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Investigation the Combination of the Bullwhip Effect Weakening and the Anti-Bullwhip Effect Strengthening

M. Ghaffari*, N. Javadian

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Abstract The process of supply chain operations, while the presence of the bullwhip effect and anti-bullwhip effect, taking into account only the cost of the supply chain, demand deviation, this presence makes the bullwhip effect due to the limited rationality driven weakening the anti-bullwhip effect strengthened so that the upstream and downstream in the supply chain cycle will show the combined effects of the weakening of the bullwhip effect and strengthening the anti-bullwhip effect, the combined effects of individual enterprises to achieve the low average inventory costs also means that the whole supply chain inventory minimum and the overall market demand for the lowest deviation, indirectly, automatically eliminated from the overall bullwhip effect or anti-bullwhip effect, making the whole supply chain whether short-term or long-term point of view is the best long-term, but also to supply chain bring significant strategic advantage.

Keywords Supply Chain Management, Bullwhip Effect, Anti-Bullwhip Effect

1 Introduction

Along with the supply chain inter-organization information system reliability of the deepening platform continues to progress, shared information continues to strengthen the bullwhip effect in supply chain operations, and other issues is to circumvent or weaken, On the other hand, with the continuous deepening of the researchers, the theory of supply chain operations is to develop, where the inventory management strategy and distribution strategy as one of the more library continue to be applied to the distribution network-in-time logistics strategy, these new theory focused on the optimal layout of the supply chain as a overall concept will eliminate the bullwhip effect and other unfavorable factors in a business interview activities, select six different industries, representing six different supply chain, in a simple an interview, and 100% indicates the presence of obvious orders Phi moving, and order fluctuations show some irregularities, indicating the one hand, the market demand for irregular cycle oscillation, on the other hand irregular characteristics may be manifested in the supply chain upstream and downstream transmission Therefore, in the actual operation of the supply chain process, unless there bullwhip effect may also exist anti-bullwhip effect phenomena, makes Ting single exhibit inconsistencies increase or decrease trend.

* **Corresponding Author. (✉)**
E-mail: ghaffari@ustmb.ac.ir (M. Ghaffari)

M. Ghaffari
Phd Student, Department of Industrial Engineering, Mazandaran University of Science and Technology, Babol, Iran.

N. Javadian
Assistant Professor, Department of Industrial Engineering, Mazandaran University of Science and Technology, Babol, Iran.

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Easy as a starting point, the paper assumes that in conditions of perfect information game, and then seek the minimum deviation of decision-making by the orders of the supply chain to meet the conditions for mining supply chain bullwhip effect phenomenon more favorable theoretical analysis, contribution of the paper or the significance of the in addition to recognize the importance of the bullwhip effect in the supply chain, but with the people and the complexity of the market and fuzzy characteristics, the same to recognize the presence of other effects in the supply chain, these effects on the supply chain management, more research needs to solve.

2 Literature review

Prevalence demand for our products in quantities volatility and the actual market sales of the product from downstream to upstream of the supply chain.

Amount of variation compared to gradually enlarge the phenomenon, known as the "bullwhip effect" is generally believed that a description of the phenomenon of the "bullwhip effect" from the Forrester[1], and later the society and academia generally accepted concept of "bullwhip effect" by Lee et al. [2] after the "bullwhip effect" is very much, from the description of the phenomenon itself to find the law to the solution [3-5], many papers have made its own contribution, the study has far-reaching impact of the bullwhip effect. Sterman [6] explained by describing a game bullwhip effect = participants in the game play a beer sales in different roles in the supply chain (beer retailers, wholesalers, distributors and brewers), as the game progresses, the customer needs a slight change will upstream suppliers, orders and inventory levels have an enormous effect of bullwhip on the inventory [7], set off changes in the way of inventory management a more systematic and complete presentation of the bullwhip effect generated four reasons, demand constantly updated forecast quantities strategy, the price is passive, rational behavior and short game, and how the four reasons causing the bullwhip effect and how to overcome were studied, some effective coping strategies in addition, cattle whip effect some new discoveries, and the supplier's distribution mechanism bullwhip effect, and put forward the bullwhip effect in the requirements process is the use of their respective manufacturers and retailers the results of the inventory policy process information. Merkuryev [8] according to the supply chain upstream end market demand sharing mechanism, combined with two species inventory policy to prove that even if the upstream firm demand information sharing, frequent orders can’t eliminate the bullwhip effect.

Existing literature around more quantitative and empirical analysis of the bullwhip effect, different demand forecasts technical 'such as the moving average method to quantify the lead time forecasting techniques lead to the amplification effect that needs forecasting and lead two important reasons affecting the amplification of demand fluctuations, and proved through information sharing can effectively reduce the bullwhip effect, but not completely eliminated [9], The time series analysis is also widely used in the bullwhip effect [10, 11]. Alwan [11] optimized by using the mean square error (MSE) prediction mechanism, pointed out that the bullwhip effect dependence downstream demand structure of the process. Imre [12] used the HMMS model of bullwhip effect, to consider the suppliers and manufacturers of centralization and decentralization are two cases that focus on model for suppliers and manufacturers showed a lower total cost, means that through collaboration to bring cost-effective production and inventory solutions are also very common empirical, attractive starting from the point of view of supply chain management forecast, concepts and models of the bullwhip effect of the introduction of virtual enterprise, the process of operation, the

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member companies of the upstream and downstream virtual enterprise demand information to prove the existence of the bullwhip effect in a virtual business operations.

