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Analysis on the Inventory Level Based on the Agile Supply Chain Whose Demand Process Subjected to First-Order Autoregressive

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Abstract:

For analysis of inventory level problems, this paper proposes an inventory level analysis of agile supply chain (ILAASC) based on demand process subjected to first-order autoregressive, and designs an analysis method on the inventory level based on the agile supply chain under the constraint of keep the order of local inventory level. The experimental results show that the analysis method of inventory level based on the agile supply chain whose demand process subjected to first-order autoregressive can not only ensure that the supply chain is not damaged, but on this basis, it can also guarantee that the coordination between the various inventory levels is improved. The obtained supply risk solution set not only has a better target value than the existing cooperative coevolution method, but also has good solution divergence. Coordinationof the inventory optimizes the agile supply chain, eliminating superfluous factors. As a result, unnecessary resources are saved.

Keywords:*Demand process obeys, First-order autoregressive, Inventory level, Coordination, Resources saving.*

I. INTRODUCTION

In the modern market economy, supply chains tend to be applied to inventory levels for analysis [1]. Therefore, in reality, a supply chain needs to cooperate with multiple inventory levels, and there will be a supply relationship between each other [2]. In addition, it is also necessary to realize that the supply chain and inventory level are relatively independent, and their respective characteristics are different. However, there is a very close partnership between them [3-6]. For both sides, it is necessary to take into account the coordination problem of inventory supply, and the two sides should be able to achieve good cooperation [7,8]. But the

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inventory level is in a relatively disadvantageous position in this process, and the operational capacity of the entire inventory level will be affected [9,10].

Although some scholars have built an analytical model for inventory level, when there are multiple inventory levels, there is relatively little analysis on how to optimize inventory level through coordination. According to the actual situation, the inventory levels are independent from each other, and all the behavior of the inventory level is to be able to maximize its inventory level. The connection degree between inventory levels are very low, and the key information related to the amount of its inventory is not to be shared with each other. Therefore, this method stays in the ideal case, and it is very difficult to achieve in reality. It is possible for all inventory levels to maximize returns through coordination. Therefore, this paper takes this as an objective to analyze the coordination problem of supply risk inventory level under the obedience of the demand process. The aim is to reduce redundant waste on the inventory level, in order to save resources.

II. EXPERIMENTAL ANALYSIS ON THR INVENTOR LEVEL BASED ON SUPPLY CHAIN

In analysis of the inventory level based on the agile supply chain, the first step is the supply chain stage, followed by the inventory level stage. The main impact of the former on the latter is reflected in the time required for the coordination of supply chain inventory supply, and the specific performance is that there is a cohesive constraint between the two, that is, $s_{i,j,d} \geq e_{i,j,u}$. The starting time of inventory level i coordinates inventory supply $J_{i,j}$ should be able to start after the supply chain has completed its inventory supply coordination, which means that the $e_{i,j,u}$ at this time is equivalent to the inventory supply $J_{i,j}$, and the release time required for the inventory level is $r_{i,j}$.If the inventory level wants to improve its coordination, the release time must be improved and adjusted. Moreover, for the inventory level, the results obtained after the supplement of new coordination scheme should be better than the original coordination target. If this goal cannot be achieved, the coordination is not necessary.

$$\sigma = \sum_{k=1}^{m} u_k \left(O\left(\alpha_k^{'}\right) - O\left(\alpha_k\right) \right) \quad (1)$$

$$v_i O\left(\beta_k^{'}\right) + \sigma_i > v_i O\left(\beta_k\right) \quad (2)$$

So, all the inventory levels are needed to share this part of the supplement σ, and the specific allocation principles are as follows:

It is required that supplementary parts shared by the inventory level is proportional to the return parts that it can obtain through the new coordination scheme, that is to say, the more the gains are obtained, the greater the supplement parts that need to be taken. The sum of supplement provided by the total inventory level is σ. δ_i represents the coordinated cost difference of the inventory level i under the original coordination scheme and the new coordination scheme, and using $\beta_i^{'}$ to represent the new coordination taken by inventory level i

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under the new coordination scheme.

