Integrating Ideality with the System Operator
Part 1: A Tutorial – Applied to the Bullwhip Effect

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Abstract

This article is the first installment of a two part series that presents a novel technique for integrating the system operator with ideality. The system operator and ideality are TRIZ tools that assist with developing a thorough understanding of a problem as well as facilitating solution generation. This article provides a tutorial for the integration technique through application to the supply chain bullwhip effect.

Introduction

Many problems in the business world tend to be complex and difficult to define since most business systems are human systems. Problems within the business systems typically stem from the complex relationships inherent in the system. It may be easy to identify that a problem exists, but understanding and defining the scope of the problem within a business system is often extremely difficult. One such business management problem is the supply chain bullwhip effect.

TRIZ offers several tools that provide a systematic and methodical approach to understanding problems. The system operator and ideality are two tools that may be used to meticulously analyze and understand a problem, which in turn provide a framework for solution generation.

This article, the first in a two part series, describes the system operator and ideality as well as a novel technique for integrating the two tools. The technique is described and explained through an application to a well-known business management problem, namely the supply chain bullwhip effect. The integration of the tools is presented as a tutorial that illustrates how the technique could have generated “the known solution” to the bullwhip effect. A second article in this series will continue the presentation of the technique by applying it to a problem for which the solution is not previously known.

Supply Chain Background

What is a supply chain?

A supply chain consists of all activities associated with a customer's request for a good or service from the transformation and flow of goods from raw materials through to the customer [1, 2]. As illustrated in Figure 1, a typical supply chain includes customers, retailers, distributors, manufacturers, and suppliers. Additionally, the supply chain includes all functional areas within each of the organizations such as, manufacturing, order procurement, marketing, planning, finance, customer service, engineering, sales, and distribution. As indicated by the arrows in Figure 1, information and goods flow both up and down the supply chain. Essentially, a supply chain is a network of linked organizations that come together to fulfill a customer's desire for a particular good or service.

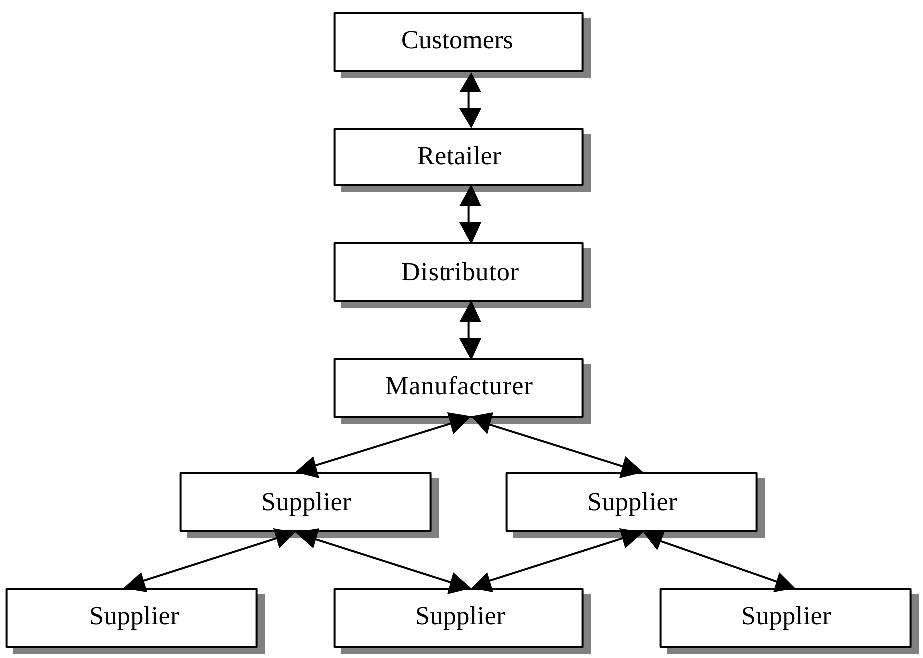

Figure 1: Model of a Supply Chain

Figure 2 shows a partial supply chain for a hosiery manufacturer. The retailer provides socks to the customer in exchange for funds. The retailer makes replenishment orders based on consumer demand with the hosiery manufacturer who in turn replenishes the socks for funds transferred from the retailer. Likewise, the hosiery manufacturer transfers goods, information, and funds with its suppliers. Similar transactions occur throughput the supply chain as a result of consumer

