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The Beer Game Revisited: Creating a Model for Collaboration
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The Beer Game Revisited: Creating a Model for Collaboration

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Submitted to the Zaragoza Logistics Center

EXECUTIVE SUMMARY

Introduction

This thesis revisits the beer distribution game and modifies the model to account for a collaborative environment. The rule set and structure of the game are changed to represent first simple information sharing and then co-managed inventory, a more radically collaborative business practice. This approach is taken to critically evaluate collaborative planning and information sharing in the context of a small business. More specifically, this thesis will identify the quantifiable benefits achieved through collaboration.

Background

The Beer Distribution Game

The game is played by industry teams. A team consists of a minimum of four people; at least one person is needed at each level of the supply chain to make decisions. There is a factory that produces beer, a distributor, a wholesaler, and finally a retailer that fulfills customer demand. These are represented as squares on a table with two smaller squares between each larger square. The smaller squares represent shipping delays between the levels. Each decision maker sits at their respective level of the supply chain creating a linear distribution down the table.

The goal of the game is to minimize team costs. Since the purchase cost is disregarded, the costs that are being looked at are the holding cost and the backorder cost. These costs are $0.50 and $1.00 per case, per week respectively. Costs are assessed at each level such that each DMU is responsible for a portion of the team costs.

There are not many rules to the game, but the few rules that do exist must be adhered to very carefully. First, the individual decision making units (DMUs) corresponding to each level (retailer, wholesaler, etc.) must act as silos. They are not allowed to communicate with the other levels of the supply chain in any form beyond a number of beer cases on their order form. This form, consequently, is only to be passed one level upstream (wholesaler to distributor, distributor to factory, etc.). The second rule is to not skip any of the steps and to wait for the proctor's instruction to continue with the next step.

the beginning of each period, chips representing beer cases are moved one spot down stream on the board. Beer that was in transit is, thus, received. The amount received does not necessarily equal the quantity ordered. The orders from the previous period are then put into transit if enough inventory is on hand. If the on hand inventory is insufficient, the remaining portion of the order must be filled in the next round and will be treated as a backlog. The next step is to calculate holding and backlog costs and is done by counting inventory or calculating the cumulative backorder. The final step is to generate new orders and "send" the orders upstream bringing the system to the beginning of the next period.

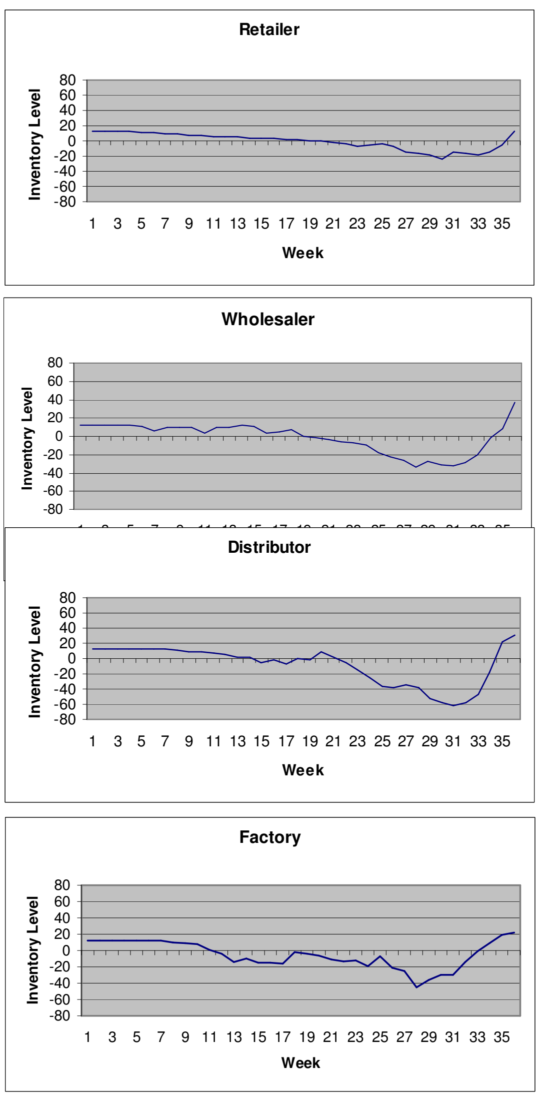
The simulation is oversimplified, not taking into account any calculations of capacity constraints, labor requirements, machine availability (on the factory level), and so forth. The only decision is a seemingly straight forward decision on how much to order for the next period. Players are asked at the end of the game what they would change about the game to improve their results and to reduce the bullwhip effect. The most typical answer is to collaborate, or to share information, or simply to be able to talk to the other players in their team.