δ_i can be expressed by the formula (3), and σ_i is expressed as the formula (4):

$$\delta_i = v_i\, max\left(0,\left(O\left(\beta_i\right)-O\left(\beta_i^{'}\right)\right)\right) \quad (3)$$

$$\sigma_i = \frac{\delta_i}{\sum_{i=1}^{m}\delta_i}\sigma \quad (4)$$

The coordination problem of inventory level is:

$$Mimv_1 O\left(\beta_1^{'}\right)+\sigma_1$$
$$\vdots$$
$$Mimv_m O\left(\beta_m^{'}\right)+\sigma_m$$
$$s.t.\sigma = \sum_{i=1}^{m} u_k\left(O\left(\alpha_k^{'}\right)-O\left(\alpha_k^{'}\right)\right), v_i O\left(\beta_i^{'}\right)+\sigma_i > v_i O\left(\beta_i\right), \sigma_i = \frac{\delta_i}{\sum_{i=1}^{m}\delta_i}\sigma$$

III. METHOD: ANALYSIS ON THE INVENTORY LEVEL BASED ON THE DEMAND PROCESS OBEY THE AGILE SUPPLY CHAIN

3.1 Method Framework

In analysis of the inventory level based on the agile supply chain designed in this paper, it is assumed that each inventory level maintains a relative evolutionary demand process obeys, and on this premise to calculates evolution. In this case, the corresponding solution of the demand process obeys is the local coordination of the corresponding inventory level, but it is required that each solution should contain the corresponding objective function value of each inventory level, and then the quality of the solution is evaluated in the coordination process. Moreover, supply can be used as a coordination content to transfer it to the supply chain, so as to the analysis and evaluation of local coordination can be realized. The supply chain can also be able to use some rules to analyze the inventory supply coordination of each inventory level, and carry out multi-objective evaluation with the help of coordination problems. By analyzing the results of the evaluation, we can determine whether the solution is a required solution under the constraint condition. If the solution is consistent with the constraint condition, it is proved that the local coordinated solution is feasible, and the inventory level will get the returned multiple objective value. Otherwise, it will be determined that the local coordination solution is not feasible, and the multiple objective value will be infinitely large at this time.

In the process of coordination, the supply chain will be able to obtain a non-dominant solution, and this solution set covers the corresponding global coordination solution of each inventory level in the whole inventory level, which includes the inventory supply ordering in each supply chain and the start and end time. In addition, it also includes the corresponding marshalling sequence of each inventory level in the entire inventory supply. However, their corresponding start time and the end time are not reflected in it. Its target value covers the corresponding coordination cost of the inventory level and coordination cost that the supply chain is facing after the implementation of the supplement.

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3.2 Local Evolution Method of Inventory Level Coordination

The demand process obeys maintained by the inventory level is made up of local coordination solutions, and can evolve the method in this demand process obeys. The global coordination target value can be calculated by combining the local coordination. Moreover, we can also use the obtained multi-objective value to analyze and evaluate the local coordination solutions of inventory level, and the entire evaluation is achieved in a multi-target situation rather than a single-target situation. Therefore, the local coordination problem of inventory level can be transformed into a multi-objective optimization problem, and then the corresponding method is used to solve the problem.

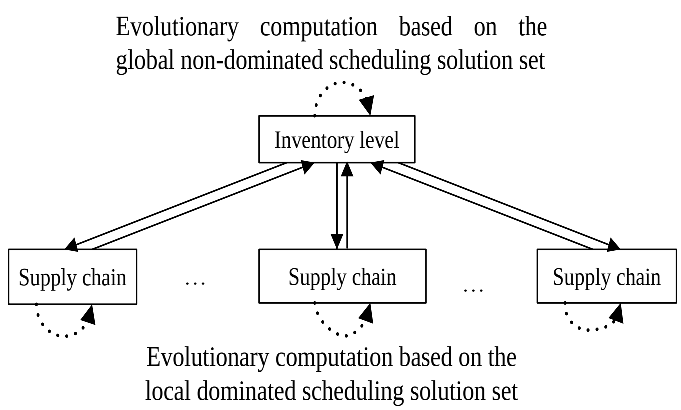

Fig1: The analytical framework of inventory level based on the agile supply chain

