THE WOOD SUPPLY GAME

A Logistics Flight Simulator for the Forest Sector

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Summary

Efforts to improve efficiencies in the forest industries have mainly focused on problems within the borders of the company. Thus, there is an unexploited potential for increased efficiency through integrating and coordinating activities between companies. This poster presents games that mimic the forest industry and demonstrate to the players how the structure of the system, including restricted access to demand information, can result in a mismatch between supply and demand. The resulting chaos, characterised by rapid transitions from situations with considerable backlogs of orders to situations with excessive inventories, makes it difficult for the players to regain control of the system.

Introduction

The Beer Game (BG) was developed by Sloan School of Management in the 1960s and is one of the most frequently used student exercises in management and logistics education. The four players are each managing a company in a distribution chain consisting of a brewery for beer, a distributor, a wholesaler and a retailer who delivers beer to consumers.

Transition from Beer to Wood

BG is a chain with no branching of the material flow, and where no production occurs (Figure 1). With the aim of increasing the relevance for logistics in forestry, flows of divergence (such as in log and lumber manufacturing) and convergence (such as mixing several raw materials for paper production) were included in the game structure.

The modification of BG into the Wood Supply Game (WSG) involves connecting a lumber chain with a paper chain by introducing the forest as a common source of raw materials (Figure 1). A wood supply group diverges the material flow by delivering pulpwood to a paper mill and sawlogs to a sawmill. The paper mill supplies the paper chain, while the sawmill is, in addition to delivering lumber products to the lumber chain, also delivering chips to the paper mill. Hence, the mixture of chips and pulpwood for paper production constitute a point of convergence, while bucking into sawlogs/pulpwood (wood supply group), production of lumber/chips (sawmill), and production of paper/by-products (paper mill) constitute points of divergence (Figure 1).

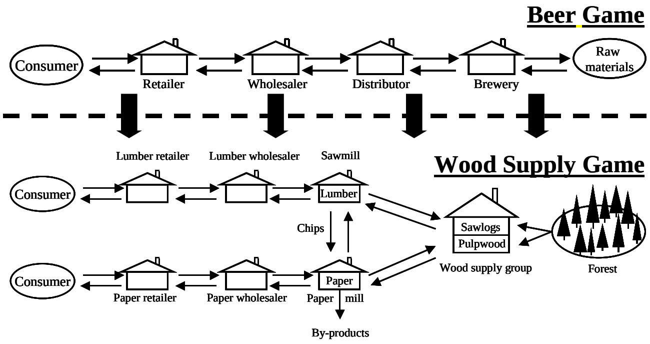

Figure 1
The structure of the standard Beer Game and how it is modified in the Wood Supply Game. Each of the games requires one player to operate each company (except "consumer" which is a deck of demand cards).

Methods - Playing the game

The game as played in real life is shown in Figure 2. The objective for the players is to minimise the total costs of the chain, and there are only two cost drivers to consider:

- A weekly unit cost of keeping inventory.
- A weekly unit cost of accumulating a backlog of orders (being out of stock). One unit in the backlog of orders equates to twice the cost of one unit in inventory.

WSG is played for a fixed number of cycles (weeks). Each cycle involves certain activities: Receiving raw materials, order processing, shipping of products, inventory control and placing new orders. Inventories and goods in transit are visible to all players. Order levels, on the other hand, must be kept secret for others than the sender and the receiver. Hence, the retailer is the only player with knowledge of consumer demand. It requires two weeks to transfer orders between players and two additional weeks to ship products back to the customer. Consumer demand is identical for all competing chains, and is also constant during the game, except for one change occurring early in the game.

Figure 2.
Students playing the wood supply game. The forest is to the right in the picture, while the consumer markets for paper and lumber products are to the left. Products moves from right to left, while orders moves from left to right.

Results and lessons learned

Costs incurred by the different players are distributed unevenly (Figure 3). In WSG, as in BG, costs are higher for positions further away from the markets. The wood supply group has lower costs than the mills. This can be explained by shorter delivery lead time for the wood supply group. Varying costs for the positions (Figure 3), obviously result from differences in the two cost drivers: accumulation of inventory and accumulation of backlog.

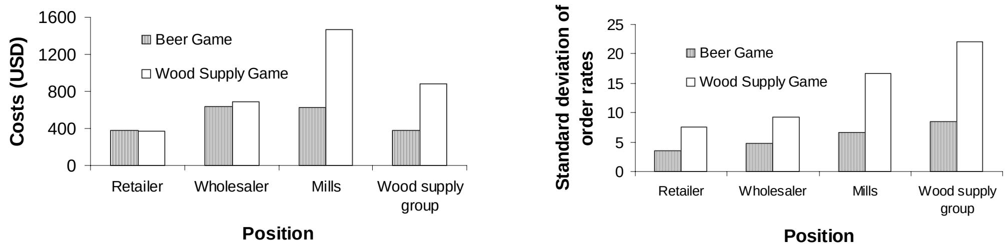

Figure 3.
How costs (left) and the standard deviation of order rates (right) are for the different positions in WSG (N=12), compared to the corresponding positions in BG (N=11).