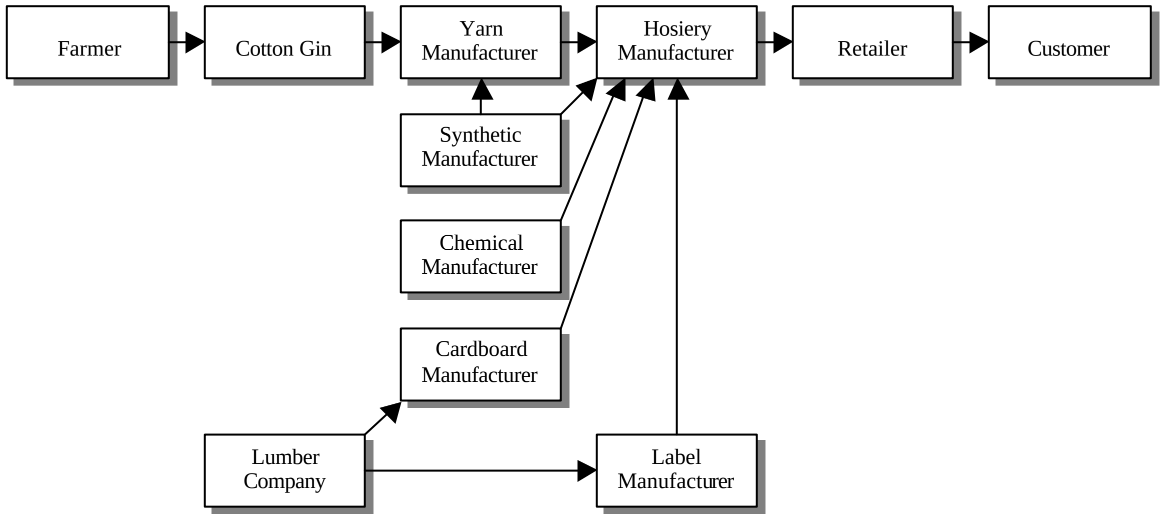

Figure 2: Partial Supply Chain for a Hosiery Manufacturer

demand for socks. The hosiery example illustrates the complex nature of a supply chain. Immense amounts of information, goods, and funds are transferred up and down the chain. Owing to this level of complexity, enigmatic problems may arise within the supply chain.

What is the supply chain bullwhip effect?

The bullwhip effect describes a phenomenon in which information about consumer demand becomes increasingly distorted as it moves up the supply chain from retailers to wholesalers to manufacturers to suppliers. Figure 3 provides an illustration of the demand perturbations at distinct levels within the supply chain. The distortions in the perception of demand within the supply chain make it difficult to match supply to actual demand, which results in higher costs, product shortages, finished goods obsolescence, unpredictable orders, and excessive capacity.

Although the ultimate consumer demand is relatively stable at the retailer, the demand becomes increasingly variable as it advances up the supply chain (retailer to wholesaler, wholesaler to manufacturer, and manufacturer to supplier). In general, the orders to suppliers have a larger variance than sales to the buyers. This variance is amplified as orders propagate up the supply chain in part due to distortions in the chain (length of the chain, shipping times, lead times, etc.) [3]. In terms of lead-time, the supply chain members furthest from the end customer generally experience the highest variation in demand.