The maintenance of the demand process obeys diversity is realized by using the fitness sharing strategy proposed by Fonsecay and Fleming. In the corresponding solution space, a number of microhabitat can be obtained according to the different similarity degree of individual. d_{ij} represents the similarity degree between individual i and j, and it can be understood as the multi-objective value Euclidean-distance of the solution in m-dimensional space.

$$d_{ij} = \sqrt{\sum_{k=1}^{m}\left(o_{ki} - o_{kj}\right)^2} \qquad (5)$$

o_{ki} and o_{kj} respectively represent the kth (k=1, …, m) target values of solution i and j, m reflects the amount of inventory level, which is equivalent to the number of targets in the problem. Combined with d_{ij}, it can be found that there is a shared function $sh\left(d_{ij}\right)$ between individual i and j, which can be expressed as follows:

$$sh\left(d_{ij}\right) = \begin{cases} 1 - \left(d_{ij}/\sigma_{share}\right)^{\alpha}, & d_{ij} < \sigma_{share} \\ 0, & else \end{cases} \qquad (6)$$

α reflects the parameters that can have a decisive impact on the nature of a shared function, and its value is generally $\alpha = 1.\sigma_{share}$, In order to control the parameters that allow the sharing degree, the solution of the value can be expressed by the following formula

$$N\sigma_{share}^{m-1} - \frac{\prod_{i=1}^{m}(M_i - m_i + \sigma_{share}) - \prod_{i=1}^{m}(M_i - m_i)}{\sigma_{share}} = 0 \quad (7)$$

Where, N is the scale of the demand process obeys. According to $sh(d_{ij})$, the fitness f_i of the modified individual *i* is f_{mi} .

$$f_{mi} = \frac{f_i}{\sum_{j=1}^{N} sh(d_{ij})} \quad (8)$$

3.3 Global Evolution Method of Inventory Level Coordination

The main idea of analysis of inventory level based on the agile supply chain is to select two individuals with the least similarity from the global non-dominated solution to implement the jump gradient solution combination, and then exclude those individuals that the distance from the combined individual is less than δ , and do the cycle operation according to the process again, so that the last remaining number is less than two in global supply risk solution set. Then, the jump gradient solution set is used to update the global supply risk solution set. The reason why the combinatorial operation of jump gradient solutions is used is to realize the efficient use of the representative model of the non-dominant solution. Moreover, a number of new solutions can be obtained by the progressive combination, which can achieve a better solution set near the global non-dominated space. As shown in Figure 2, it reflects a simple operation for the combination of jump gradient solutions, and is satisfied with the $d_{ij} > d_{sr} > d_{uv}$. In the path between solutions *i* and *j*, *s* and *r* and *u* and *v*, a lot of new solutions can be obtained with the help of the combination of jump gradient solution, and in the obtained new solution, some genes of the solutions of two ends of the path can be obtained.

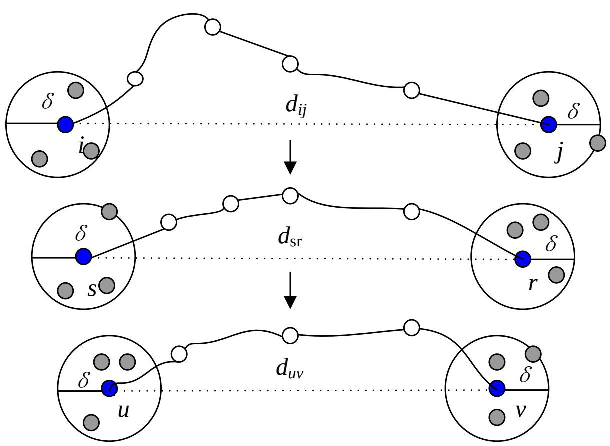

Fig 2: A schematic diagram of combination of jump gradient solution

3.4 Demand Process Obeys Mechanism

Assuming that $R = \{r_1, \ldots, r_n\}$ and $S = \{s_1, \ldots, s_n\}$ represent two queues that need to be merged, both R and S have a particular order, each element is an inventory supply, and they all correspond to a certain processing time, at the same time, the order of the two queues is not to be changed. On this basis, the merging is made so that the time required for the obtained queue

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should be minimal after the final merger.