Gérard [13] considered the turn when the needs of the retailer and the fixed production capacity over suppliers in the supply chain system that contains one supplier and N retailers-to-Earn the allocation of belonging to a shortage of the scope of the game. the specific impact of order enlarge variable rate, the parameters of the product supply ratio, inventory levels, and further study how demand information sharing order oscillations and inventory levels [14] effectively reduce the bullwhip effect can be avoided through a specific mechanism for the replenishment [15] analyzed the measurement of the bullwhip effect that the bullwhip effect is not outdated.

With the deeply study of the bullwhip effect, scholars saw the presence of anti-bullwhip effect or inverse bullwhip effect, the existence of anti-bullwhip effect, pointed out that the bullwhip effect and anti-bullwhip effect can be considered to be a pair of dual phenomenon, and can be transformed into each other under certain conditions, this conclusion a complete overview of the phenomena observed in reality, studies indicate that enterprises conditions remanufacturing reverse logistics "reverse bullwhip effect fly and that the existence of this effect is internal, reverse bullwhip effect" is not a dual phenomenon of the bullwhip effect on the forward supply chain bullwhip the effect of amplification. reverse logistics node in decision-making will supply information from the downstream node pessimistic decision, consciously or unconsciously, to reduce the supply is expected and this reduces the expected signal from the bottom along the reverse logistics node on progressively reduced, eventually leading manufacturer expects further reduced, allowing manufacturers to make adding new share inventory ratio, reduce the decision-making of remanufacturing inventory ratio this effect and forward supply chain bullwhip effect just On the contrary, it is known as "reverse bullwhip effect".

Bullwhip effect study is very rich, but not many studies on the anti-bullwhip effect, this in the supply chain up and down speaking operators, to study such problems provide ideas and methods.

3 Prove the existence of the anti-bullwhip effect

Exposition of the existing literature on the bullwhip effect, supply chain enterprises face by fluctuations in demand, greater than the upstream and downstream enterprises face by fluctuations in demand. Chen[9] introduced indicators: BE=Var(SD)/Var(RD), bullwhip effect to measure the severity of the size of the coefficients with BE, BE value the greater the bullwhip effect is more serious the greater the harm suffered by the manufacturer.

First, learn the definition of the bullwhip effect, make a note on the concept of anti-bullwhip effect in the upstream and downstream in the supply chain operation mechanism, due to market volatility, the ability of decision makers and habits, information distortion, prediction bias factors make supply chain upstream to downstream supply orders fluctuation is less than the demand fluctuations.

Mathematical proof of the existence of the "anti-bullwhip effect", learn from Chen [9] proved the existence of the bullwhip effect to prove the existence of anti-bullwhip effect.
Build AR (l) market demand model:

$$D_t = \mu + \rho D_{t-1} + \varepsilon_t \tag{1}$$

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Therefore:

$$E(D_t) = \mu/(1-\rho), Var(D_t) = \sigma^2/(1-\rho^2) \quad (2)$$

Table 1 Dismissed and description of relevant parameters

Parameter	Explanation
μ	Non-negative constant
ρ	Order auto correlation coefficient, P <1.
ε_t	Error term, which means that fluctuations in market demand variable error, to meet independent and identically distributed, in line with symmetrical distribution of the $\varepsilon \in N(0,\delta^2)$.
D_t	A t of market demand, to meet the simple AR(1) model.
y_t	Retailers order point method to get the highest inventory levels.
$\hat{D}_t^L$	Retailers t the commencement of the L-period market demand estimates.
$z\hat{\delta}_{\varepsilon_t}^L$	Retailers L during the safety stock, in which: Z to service level coefficient $z\hat{\delta}_{\varepsilon_t}^L$ master L-period forecast error standard deviation estimated.
e_t	t forecast error $e_t = D_t - \hat{D}_t^1$.
$C_{L,p}$	The constant function.
P	Period for calculating the average market demand.
q_t	Issued by the supplier to the retailer shipments.

According to Chen [9] called a function of the maximum inventory levels:

$$y_t = \hat{D}_t^L + z\hat{\delta}_{\varepsilon_t}^L \quad (3)$$

$$\hat{D}_t^L = L\left(\frac{\sum_{i=1}^{p} D_{t-i}}{p}\right), \hat{\delta}_{\varepsilon_t}^L = C_{L,P}\sqrt{\frac{\sum_{i=1}^{p}(e_{t-i})^2}{p}} \quad (4)$$