Revisiting the Beer Distribution Game

This thesis, being aimed at small businesses, will look back at the beer game with a slightly different perspective. For a portion of the research involved in writing this thesis, a group of intelligent, veteran beer game players were hand selected to play the game a few more times. These players are candidates for master of engineering degrees in logistics at the MIT-Zaragoza International Logistics Program in Zaragoza, Spain.

Increasing customer demand

Inventory Position Results for the Initial Game



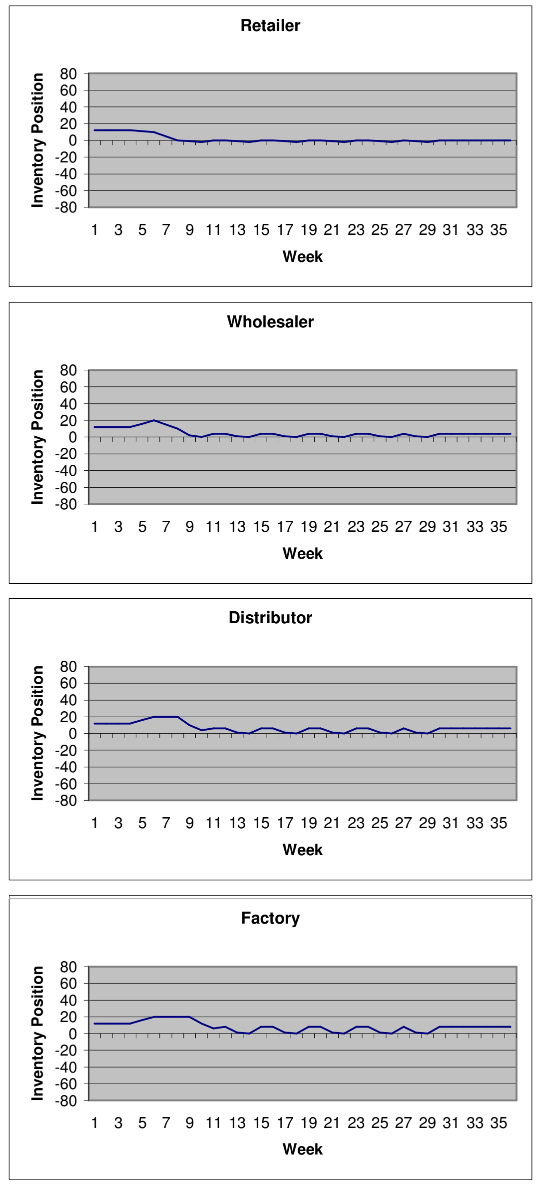
The game was played with a demand pattern representative of a small business entering a market and gaining market share. The demand increased fairly steadily with only one break in the pattern which occurred late in the game. The first round was played with the standard rules. The inventory position of each level gives us an insight into the costs of the system and additionally shows the variability. The inventory position results of the first game are shown to the left.

The amplification that the beer game is known for appeared even with these experienced players. This highlights one of the key points of the game; there is an almost unavoidable amplification of variability as orders are passed up the supply chain.

Following the research that has been done in system dynamics which was discussed in the literature review section, the next thing that this thesis will look at is automating the system to avoid the behavioral causes of the bullwhip effect. To do so, some ordering rules had to be developed to get as close to optimal overall costs as possible. The optimal cost for the game is obviously zero, but due to initial inventories and the fact that backorders cost more than inventory, it is expected that some level of inventory will be carried. The inventory will act as a smoothing factor for variability in demand.