In addition, the virtual element S_0 can be added before the S_1 element of the queue S, which does not participate in the coordination. Assuming that in this queue, the distance between s_i and $s_{i+1}(i=0,\ldots,n)$ can be expressed as $p_i(i=0,\ldots,n)$, and the position queue $P=\{p_0,\ldots,p_n\}$ can be obtained based on these positions. Merging R into S, that is, the elements of the former are filled in P.

It is required that the element $\{r_i,\ldots,r_n\}$ in R can be filled to the queue $\{p_j,\ldots,p_n\}$, that is, the merge queue can be obtained with the S, its cost will be $C_{i,j}$, Thus, the cost of the complete solution of the problem is $C_{1,0}$.

State: $C_{i,j}$

The state transfer function is shown below:

$$C_{i,j}=min\left(d_{ij}+C_{i+1,j},C_{i,j+1}\right),1\le i\le m-1 \quad (9)$$

According to the state transfer function, it can be found that the location of any element in R queue is arbitrary, and multiple elements can be placed at each location. However, it is required that its original order can be maintained, and it is also necessary to consider whether the *jth* position will be occupied. There are two situations to discuss.

Case1. If the *jth* position is occupied at this time, and the element at this position is the *ith* element, then an element in R queue is cut, but its *i+1~mth* element is likely to be in the *jth* position, and is contained in sub-question $C_{i+1,j}$.

Case2. The jth position is not occupied, that is, at this position, there is no any element in R, which shows that the R queue starts from the j+1th position, and it is equal to the order of sub problem $C_{i+1,j}$.

Boundary conditions:

if $i>m$, then $C_{i,j}=0$

if $j>n$, then $C_{i,j}=\infty$ □

$C_{i,n}=d_{i,n}$

$C_{i,n}=d_{i,n}$ includes $C_{k,n}=d_{k,n}\,(i<k\le m)$

For the SCS method, the aggregate has m(n+1) states, and each transition state and the two states are corresponding to each other. The time required for each state transfer includes the time required to calculate the d_{ij} and the two d_{ij} values. For the calculation of the d_{ij} value, it is required that the time required for the inventory supply after the *jth* position in the S plus the corresponding time of the *ith* inventory supply in the R. Because 0≤j≤n is satisfied, each time the inventory supply is added, the number will be less than or equal to n+1. The elements in the S will only be added once, so the average addition time will be less than 2. Therefore, we can get that the average time required for each state transfer is equal to $O(2)$, and the corresponding upper limit of the overall time complexity will be $O(m(n+1))$.

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IV. SIMULATION EXPERIMENT

In order to verify the effectiveness of analysis on the inventory level based on the agile supply chain proposed in this paper, and the following experiments are carried out in this paper. An agile supply chain is first used to analyze the inventory level in the problem of the multi-supply chain demand analysis and coordination, and then compare and analyze the relationship between independent coordination and coordination. The second is to compare the demand process obeys the coevolution method and the analysis on the inventory level based on the agile supply chain proposed in this paper, from which reveal the advantages and disadvantages of analysis on the inventory level based on the agile supply chain.

The method of this paper uses Java to write. Assuming that the scale of the corresponding evolutionary demand process obeys of inventory level is 100, each method is repeated ten times in each example, and then the 10 non-dominated sets are merged to get a non-dominated set, which is the result set of the solution. Assuming that both the inventory level and the cost of the supply chain are 0.5, that is, $\mu_i = v_i = 0.5$.