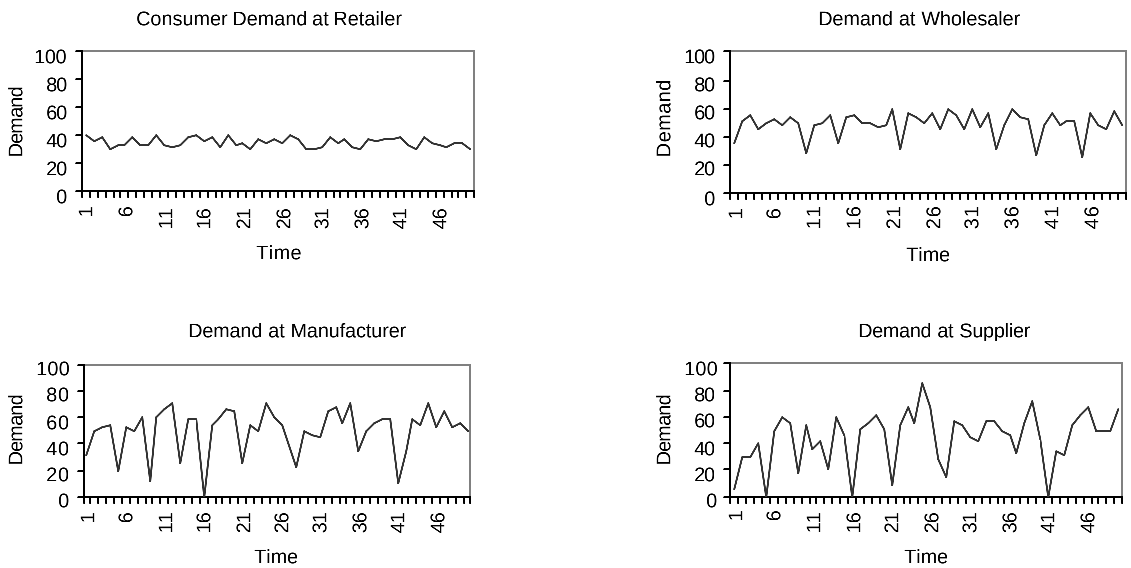

Figure 3: Demand Perturbations at Distinct Levels within the Supply Chain

The lead-time of information and material is the primary root cause of the bullwhip effect since the information regarding a change in end customer demand is delayed in time as the information propagates through the supply chain [5, 6]. As a result, the demand experienced by the supply chain members furthest from the end customer can be significantly out of phase in time and magnitude with true end user demand. As a result, suppliers are reacting to a demand that may or may not be the same as the current end customer demand. Confounding this issue is the time required for suppliers to adjust their manufacturing capacities and inventories in reaction to the information regarding a change in demand. Suppliers can find themselves riding a wave of increasing capacities and inventories immediately followed by reductions in capacity and inventory. The time required to accomplish these changes in capacity and inventory reduces the supplier’s ability to appropriately react to the true change in demand. Thus, the bullwhip effect increases with longer lead-times.

The System Operator and Ideality

The System Operator

The system operator tool provides a systematic method of describing a problem. The tool divides the problem into three levels and three “time zones.” The division results in a three by three matrix as shown in Figure 4 for a hosiery manufacturing operation. Each of the nine system spaces represents a particular space and time. The matrix directs users to systematically think about each level, resulting in a better understanding of the problem as a whole.

The problem is divided into three levels that are the system, the super-system, and the sub-system. The system is the actual product or process being modeled. The super-system is the surrounding system or environment to which the process or product belongs. The sub-system is the components or sub-processes of the process or product.

Past – Super System Suppliers	**Present – Super System** Apparel Manufacturing	**Future – Super System** Retail Industry
Past – System Yarn Suppliers	**Present – System** Hosiery Manufacturing	**Future – System** Retailer
Past – Sub-System Supply Processes Transportation	**Present – Sub-System** Manufacturing Processes	**Future – Sub-System** Transportation Sales Force

Figure 4: The System Operator Matrix for a Hosiery Manufacturer

The three “time zones” that the problem is divided into are the past, the present, and the future. The “time zone” portion of the system operator tool directs users to think in terms of time. However, the division of time into three distinct “time zones” tends to direct the user to think about time discretely. For example, if we think about the past system for a sock, then the system operator tool may direct us to look way into the past at the historical development of a sock. However, time is not discrete; it is continuous. Thus, when using the system operator tool the user should also think continuously in time. For example, if we look into the past system of a sock, then we may consider that the sock was a yarn prior to becoming a sock and before that the yarn was a fiber and before that the fiber was growing in a cotton field. Thinking in terms of continuous time helps the user to fully understand the problem and the sequences of events that leads to the problem.