When the entire supply chain on the average inventory is zero, the supply chain supply issued by the supplier to the retailer that is able to satisfy the relation:

$$q_t = D_t - (y_t - y_{t-1}) \quad (5)$$

Not change the result of the case, in order to simplify the proof make Z=0 formula 3 and 4 into equation 5, we have:

$$q_t = D_t - \hat{D}_t^L + \hat{D}_{t-1}^L = D_t - L\left(\frac{\sum_{i=1}^{p} D_{t-i}}{p}\right) + L\left(\frac{\sum_{i=1}^{p} D_{t-i-1}}{p}\right) = D_t + \frac{L}{p}(D_{t-p-1} - D_{t-1}) \quad (6)$$

Prove calculation q_t variance:

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$$\begin{aligned}\operatorname{var}(q_t) &= \operatorname{var}(D_t) + \operatorname{var}(\frac{L}{p}(D_{t-p-1} - D_{t-1})) + 2\operatorname{cov}(D_t, \frac{L}{p}(D_{t-p-1} - D_{t-1})) \\ &= \operatorname{var}(D_t) + (\frac{L}{p})^2 \operatorname{var}(D_{t-p-1} - D_{t-1}) + 2(\frac{L}{p})\operatorname{cov}(D_t, (D_{t-p-1} - D_{t-1})) \\ &= \operatorname{var}(D_t) + (\frac{L}{p})^2 (\operatorname{var}(D_{t-p-1}) - \operatorname{var}(D_{t-1})) - 2\operatorname{cov}(D_{t-p-1} - D_{t-1}) \\ &+2(\frac{L}{p})(\operatorname{cov}(D_t, D_{t-p-1}) - \operatorname{cov}(D_t - D_{t-1})) \\ &= \operatorname{var}(D_t) + 2(\frac{L}{p})^2 \operatorname{cov}(D_{t-p-1} - D_{t-1}) + 2(\frac{L}{p})(\operatorname{cov}(D_t, D_{t-p-1}) - \operatorname{cov}(D_t - D_{t-1}))\end{aligned} \tag{7}$$

$$\frac{\operatorname{var}(q_t)}{\operatorname{var}(D)} = 1 - 2(\frac{L}{P})^2 \rho^P + 2\frac{L}{P}\rho^{P+1} - 2\frac{L}{P}\rho \tag{8}$$

Due to: $|\rho| < 1$, Therefore $2\frac{L}{P}\rho^{P+1} - 2\frac{L}{P}\rho < 0$, apparently $\frac{\operatorname{var}(q_t)}{\operatorname{var}(D)} < 1$.

Indicating the supply chain upstream to downstream supply orders too weak action is less than the demand search automatically, so there is the anti-bullwhip effect.

4 Bullwhip effect with the combined effects of the anti-bullwhip effect perfect information game

4.1 Assumptions

Supply chain enterprises for various fields relies on intrinsic behavior of either showing the bullwhip held either exhibit anti-bullwhip characteristics, the whole supply chain bullwhip does not fully comply with a single characteristic or anti-bullwhip characteristics, in line with the actual operation of the law models for a possible decision alternatives, to find the optimal mode of operation of enterprises continue to make new improvements to improve its supply chain management or reduce the bullwhip effect, one very important aspect is to eliminate the asymmetry of information in the supply chain achieve full sharing of information, the inter-organizational information systems in the supply chain management operation to a certain extent to solve the problem of asymmetric information, cooperation and work together to ensure that upstream and downstream enterprises, but also reduces the information search cost, can effectively avoid the moral hazard, the optimal decision model to build the ideal supply chain has laid a theoretical basis for the actual possible thesis one node to another perspective: the dual attributes of the economic and social causes the supply chain performance the bullwhip held and conditions under which an upstream or downstream node know the behavioral characteristics of the node will then make the judgment of the anti-bullwhip effect may be due to its performance because the node bullwhip held risks favorite, risk-averse, risk neutral and easy to change, this is not easy to change the behavioral characteristics of its long-term cooperation under the upstream business or downstream enterprises directly under the observed, although it was hardly more non-directly upstream or downstream of the observed to out of this perspective, supply chain node along with the bullwhip characteristics and anti-bullwhip characteristics, bullwhip effect and anti-bullwhip effect in the same supply chain, and this presence because of bounded rationality driven by the weakening of the bullwhip effect and strengthen the anti-bullwhip effect.

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Taking into account the market volatility, the ability to decision-makers and habits, information distortion, prediction bias and other factors, the decision-makers are not fully rational, bounded rationality, a corporate supply chain based on past experience with actual market its upstream or downstream of bullwhip characteristics or anti-bullwhip relies on judgment to determine their own actions, but the supply chain is not present the bullwhip and anti-bullwhip alternating affected by various factors but showed irregular action decision makers bounded rationality.

Assumption 1: Supply chain decision-makers of action are limited and rational.

Supply chain upstream and downstream enterprises to strengthen cooperation between, there is a commitment to transfer cargo unconditional return commitment to unconditional return and transfer cargo will promote the bullwhip effect: retailers allow suppliers do not supply completely, incomplete supply and inventory costs, transportation costs that causes the suppliers supply is less than demand, and promote anti-bullwhip effect.

Assumption 2: Allow suppliers not to fully meet the supply shipments and there is a return mechanism.

The General Retailers unit inventory costs are higher than the supplier unit inventory costs, so retailers for inventory costs are minimized, retailers up a supplier under more orders than on the first-tier suppliers to report to the Tier supplier and multiple orders far less a total retailers selling products because suppliers.

