

**BEGA – ANDROID-BASED BEERGAME SIMULATION SOFTWARE  
FOR INTERACTIVE TRAINING AND INNOVATION**

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**Abstract**

*The supply chain management challenges and inventory holding problems can easily be demonstrated by the widely known BeerGame simulation. In the Szabó-Szoba R&D Laboratory, we developed an android-based software application for tablets and smart phones for the purpose of having an adaptable, entertaining and effective program which can provide a real life experience to the participants about the nature of the bullwhip effect. Having an appropriate and comprehensive performance measurement system with the critical parameters and KPIs is inevitable for finding the right solutions - We used four perspectives of the Balanced Scorecard method. The innovative force of our research is based on the trainings: the discussion on outcomes and the team learning. The purpose of the current development is to build a new feature in the software: an artificial client can substitute one or more players in the supply chain, which makes decisions by using genetic algorithms.*

**Key words**

*BeerGame, Balanced Scorecard, Bullwhip effect, Genetic Algorithm*

**INTRODUCTION**

The BeerGame logistics management game is widely used to demonstrate the inventory imbalance problems in supply chains. In the frame of the game, participants impersonate a four stage supply chain, and make their own decision about actual orders in every round according to the previous demands and expectations. The factory is responsible for production, and the other three collaborators for distribution towards the customer. The aim of the players is rather simple: each of the four traders has to fulfil incoming orders by forwarding the required units of beers to the partners in the chain with minimal total cost (the charge of inventory holding is 1, in the case of backlog the related cost is 2). Communication and collaboration are not allowed between the supply chain stages. This game can be used in

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the formal education and in trainings, as well to model real life situations and to highlight the difference between the practice and theory by the learning-by-doing method.

## **THE BULLWHIP EFFECT**

The competing supply chains are characterized by the ever growing extension. The need of mass-production keeps increasing in the industry while, on the costumers' side, the demand of unique goods is extending. These cross-purposes cause the elongation of supply chains and turn them into the supply networks with more and more processing, forming, storage stations, all in all resulting in huge transportation and forwarding needs. This system structure has a serious and inseparable drawback, the presence of the bullwhip-effect (1).

Because of the growing globalization of supply chains/networks, we can observe an increasing number of the bullwhip-effect which is a really expensive phenomenon: at different stages of the distribution channels, high inventory levels arise, although, at the same time, other stages suffer from serious shortages. Therefore, the end users in many cases cannot get the desired product. On the other hand, insufficient or excessive production and warehouse capacity establishment and its inappropriate coordination cause the inaccurate production, delivery and distribution plans. The consequences are the growing total cost of supply chains, lower profit rate, and loss of competitiveness. The inappropriate usage of resources implies the increasing logistics costs and declining customer service and its adverse effects, which worsen the performance of companies and supply chains (1).

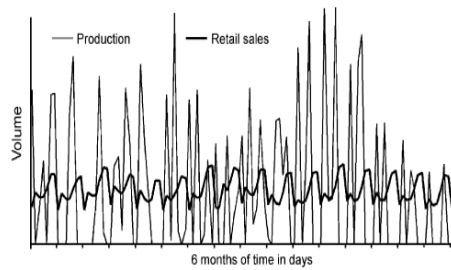
The inventory levels at different points of supply chains vary separately from the real costumer demand because of the bullwhip-effect. The usage of resources as production-, distribution-, and warehousing capacities is apparently not effective. The emerging shortage and unnecessary accumulation of inventories at different stages with the passage of time and the fulfilment of the backlogs of orders run through the whole supply chains. Therefore the systems/networks loose their balances and these swings maintain the presence of the bullwhip-effect for an indefinite time. Despite the fact that this phenomenon has been known for long time, its examination, accurate detection and modelling, is still a subject of intense scientific interest (1).