Ideality

Henry Altshuller, considered to be the father of TRIZ, defined ideality as an equation where the numerator is a sum of all useful functions performed by a system and the denominator is the sum of all undesired effects associated with the system [4]. Any form of cost, including labor, materials, tests, waste, injuries, and ecological damage, is included in the undesired effects. Changes to a design that increases the numerator and/or decreases the denominator are said to bring the system closer to ideality [4].

Altshuller arrived at the conclusion that the ideal system performs a function without actually existing [4]. In fact, there is no need for a system at all because the real desire is to have a function. For example, we do not need a hosiery supply chain; what we need is a sock. Practically, the ideal system is an unobtainable goal, but we can try to approach it.

Resources

Utilization of resources is a method of approaching ideality. A resource is any substance, field, property, or other attribute available in a system or its environment that is available for improvement of the system [4]. Resources can be divided into two basic categories: those readily available and those that are derived after some kind of transformation [4]. Raw materials, products, waste, and other elements may not be useful in their existing state, but after transformation they may become such a resource [4].

Any system that has not reached ideality should have resources available for improvement of the system. The basic questions to ask are: can a resource in the system or its environment be changed to create space, time, an object, or a function? Or can a resource be changed to eliminate an undesired object or function? The premise is to answer the questions regarding resources in such a way as to increase the numerator and/or decrease the denominator of the ideality equation.

A Technique for Combining The System Operator with Ideality

Combining the system operator with ideality provides a powerful technique for analyzing, understanding, and defining a problem. The technique identifies resources at each of the interfaces defined by the system operator matrix. The steps are summarized in Table 1.

Table 1: Steps for Integrating the System Operator with Ideality

1. Define and draw the system operator matrix for the problem
2. Put yourself inside each of the nine boxes of the matrix.
3. "Look" into the adjacent boxes and identify resources that are available at that particular interface.
4. List any of the resources that can be used or eliminated to increase ideality.
5. List any resource that can be changed to increase ideality.
6. Repeat steps 2-5 for each of the boxes.
7. Analyze possibilities for solution directions.

The technique of combining the system operator with ideality may provide new insights into the problem. By viewing the problem from different perspectives from each of the nine boxes, resources may be identified that may have otherwise gone unnoticed. Generally, the system operator provides a structured framework for resource identification.

Application of the Technique to the Supply Chain Bullwhip Effect

The technique of combining the system operator with ideality provides a thorough and exhaustive analysis of the supply chain bullwhip effect. This article presents the analysis of the present system of the hosiery example in Figure 4 to illustrate the technique.

Inside the Present System Looking to the Past System

Yarn suppliers are one of the past systems for hosiery manufacturing. The following list contains some of the resources available for solving the problem at this interface.

- Hosiery manufacture's demand data
- Purchase orders
- Contractual agreements
- Electronic data interchange
- Inventory levels
- Transportation medium
- Accounts payable/receivable
- Lead-times
- Location of suppliers
- Historical demand data

Employing ideality yields the following list of directions for possible solution generation at this interface. The underlying theme of the list is to reduce the lead-time for information flow and material flow.

- Can the order placement system be improved?
- Can the yarn manufacturer have access to the hosiery manufacturer's demand data?
- Can contractual agreements stabilize demand?
- Can a model be used to accurately forecast demand?
- Is the yarn manufacturer the "right" supplier for the hosiery manufacturer?
- Is it possible to reduce the lead-time between order receipt and delivery?
- Is it possible for the hosiery manufacturer to more quickly communicate their information regarding a change in demand?