Assumption 3: Retailers up a multi-supplier under the order number of products than the previous supplier to a multi-supplier under Order Quantity far less (showing bullwhip effect).

Downstream from the supply chain to the upstream process, in order to stabilize the market and maintain a competitive advantage, retailers up a supplier under less orders than retailers up a supplier more than an order amount far less, and on a suppliers less under orders to a multi-tier suppliers under orders to much, in turn, less under the orders is decreasing.

Assumption 4: The retailers up a few suppliers under the order number of products than retailers higher level suppliers under more Order Quantity far less, and downstream from the supply chain to the upstream process, less under orders is decreasing.

Supplier common psychological phenomenon, when the previous supplier in observing the suppliers or retailers? Determine the supplier or retailer orders and demand fluctuations, a supplier will not fix what is.

Assumption 5: For strategic reasons, the suppliers observed and retailers exist under Order Quantity or less under Order Quantity, no less or more orders under orders number (anti-bullwhip effect constraints).

Information in the supply chain when the rational person in the observed action consistent with the risk appetite of the other companies in its supply chain, decision-making habits, according to the results of the actions of other actors make decisions to their advantage, that the optimum strategy. fully shared conditions, everyone make their own profitable decisions are based on other decision makers to make a favorable decision under the premise of the game, so everyone make decisions to their advantage, in fact, the most favorable decisions for the entire supply chain as a whole, can do low inventory costs, even over a period as an enterprise can achieve zero inventory.

4.2 The application of the anti-bullwhip effect

Case 1, perfect order supply chain game (Fig. 1)

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Stack in the decision-making habits is not easy to change its long-term cooperation will be the upstream enterprises directly under the immediate downstream enterprises observed, so that the supply chain game perfect conditions, of course, more cross-class information is difficult to be observe, but this does not affect the perfect information game.

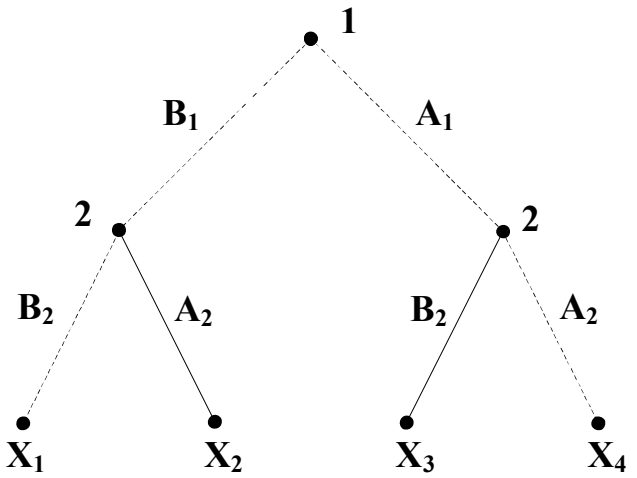


Fig. 1 Second-order supply chain decision tree

1) The combined effects of B_1,B_2, $\left|Q(B_1)-Q^*\right|<\left|Q(B_2)-Q^*\right|$ and $\left|Q(B_1)-Q^*\right|<\left|Q(B_2)-Q(B_1)\right|$ then $\left|X_1-X^*\right|\gg 0$.
2) The combined effects of B_1,A_2, $\left|Q(B_1)-Q^*\right|>\left|Q(A_2)-Q^*\right|$ and $\left|Q(B_1)-Q^*\right|>\left|Q(A_2)-Q(B_1)\right|$ then $\left|X_2-X_+^*\right|\sim 0$.
3) The combined effects of A_1,B_2, $\left|Q(A_1)-Q^*\right|>\left|Q(B_2)-Q^*\right|$ and $\left|Q(A_1)-Q^*\right|>\left|Q(B_2)-Q(A_1)\right|$ then $\left|X_3-X_-^*\right|\sim 0$.
4) The combined effects of A_1,A_2, $\left|Q(A_1)-Q^*\right|<\left|Q(A_2)-Q^*\right|$ and $\left|Q(A_1)-Q^*\right|>\left|Q(A_2)-Q(A_1)\right|$ then $\left|X_4-X^*\right|\gg 0$.

X_4 relative to the X_4, have $\left|X_4-X^*\right|<\left|X_1-X^*\right|$.

The visible second supply chain perfect information game, the equilibrium of the game: the combined effects of B_1,A_2 or A_1,B_2 combined effects when considering only the cost of supply chain inventory, the A_1,B_2 combined effects slightly superior. B_1,A_2 combined effects; consideration of enterprise development, to maintain market advantage, then A_1,B_2 combined effects of slightly inferior the B_1,A_2 joint role, now only study supply chain costs, demand for bias and other issues that the upstream and downstream in the supply chain cycle will show the combined effects of the weakening of the bullwhip effect and strengthen the anti-bullwhip effect. Now the second-order extended to n-order analysis.

Two kinds of perfect information game n-order supply chain can be seen is Fig.2.