Based on many scientific researches, the trigger of the bullwhip effect can be traced by the lead time of information and material. A supply chain's reaction on a change in the end customer demand is delayed firstly because it takes time to pass on information about the change to suppliers, and, secondly, because these suppliers need time to adjust their capacities and deliveries. The longer a supply chain is unable to react to a changed demand, the heavier it needs to react as soon as this is possible. The bullwhip effect increases with longer lead times. In addition to the lead time of information and material, the bullwhip effect is caused by other factors:

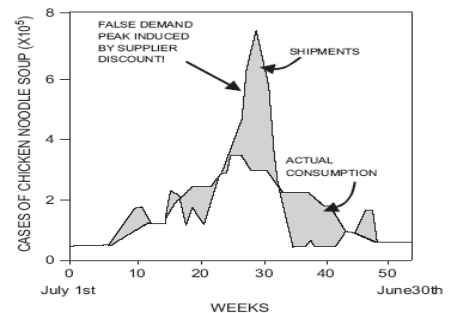
- Demand forecast based on orders of the succeeding tier
- Historically oriented-techniques for demand forecast
- Batch ordering
- Price fluctuation
- Exaggerated order quantity in case of delivery bottlenecks

Commonly, demand amplification is mostly caused by some internal mechanism or event; it is not due to something external to the system. Although the customer demand may be extremely volatile, it is self-induced worsening of any situation. As bullwhip is a time-

varying phenomenon, graphical representation of system behaviour is extremely helpful. The next Figure shows specific demand amplification in a six month period.



**Fig. 1** Demand amplification typical of time series to be viewed through the “variance” lens (Porter, 2005) [2]



**Fig. 2** Demand amplification of time series to be viewed through the “shock” lens – Fisher 1997 [2]

The previous Figure is a typical example which illustrates how a major manufacturer “gambling” by offering a temporary discount severely disrupts the system both upstream and downstream. This causes a “shock” to the system forcing retailers to stock up rapidly, then run stocks down as they realise customer sales are relatively smooth. In this case we can easily catch the bullwhip-effect (2).

## BEERGAME

The beer distribution game (also known as BeerGame) is a simulation game developed by a team of professors of MIT Sloan School of Management in early 1960’s to demonstrate a number of key principles of supply chain management. The Game is played by teams of at least four players, often in heated competition, and takes from one to one and a half hours to complete. A debriefing session of roughly equivalent length typically follows to review the results of each team and discuss the lessons involved.

### History

The BeerGame (or beer distribution game) was invented in the 1960s by Jay Forrester at MIT as a result of his work on system dynamics. The BeerGame has proven to be a very simple, yet effective experiential exercise for teaching the dynamics of marketing and logistics channels specifically and systems in general. Since then, the BeerGame had been played all over the world by people at all levels, from students to presidents of big multinational groups. The purpose of the game was to show how the patterns we create in our relations with the world around us sometimes give unexpected and undesired results. This is an expression for what is called system dynamics. Jay W. Forrester in the USA first developed the ideas and theories behind this branch of science. The game can represent how we (re)act in such trading situations, and how these situations lead us into standard ways of “thinking” that we accept without question, don’t we? (3)

### BeerGame, on the tablets

After we held some BeerGame training with the traditional forms of the concept, it became clear that we need a better solution for further experiments and analysis of the results.

For this, we started to develop the BeerGame software for android devices in the Szabó-Szoba Laboratory. The purpose of this project is to join together the advantages of previous implementations. In the actual state of the software, the processes at the different positions are totally synchronised; the documentation is automated but easy to follow. With this, we successfully excluded the drawbacks of the original, paper based form of the game. That version was hard to follow - even more if somebody plays for the first time - because of the complexity of the rules. In fact, it slows down the gameplay and gives place to the mistakes. Unfortunately, it is really hard to puzzle out the errors and to correct them, what takes away the fun. The BeerGame application also prevents the opportunity of cheating or making accidental mistakes. The results are immediately apparent, help the discussion of experiences and better understanding the background of the bullwhip effect. At this point, it is really important, that the participants can share their experiences, observations and knowledge. The tablets are very practical and manageable and provide an excellent graphical appearance. The only drawback we found until now is that it is not really expressive in material handling. A solution to this can be the involving of other devices or better graphical visualization.

### **Training environment**

The game in our trainings lasts for 24 round. This is long enough to see the trends and the challenges, also short enough not to get bored. By this time, every participant gets some experience about managing a supply-chain, can observe the difficulties, possibilities, typical tricks and some coincidences. That is the time when they can share the feelings, experiences and some information with each other by the lead of the trainer. This discussion is very important in the aspects of recognition and learning. Typical observations:

- the evolved shortage spreads along the chain,
- usually the factory has the biggest shortage and the retailer has the least,
- at the half of the gameplay (10-12th round), each of the participants gets frustrated by the appearing backlogs and makes the decisions in panic – worsening the situation,
- the period with the shortages is followed by a period with high inventory level,
- the bullwhip effect emerges without exception.

