adequate management of the orders and the inventory of the retailer in the first weeks, but due to a lack of products in its inventory generated an increase in orders from the tenth week. The wholesaler and the retailer generate similar orders, but the effect of increased orders from retailer generates a higher fluctuation in the wholesaler. The effect of higher orders becomes more evident in the factory.

The experiment with known demand, initially remains in balance, but generated a swing and amplification of the orders from the eighth week, despite knowledge of the demand. The participants despite knowledge of demand had a tendency to want to order more real to correct the lack of inventory and delay in delivery of products. The initial guess at this stage was that knowledge of demand would reduce the total cost and reduce the level of orders.

The experiment with visualization of the flows (orders and products) reduces the variability of orders and abrupt changes, creating stability in the entire system. The results show that the performance was improved in the sense of visibility of orders and product flow, reducing the variability of orders. However, it shows very variable inventory levels.

The experiment with coordination displays a stable environment from the first weeks with a reduced amplification and the variability of the orders. The suit is similar to the previous scenario with values from 2-12. The stage from the beginning shows a slight decrease in the variability of orders respect to the previous scenario, a more stable one.

Exp.	Demand	Supplier	Wholesales	Distributor	Factory
1	07.47	16.80	25.37	59.10	65.67
2	07.47	11.20	14.90	19.53	24.80
3	07.13	07.73	08.57	09.07	09.33
4	07.27	08.17	07.87	08.40	08.80

Table 1. Means of orders placed

Exp.	Demand	Supplier	Wholesales	Distributor	Factory
1	01.38	16.88	27.36	95.92	87.12
2	01.38	07.61	10.10	13.30	24.42
3	02.56	02.84	04.97	08.71	10.42
4	02.40	03.28	02.65	02.30	02.91

Table 2. Standard Deviation of orders placed

RESULTS

- The experiment presents increasing of the level of information, reduces the amplitude and variability of the orders, having a direct effect on the cost of the total which ultimately affects the product price that has to be paid by the customer.
- The results show a tendency to reduce the total costs as the level of information increases in each participant. Experiment 3 (visibility) and 4 (coordination), show a reduction of costs and a stability in the orders.
- The participants in all the scenarios show the following behaviors:
  - Generate additional orders to meet sudden changes in demand.
  - Reduce orders when they have excess inventory, without considering the impact on suppliers.
  - Reduce when orders are reduced downstream.
- According participants interviews, experiment four (coordination) has a degree of uncertainty without trust.
- The participants were interested in the impact of: risk management, financial performance and sustainability.

CONCLUSIONS

- After this experience the company implemented actions to integrate internally, externally and electronically:
  - Collaboration among all their decision makers.
  - Communication and real time share key information.
  - Synchronize the production: retailer, distributor and plant.
  - Carbon footprint: first plan to calculate it in their manufacturing processes.
- The company left the plan to incorporate sustainability in their supplying chain management practices. They need organization changes and trust to become a driver for bringing positive change in the society.
- The experimental extension of this study will add these options:
  - The probability of risk in the flows.
  - The four financial statements: balance sheet, income statement, owner equity statement and cash flow; for each participant and general.
  - The measure sustainability metrics: energy consumption, water consumption, green house emission (CO_2, CH_4, N_2O).

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