Changes in inventory

Studying one particular game, inventories for all positions are rather stable the first couple of weeks, and start shrinking for all positions after 5-8 weeks (Figure 4). Backlogs (negative inventory) are most notable for the sawmill, followed by the wholesaler and the wood supply group. Inventories for each position result from placed orders and order pattern upstream in the supply chain.

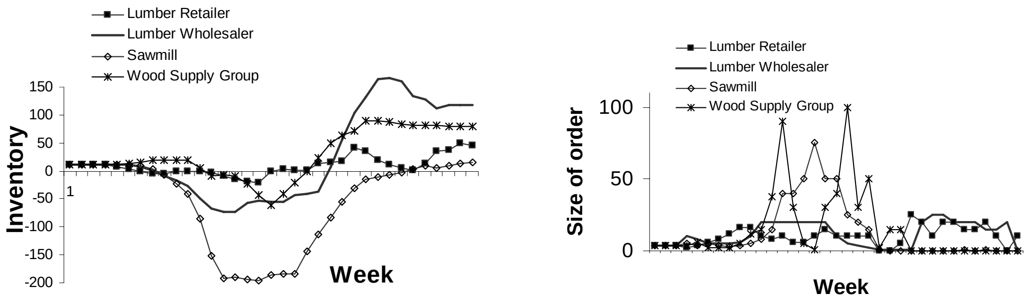

Figure 4.
Development of inventory and the corresponding development of the size of order for one particular WSG.

The placed orders have the highest peaks for the wood supply group and the sawmill (Figure 4). During the post game debriefing session, most players comment on the huge variation in the orders they placed, and blame this on a volatile market. However, during a WSG market demand never exceeds 10, and only changes once. Evidently, the system itself was responsible for most of the dynamics observed.

Based on this, the observed variation of order rates is amazing, but well known in situations where several actors in a sequence make their decisions based on incoming orders from their immediate customers. Systems characterised by restricted access to information (on consumer demand), and time lags between neighbouring actors often experience that demand amplifies upstream in the supply chain. One relevant measure of demand amplification is the standard deviation of the order rate. It is obvious from Figure 3 and Figure 4 that the standard deviation of order rates is increasing upstream in the supply chain.

Although demand is identical, the development of the two chains in a WSG often differs. This causes problems in the points of divergence and convergence. For example, the sawmill might face huge demand for lumber and no demand for chips, thus increasing chips inventory. For the point of convergence, the problems occur when one of the vendors fails to deliver one of the raw materials (pulpwood and chips) that are both required for paper production. The increased complexity and dependency leads to reduced performance for WSG compared BG (Figure 3).

The key role of inventories is to decouple material flows, and thereby reduce their inter-dependency. Recent trends in the forest industry include attention to inventory reductions in order to reduce costs. These savings may, however, become difficult to realise unless operations are considered jointly and information on supply and demand are released to customers and suppliers. In a supply chain with small inventories and high degrees of dependency, there is a risk of increasing the variation of demand. Effects of demand amplification are stronger towards companies upstream in supply chains; the wood based industries and forest operations (Figure 3).

Integrating transport costs

In the most resent version of the game three chains (WSGs) are integrated through a common source of raw materials, where the nodes in the network illustrate supply points in the forest (Figure 5). Transport costs depend on the distance from the supply point to the chain at issue. In situations where supply exceeds demand, wood can be procured from desired locations with moderate transport costs. However, when demand exceeds supply additional transport costs apply in wood procurement. Pilot experiments using this larger version of WSG indicate that the chains with the highest variances of order rates are also penalised with increased unit costs of transportation. This compares well with wood procurement in real life, as procurement costs tend to increase in situations with limited supply.

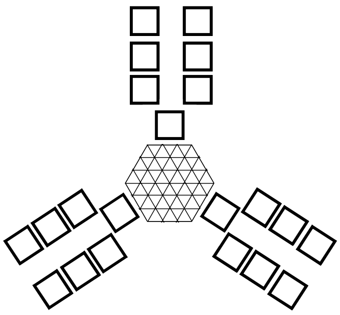

Figure 5.
In the latest version of the wood supply games, competing supply chains are integrated by being supplied form the same forest.

Conclusion

WSGs have been used in the last three years in topics of logistics in the forestry education at the Swedish University of Agricultural Sciences (SLU) and at the Agricultural University of Norway (NLH). The complexity of WSG has continuously increased, and the latest version occupies 30 students for 3 hours. The games convincingly demonstrate to the players, whether students, managers or researchers, how actors in supply chains are constantly affected by each other's decisions, and that lack of communication can cause serious difficulties for the actors concerned.

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