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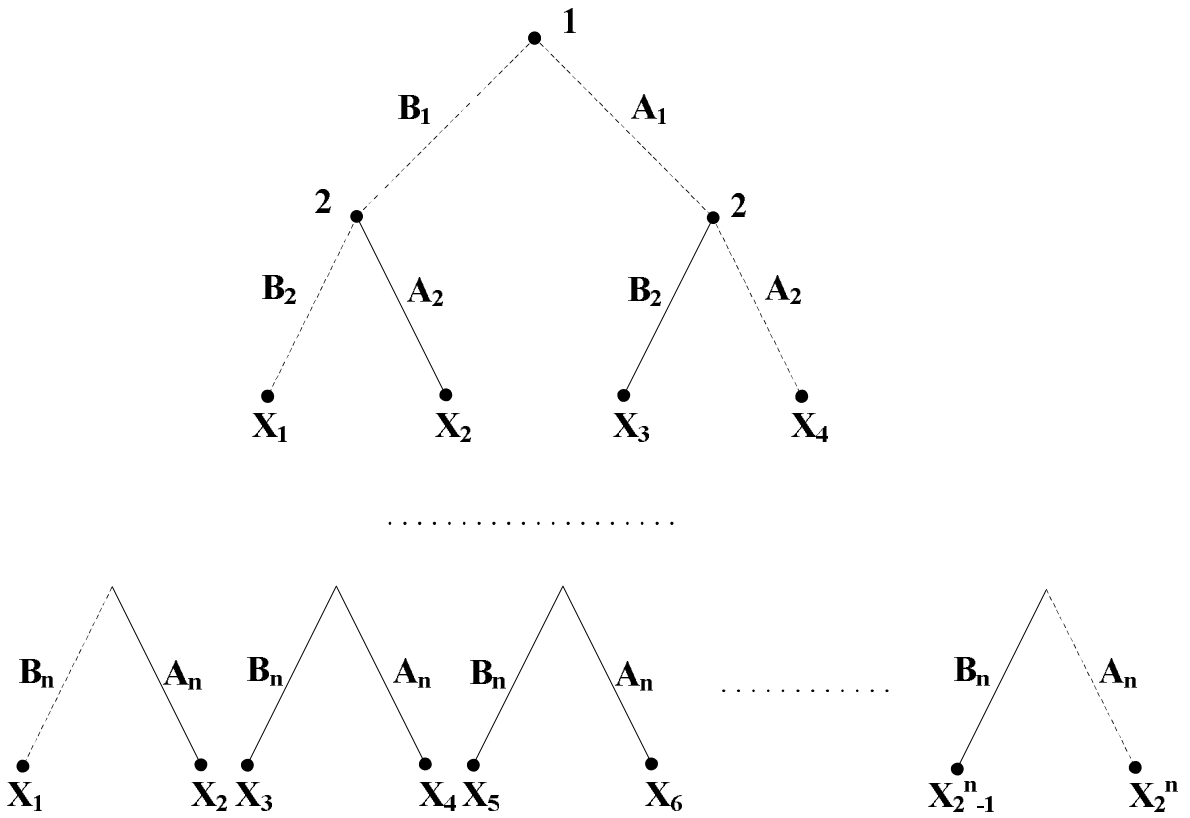


Fig. 2 n-order supply chain decision tree

1) The combined effects of $B_1,B_2,\ldots,B_n$, $\left|Q(B_1)-Q^*\right|<\left|Q(B_n)-Q^*\right|$ and $\left|Q(B_1)-Q^*\right|<\left|Q(B_i)-Q(B_{i-1})\right|<\left|Q(B_n)-Q(B_{n-1})\right|$ then $\left|X_1-X^*\right|\gg 0$.
2) The combined effects of $B_1,B_2,\ldots,B_n,A_n$, $\left|Q(B_1)-Q^*\right|<\left|Q(A_n)-Q^*\right|<\left|Q(B_{n-1})-Q^*\right|$ and $\left|Q(B_{n-1})-Q(B_{n-2})\right|>\left|Q(A_n)-Q(B_{n-1})\right|$ then $\left|X_1-X_{21}\right|>0,\left|X_2-X^*\right|\gg 0$.
3) The combined effects of $A_1,A_2,\ldots,A_{n-1},A_n$ then $\left|X_{2^n}-X^*\right|\gg 0$.
4) The combined effects of $A_1,A_2,\ldots,A_{n-1},B_n$ then $\left|X_{2^n-1}-X_{2^n}\right|>0,\left|X_{2^n-1}-X^*\right|\gg 0$.
5) When the n is an even number, the holding *A*and held *B*equal to the number of conditions combined effects B_1 then $\left|X'-X_+^*\right|\sim 0$.
6) When the n is an even number, the holding *A*and held *B*equal to the number of conditions combined effects A_1 then $\left|X''-X_-^*\right|\sim 0$.
7) When the n is an odd number, the holding A the number is less than held *B*the number (the extent of the gap is very small) under the conditions of the combined effects, $\left|X'''-X'\right|>0,\left|X'''-X_+^*\right|\sim 0$.
8) When the n is an odd number, the holding *A*greater than the number held*B*the number (the extent of the gap is very small) under the conditions of the combined effects, $\left|X''-X''''\right|>0,\left|X''''-X_-^*\right|\sim 0$.