Finding near optimal ordering rules involved running simulations in Microsoft Excel. At each level the on hand inventory for a given period equals the incoming order plus the inventory from the previous period minus the order from down stream. Trying out different ordering rules provided game costs and insight into ordering. Even with automation and these near optimal ordering by each level the following amplification occurs:

Inventory Position Results for Automation



As seen in the above graphs, the factory's variation in inventory is far greater than the variation at the retail level. All of the levels have a different base stock policy to account for the variability in inventory. The factory has a base stock policy of eight, the distributor has a base stock of six, and the wholesaler has a stock level of four. These policies represent the safety stock levels of each entity to prevent them from going into backlogs.

Each level orders equal to the demand for the period plus the error in the forecasting from the previous two periods. An interesting ordering rule can be applied to the logic of an automated system. If the cumulative need for this period can be met from inventory and the arriving order without the inventory dropping below the base stock level, the quantity being order for the period should equal zero. If the need can be exactly met by what is coming in, the order should be equal to demand. Additionally, if the need is in excess of what is in inventory and what is arriving, the order should be the demand plus the error in the forecast for the two previous periods. The use of this policy brings the inventory position back to the desired level within two periods of any demand shock.

Automation of the system under the anti-collaborative rule set corresponds to a significant savings in holding and backorder costs. However, the players where asked what they would change if they were to play the game again, and they still desired to work together rather than automate the process.

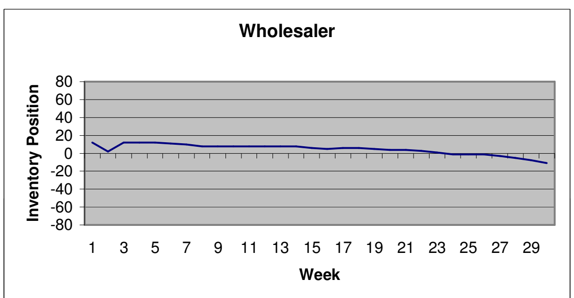
Collaborating in the Beer Game

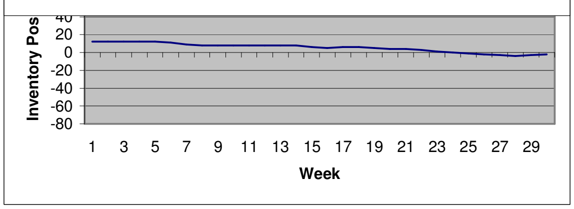
The players said that they thought they could do a lot better if they were allowed to work together, so I let them try. Collaboration within the constructs of the beer distribution game consists of simply talking to one another. Additionally, the key feature to collaboration is that everyone upstream should know what actual customer demand was for each period.

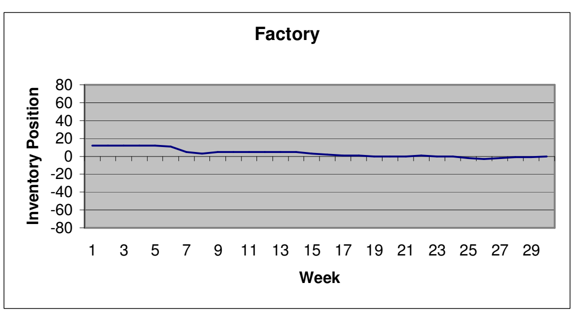
The game was played again, but this time I amended the rules. Players were allowed to communicate, but communications were very limited. They were allowed to speak only with the level directly above or below them, and they were only allowed to tell the other players what they intended to order for the next period and what they "forecasted" the demand coming from downstream would be. The players were allowed to amend their order quantities after hearing their team mates' orders to avoid excess stocks or backorders.

Furthermore, instead of customer demand being given solely to the retailer, customer demand was announced such that all levels could hear it. This process models point of sales information being distributed among all parties. It allows each step to forecast total demands of the supply chain as well as their own level specific demands. The results of the game are as follows:

Inventory Position Results for the Collaborative Game







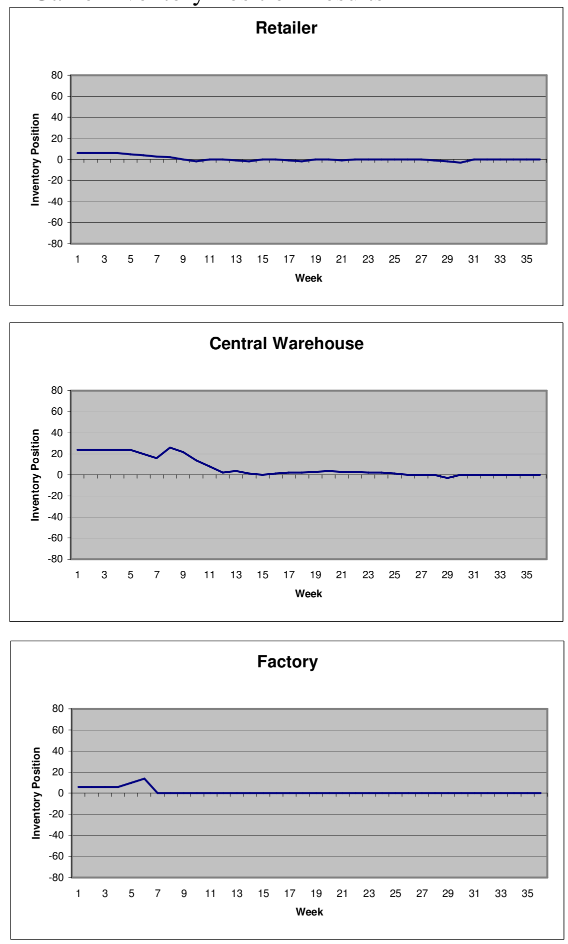
The first thing that should be noted when looking at the game results is how much the variability was reduced. Another interesting point is to note the demand shock that occurred at the wholesaler level in the first couple weeks. The distributor and factory under non-collaborative rules would have had similar shocks, but the shocks did not occur. The wholesaler must have informed the distributor what they were doing such that the distributor did not follow suit in its ordering pattern.

The costs are significantly reduced for the second game and the players expressed a feeling of accomplishment. They felt that they had done about as good as they could within the constructs of the game. It is important to note that their costs were higher than the automated game results, but no automation was necessary for them to see significant savings.

The question was once again asked: what would you change about this game if you could change one thing? The players could not think of anything else that they would do with the exception of some "outrageous" changes like allowing the retailer to make all the ordering decisions or to change the structure of the game to allow for a central warehouse with reduced lead times. The requests sounded a lot like the concept of co-managing inventory, or CMI, so after a short deliberation the players were requested to come back and play a "new" beer game.

Co-Managed Inventory in the “New” Beer Distribution Game

CMI Game Inventory Position Results



The “new” beer game is fundamentally a different game from the instructional game played the world over. With Co-Managed Inventory there should, ideally, be only one location where inventory is held. In the traditional beer game there are four stages of inventory holding, thus the game’s design had to be changed to account for CMI. The new game had a central warehouse rather than the wholesaler and distributor.

Under the new structure, the game could be played with as few as two people. There would be a person making decisions at the retailer level and another person making decisions at the factory level. The two would jointly decide how much inventory to keep in the central warehouse so there is no need for a local decision making unit at this level. Since the two levels must work together, the rules to the game are modified to allow for collaboration similar to the game discussed in the previous section. The results of the “new” beer game are shown to the right:

The game, having been set up with substantial inventory stock piles at the central warehouse, had some variation in the first few weeks as the team tried to reduce their inventory levels to close to zero.

Since the system was not automated, there were a few calculation errors that occurred in the ordering process. These errors led to the mistakes, or backlogs, discussed previously. The players, however, felt great about the game. One member from the factory level even gave a member at the retail level a congratulatory high five when I called the game after week thirty-six.

Conclusions concerning the Beer Game

Which game was the least expensive? Due to the variability in starting inventory numbers at the beginning of the game and the fact that the players were not in control of their ordering for the first four weeks, the calculation of cost looks at periods ten through thirty. The costs are as follows: standard rules - $991.50, Automation - $127, Information Sharing - $201.50, and CMI - $44.

The costs associated with holding and backorders are typically far greater than these said costs and thus looking at the game scores in a relative fashion makes more sense than in absolute terms. The cost savings seen from moving from the standard, “siloed” information, non-collaborative structure to a collaborative CMI environment are on the order of 95%.