The time frame usually lets another round. In such case, the participants are more experienced, they can focus on the discussed and relevant details, they configure some kind of tactics regarding to the consequences. In the second game, they usually feel themselves confident and assume that the bullwhip effect at this time will not upset the balance. But it does - in all cases.

The game, as we can see, is quite simple, easy to understand the tasks and the functions. A great advantage is that from the server, we can get instantly the results, so that the experiences can be discussed immediately after the game.

## **THE BALANCED SCORE CARD SYSTEM AS PERFORMANCE MEASUREMENT APPROACH**

We had to realize that the traditional efficiency measures by themselves – because they are considering mostly the financial parameters of production processes – are inadequate in providing a complete and useful overview of organizational performance (in our case it means the performance of the whole distribution channel as a system). For better understanding of

the relations not only on the operational but also on tactical and strategic levels, the use of Balanced Score Card measurement system is widely accepted: it is operating on the financial, marketing (customer-related), operational (internal-business processes) and strategic dimensions (learning and growth) (5).

In other words, the typical BSC consists of four perspectives - financial and non-financial measures to guide implementation and evaluation: financial, customer, internal/process, and learning/innovation, in addition focuses both on the short- and long-term objectives of the organization (5).

With the BeerGame software, we can create graphs to demonstrate the bullwhip-effect and its consequences regarding to the four perspectives. The typical results are shown below:

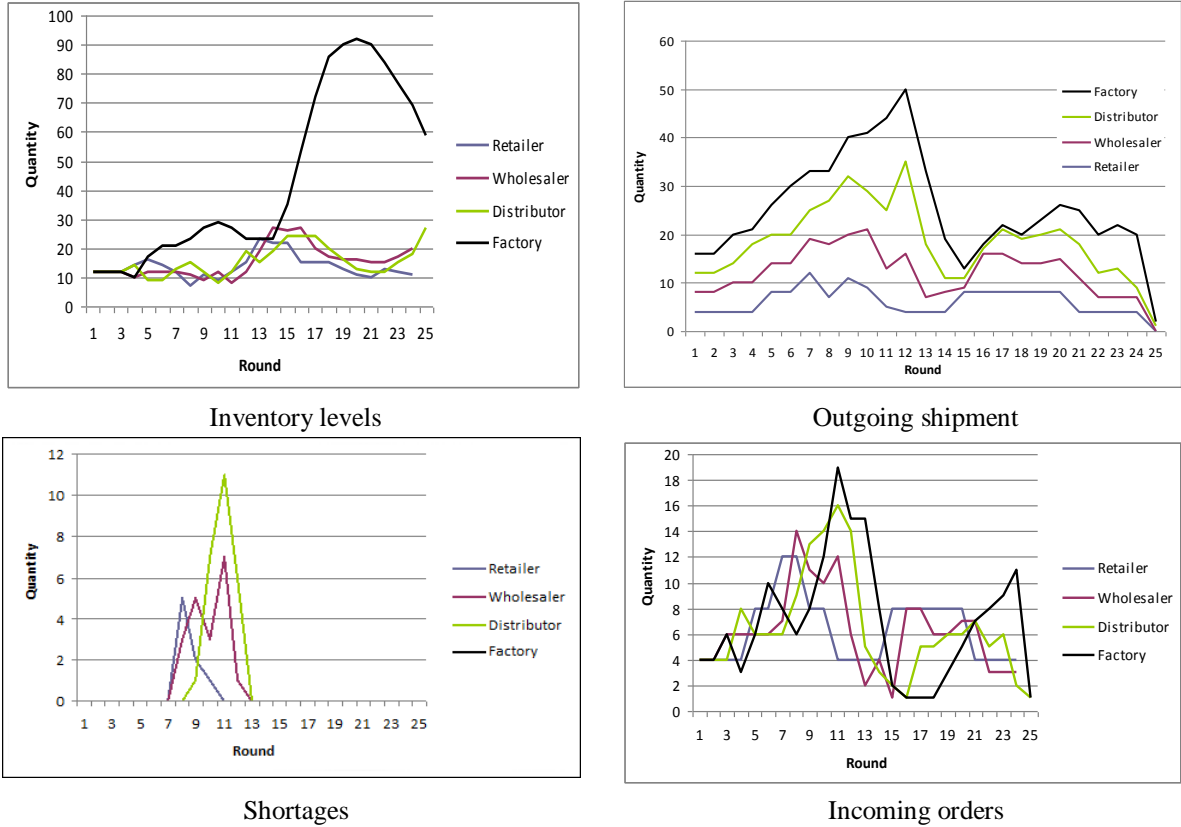


Fig. 3 Illustration of the bullwhip phenomenon (own source)

**GENETIC ALGORITHMS**

One direction of the actual research is the application of genetic algorithms. It is possible to substitute one or more players with an artificial client, who makes its decisions as close to the optimum as possible. This BeGa development might support the examination and optimization processes of different supply chains.

The Genetic Algorithms can be used in general to search in a search space. The basic idea of them is to handle the possible solutions as natural individuals and use the evolution to find the best ones. More precisely, they do this search by changing the genotype of these individuals, and giving some kind of priorities for the best ones (6).

Although, there is no definition of genetic algorithm accepted by all in the evolutionary–computation community that differentiates GAs from other evolutionary computation methods, but it can be said that most methods called GAs have at least the following elements in common: populations of chromosomes, selection according to fitness, crossover to produce new offspring, and random mutation of new offspring. The individuals are often represented by bit strings and the evolutionary modifications are made on the zeros and ones. To compare the differences between the specific individuals, all the GAs need to have a good fitness function determining how good a specific individual is. The genetic algorithms use three basic operators to find better and better solutions to the problem. The Selection operator selects chromosomes in the population for reproduction. The fitter the chromosome, the more times it is likely to be selected to reproduce. The Crossover operator randomly chooses a locus and exchanges the subsequence before and after that locus between two chromosomes to create two offspring. Finally, the Mutation operator randomly changes some of the genes in a chromosome (6).

Finding a proper fitness function is one of the most crucial points of creating optimization algorithms. In case of supply chains, it is quite difficult to find this function because there are several viewpoints from which the system should be optimal. For example we should resolve the inconsistency of every participant has a supplier and customer role at the same time and find an optimal solution. It is worsening the situation that we also have to take into consideration the performance of the whole chain. Therefore, we have to use a function which is flexible enough to be able to create a global optimum. To solve this problem, we use the four perspectives of BSC, and the fitness function is the weighted average of the values of these indicators. So the main objects of the parties can be determined by defining the correct weights of the indicators.

## CONCLUSION

Avoiding the bullwhip effect is a challenge the modern economy is facing. It is crucial to recognize the wave propagation in the chain in time, and find the solution to the inventory management problems. In the frame of the BeerGame trainings, participants can get real-life experiences in this field, and they can invent the appropriate logistics performance measurement system at the same time. On the way of the BeGA development, it will be possible to substitute one or more players in the simulation environment with an artificial client, who makes its decisions as close to the optimum as possible by using genetic algorithms. The fitness function can be derived by Balanced Scorecard performance measurement indicators. In the trainings with many company experts, we intend to create typical patterns of customer demands to highlight the need of the local, company-specific bullwhip-recognition tools and appropriate replenishment rules.

### References:

1. BHATTACHARYA, R., BANDYOPADHYAY, S. 2010. *A review of the causes of bullwhip effect in a supply chain*. Springer-Verlag London Limited.
2. TOWILL, D. R., ZHOU, L., DISNEY, S. M. 2007. Reducing the bullwhip effect: Looking through the appropriate lens. In: *J. Production Economics*, 108. doi:10.1016/j.ijpe.2006.12.024
3. <http://www.masystem.com/o.o.i.s/1365> accessed 25.03.2013
4. <http://mthink.com/dev/mthink/content/balanced-scorecard-approach>, accessed 25.03.2013

5. Chopra, S & Meindl, - Supply Chain Management - Strategy, Planning and Operations, Prentice Hall (2001)
6. MITCHELL, M. 1998. *An introduction to genetic algorithms*. Cambridge: A Bradford Bokk The MIT Press, p. 6-8. ISBN 0-262-13316-4 (HB), 0-262-63185-7 (PB)

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