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In short, in the presence of anti-bullwhip effect, simple supply chain needs deviation, the cost of taking into account the balance of perfect information game the bullwhip characteristics and anti-bullwhip characteristics of equilibrium occurs and retailer first performance in the anti-bullwhip characteristics.

Bullwhip effect weakening the anti-bullwhip effect is enhanced, and also reflects the supply chain operations take into account not only the operations of each enterprise is more important is to consider the whole supply chain operations, because the long-term perspective m cycles, the bullwhip properties and anti-bullwhip characteristics will cancel each other out in every business and make their own low-average inventory cost in the long term supply chain management process allows the bullwhip effect and anti-bullwhip effect in a single low-average inventory costs, but also means that the overall supply chain inventory minimum and the overall market demand for the lowest deviation from the overall eliminate the bullwhip effect or anti-bullwhip effect, making the whole supply chain whether short-term or long-term point of view is the most good, especially long-term also has a strategic advantage.

Table 2 The relevant parameters of the interpretation

Parameter	Explanation
B_i	Stage 1 of the supply chain bullwhip characteristics makers exhibit.
A_i	Supply Chain stage I, the decision-maker performance out anti-bullwhip characteristics.
$Q(B_i)$	Stage I of the supply chain decision makers performance the bullwhip characteristics when order or shipments.
$Q(A_i)$	Stage I of the supply chain decision-makers showed anti-bullwhip characteristics when the order quantity or the quantity available.
Q^*, X^*	End-market demand.
X_i	Upstream and downstream enterprises in the supply chain bullwhip effect and anti-bullwhip effect combined effects of a decision results under the order or the quantity available for the magnitude of the deviation of the measure and the end-market demand.
X_+^*	Slightly more than the end market demand.
X_-^*	Slightly less than the end-market demand.
X	Retailer orders to suppliers or suppliers to retailers shipments.
X^*	End-market demand.
X_0	Retailers initial stocks of goods.
X_0'	Suppliers initial product inventory.
$\overline{X}$	Retailers in the face of the next order condition to make the amount of the actual accept.
P	Commodity market prices.
P'	Supplier's commodity prices.
C_{RI}	Retailers in inventory costs.
C_{SI}	Suppliers in inventory costs.
C_T	Commodity unit transportation cost.

5 optimal gain model

According to the results of the decision-making game, profitable decisions results around the optimal X^*, X_-^* and X_+^* Bullwhip features and the combined effects of the anti-bullwhip characteristics, to comply with the rules of the game balanced build upstream and downstream supply chain the individual enterprises and the whole supply chain optimal revenue model due to factors such as location, general supplier unit inventory costs than the retailer's unit

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inventory costs low and due to the wide application of inter-organization information system, can do the ordering costs not related to the number of marginal order The fee is almost zero, so that the model does not consider the order fee.

Now the second-order supply chain structure, for example, taking into account the combined effects of the bullwhip effect and anti-bullwhip effect, the introduction of the main mediation factor, measured in the joint role of retailers in the face of orders and market demand factors make accept the actual amount of goods, to design supply chain optimization revenue models and solutions.

5.1 Order Quantity (shipments) is less than the market demand situation ($X^*>X$)

$$Max \quad U_R = PX^* - C_{RI}(X_0 - (X^* - X)) \tag{9a}$$

$$Max \quad U_S = P'X - C_{SI}X_0' \tag{9b}$$

$$s.t. \tag{9c}$$

$$X_0 \geq X^* - X$$

The solution was to meet the optimum conditions of Equation 9: $\begin{cases} x^* = x_0 - x \\ x_0' = 0 \end{cases}$

Order Quantity (shipments) is less than the market demand situation, retailers and suppliers of optimal income for the PX^* and $p'x$, retailers and supplier's inventory is zero.

5.2 Order Quantity (shipments) is greater than the market demand ($X^*<X$)

$$Max \quad U_R = px^* - (C_{RI}(x_0 + \bar{x} - x^*) + C_T(x + \bar{x})) \tag{10a}$$

$$Max \quad U_S = p'x - C_{SI}(x_0' + x - \bar{x}) \tag{10b}$$

$$s.t. \tag{10c}$$

$$C_{RI}(x - x^*) > C_{RI}(\bar{x} - x^*) + C_r(x + \bar{x}); p'x - C_{SI}(x + \bar{x}) > p'\bar{x}$$

Further,

$$Min \quad C_{RI}(x_0 - x^*) + (C_{RI} - C_T)\bar{x} + C_T x \tag{11a}$$

$$Max \quad (p'x - C_{SI})x - C_{SI}x_0' + C_{SI}\bar{x} \tag{11b}$$

$$s.t. \tag{11c}$$

$$x > \bar{x} > x^*, p' > C_{SI}, C_{RI} > C_T$$

Using the graphical method to solve a (11a), (11b). In figures 3 to 8,

$$A = \frac{C_{SI}x_0'}{p' - C_{SI}}, B = \frac{C_{RI}(x^* - x_0)}{C_T}, C = \frac{C_{RI}(x^* - x_0)}{C_{RI} - C_T}$$

have been considered.