Inside the Present System Looking to the Future System

The future system for hosiery products is a retailer. The following list contains some of the resources available for solving the problem at this interface.

- Point of sale data from retailer
- Customer demand data at retailer
- Contractual agreements
- Electronic data interchange
- Inventory levels
- Purchase orders
- Batch orders
- Cost data
- Transportation flow
- Lead-times
- Computers and software
- Market share

Employing ideality yields the following list of directions for possible solution generation at this interface. The underlying theme of the list is to reduce the lead-time for information flow and material flow.

- Can the hosiery manufacturer access the point of sale data?
- Can contractual agreements stabilize demand for the hosiery manufacturer?
- Can a model be used to accurately forecast consumer demand?
- Can demand data be obtained directly from the consumer?
- Is it possible to reduce the lead-time between order receipt and delivery via Electronic data interchange?
- Can inventory levels be lowered which will reduce lead-times?

Inside the Present System Looking to the Present Sub-System

The hosiery manufacturing processes comprise the present sub-system. The following list contains some of the resources available for solving the problem at this interface.

- Manufacturing processes
- Manufacturing schedule
- Equipment sensors
- Asset utilization
- Computers
- Warehouses
- Manufacturing flow
- Manufacturing time
- Transportation flow
- Work in progress (WIP)
- Quality data
- Materials planning

Employing ideality yields the following list of directions for possible solution generation at this interface. The underlying theme of the list is to reduce the lead-time for information flow and material flow.

- Can the manufacturing be more agile?
- Is the manufacturing process lean?
- Is work in progress optimized?
- What data is available to feed a forecasting model?
- What data is available to feed a scheduling system?
- Can manufacturing lead-times be reduced?
- Can WIP be reduced; thus reducing lead-time?

Inside the Present System Looking to the Present Super-System

Apparel manufacturing is the present super-system. The following list contains some of the resources available for solving the problem at this interface.

- Apparel industry’s demand data
- Trends in apparel industry
- Lead-time
- Manufacturing techniques
- Supply chain strategies

Employing ideality yields the following list of directions for possible solution generation at this interface. The underlying theme of the list is to reduce the lead-time for information flow and material flow.

- Can trends in the apparel industry improve the hosiery manufacturer's forecasts?
- Can strategic partnerships be formed with apparel manufacturers to reduce lead-times?
- Is it possible to give all supply chain members access to customer demand data so they know what the true end customer demand is?
- Do suitable forecasting models already exist?

Conclusion

This article presented a novel technique for combining ideality with the system operator. The technique was demonstrated through application to a common business management problem that has well known solutions. The system operator provides insights into the past and future states of a hosiery product that lead to insightful questions regarding the impact of the yarn manufacturer and the retailer. Thinking continuously in time is paramount for this tool. Combined with the system operator, ideality identifies a series of questions that have a common theme: reduce the lead-time of materials and information. Thus, the integration of the two tools leads to the generally accepted "known solution" to the supply chain bullwhip effect: reduce manufacturing lead-times in order to respond more quickly to sudden changes in demand and reduce the lead-time for information propagation through the supply chain.

In conclusion, the system operator provides a structured and methodical framework for defining a problem in terms of space and time. Ideality stretches the users thinking to a higher level of abstraction, which leads to identifying resources that are available for solution generation. Systems approach and ideality are cogent tools. Moreover, the combination of systems approach with ideality yields an extremely effectual technique for the analysis and definition of problems.

Final Thoughts

The purpose of this article is to present a tutorial on a technique for combining the system operator with ideality. Since the solution to the supply chain bullwhip effect is well known and documented [5, 6], it provides the ability to show how the technique leads to "the correct solution." However, the resources identified at each interface are intentionally limited to those that point to the solution. Therefore, the results of applying the technique to a problem for which the solution is not previously known will be presented in part two.

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