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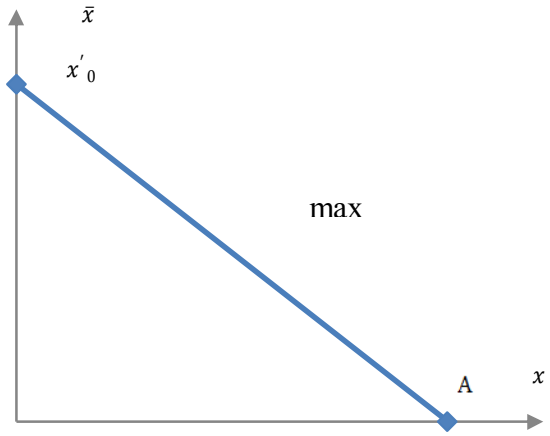


Fig. 3 Eq. (11b), a feasible solution schematic diagram

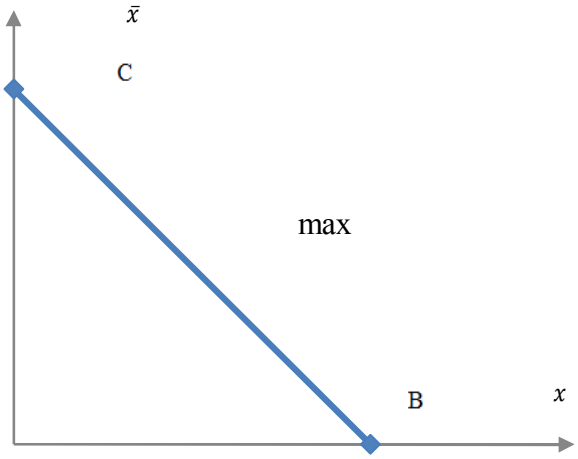


Fig. 4 Eq. (11a), a feasible solution schematic diagram

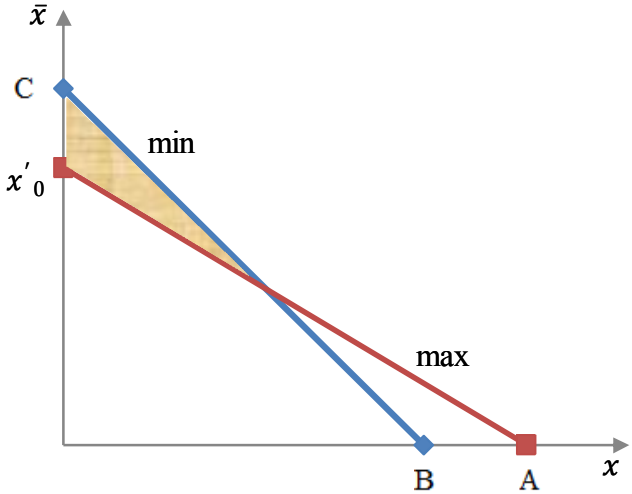


Fig. 5 Feasible solution Case 1

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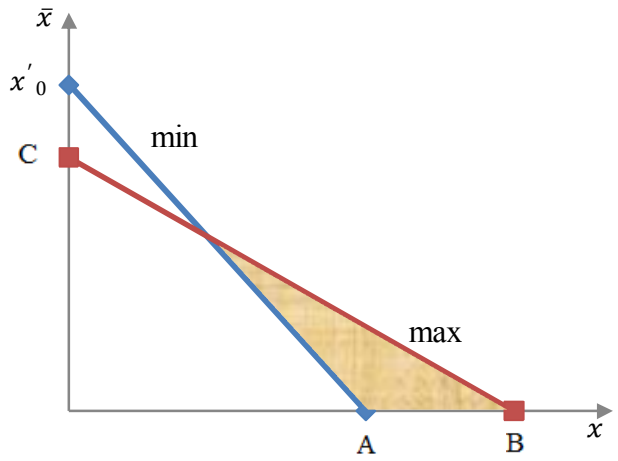


Fig. 6 Feasible solution Case 2

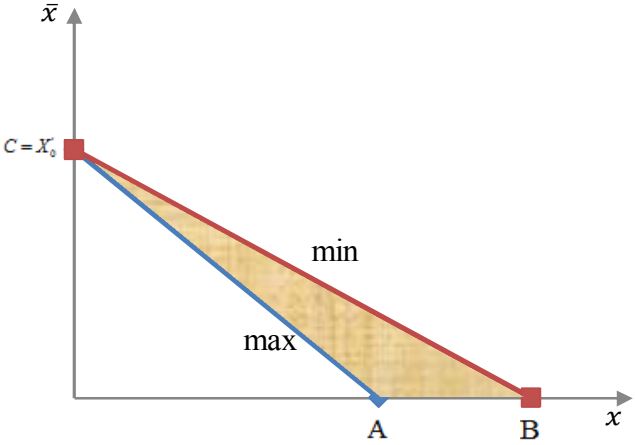


Fig. 7 Feasible solution Case 3

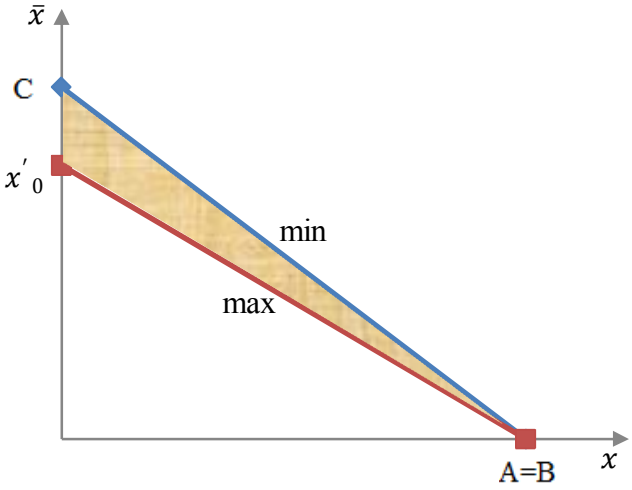


Fig. 8 Feasible solution Case 4

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Solution was, satisfies the equation 10 the optimum conditions and feasible solution:

Table 3 satisfies the condition of the order quantity (Delivery quantity) is greater than the market demand situation and feasible solution

Satisfying the Condition	Feasible Solution
$\frac{C_{RI}(x^*-x_0)}{C_{RI}-C_T} > x_0'$ and $\frac{C_{RI}(x^*-x_0)}{C_T} < \frac{C_{SI}x_0'}{p'-C_{SI}}$	Feasible solution to the situation 1
$\frac{C_{RI}(x^*-x_0)}{C_{RI}-C_T} < x_0'$ and $\frac{C_{SI}x_0'}{p'-C_{SI}} < \frac{C_{RI}(x^*-x_0)}{C_T}$	Feasible solution to the situation 2 Shaded.
$\frac{C_{RI}(x^*-x_0)}{C_{RI}-C_T} = x_0'$ and $\frac{C_{SI}x_0'}{p'-C_{SI}} < \frac{C_{RI}(x^*-x_0)}{C_T}$	Feasible solution to the situation 3 Shaded.
$\frac{C_{RI}(x^*-x_0)}{C_{RI}-C_T} > x_0'$ and $\frac{C_{SI}x_0'}{p'-C_{SI}} = \frac{C_{RI}(x^*-x_0)}{C_T}$	Feasible solution to the situation 4 Shaded.
$\frac{C_{RI}(x^*-x_0)}{C_{RI}-C_T} < x_0'$ and $\frac{C_{RI}(x^*-x_0)}{C_T} < \frac{C_{SI}x_0'}{p'-C_{SI}}$	No feasible solution.

6 Conclusions and outlook

In the process of supply chain operations, while there bullwhip effect and anti-bullwhip effect, taking into account only the cost of the supply chain, demand deviation, this presence will be driven by bounded rationality makes the bullwhip effect weakening the anti-bullwhip strengthen the effect, so that the upstream and downstream in the supply chain cycle will show the combined effects of the weakening of the bullwhip effect and strengthen the anti-bullwhip effect, the combined effects of individual enterprises to achieve the low average inventory costs also means that the whole supply chain inventory the lowest overall market demand for the lowest deviation, indirectly, from the overall automatically nitrate addition to the bullwhip effect or anti-bullwhip effect makes the whole supply chain whether short-term or long-term point of view is the best, if the long-term, but also supply chain enterprises bring significant strategic advantage.

Results from solving supply chain optimization revenue model, if the conditions for the order quantity (shipments) is less than the market demand situation ($X^*>X$) optimization of the conditions required to meet the $X^*=X_0-X$, that the market demand is exactly equal to the retailer's initial inventory and orders and inventory to zero for the next issue of the retailers in terms of inventory to zero is not a dangerous action, the best overall trends from the supply chain, supply chain every business seeks self-balancing short goods to retailers in terms of a period of zero inventory or a long period of zero inventory is a good thing, the retailer's unit inventory costs are higher than the supplier of the unit inventory costs from the overall concept of supply chain enterprises reached zero inventory or low inventory is beneficial, but also the future development trends; conditions for the order quantity is greater than the market demand situation ($X^*<X$), retailers and suppliers optimal revenue is not unique, but at a certain interval the scope of this interval range reflects the long-term effects of fluctuations in the supply chain.

Now given several unresolved in this article and future research directions: first, we consider only the conditions of perfect information bullwhip effect and mechanism of action

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of the anti-bullwhip effect is not considered imperfect information conditions, taking into account the combined effects of the bullwhip effect and anti-bullwhip effect, the design supply chain optimization revenue model only second-order supply chain structure, for example, to analyze the supply chain structure of order n, further research can be expanded to nechelon supply chain structure to optimize revenue model, third, the starting point of the thesis is that the actual operation of the supply chain, there may be a variety of effects, these effects will produce complex results reinforce or offset, it is necessary to observe and analyze a variety effects of the problems arising from short papers to new ideas for research from this perspective, with the people and the complexity of the market and fuzzy characteristics is increasingly apparent, to recognize the presence of other effects in the supply chain, these effects on more real value of supply chain management.

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