As shown in Figure 3, it represents a coordinated improvement degree $\eta_i (i=1,\ldots,m)$ that can be obtained by the inventory level through using the agile supply chain to analyze inventory level, and the value of η_i can be calculated by formula (10). Figure 3(a) reflects the coordinated improvement degree that the inventory level can be achieved when there are two inventory levels. Figure 3(b) reflects the situation that there are three inventory levels, and using d1win% , d2win% and d3win% respectively to represent the corresponding coordinated improvement degree of the 1st to 3rd inventory levels. Using sumwin% to represents the corresponding average improvement degree of the total inventory level, and using *x_y* to represent the abscissa, in which x represents the number of the inventory supply, and *y* represents the number of inventory levels, and the ordinate corresponds to the value of η_i.

$$\eta_i = \frac{O(\beta_i) - O(\beta_i^{'})}{O(\beta_i)} \times 100 \qquad (10)$$

From Figure 3, it can be concluded that the use of the agile supply chain for the analysis of the inventory level fully ensures the consistency of the supply chain, that is, there is no change in the supply chain, and also makes the inventory level reach a better coordination level. If there are two inventory levels, then the minimum improvement degree that can be achieved is about 32% and the maximum improvement is about 82%. If there are three inventory levels, then the maximum improvement degree that can be achieved is about 77%, while the minimum of nearly 6%. Therefore, it can be proved that the analysis on the inventory level based on the agile supply chain has its advantages and is effective.

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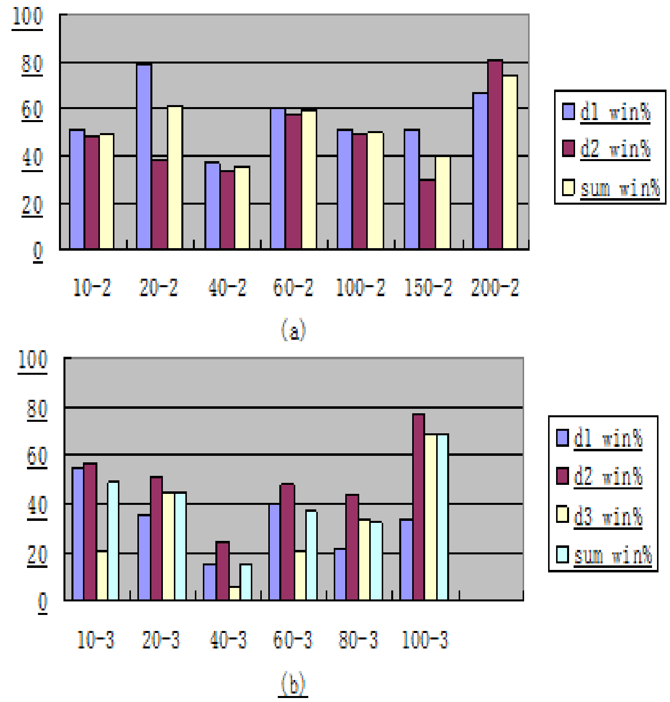

Fig 3: Coordinated returns of inventory level coordination on different examples

In order to further analyze the superiority of inventory level coordination in multi-objective constraint problems, in examples, this paper compares and analyzes the results obtained by using agile supply chain to analyze inventory level and three ways of MOCCGA, NSCCGA and GBCCGA. In order to ensure fairness, the time of the operation of various methods is the same in the example, and the final non-dominant solution is compared and analyzed.

In general, the analysis of the performance of the multi-objective method can be carried out by two methods. One is to analyze the corresponding target values of each non- dominated solution, the other is to compare the dispersion of the non-dominated solutions in the solution space. As shown in Figures 4 and 5, it reflects the non-dominated solutions that can be obtained in the case of two and three inventory levels.

Figure 4 (a) ~ Figure 4 (f) successively represents the corresponding non-dominated solution of each method under the different inventory supply (10, 20, 40, 60, 80, 100), and the axis corresponds to the local coordination target of the inventory level. The analysis of Figure 5 shows that in each example, using agile supply chain to analyze the inventory level can get a relatively superior non-dominated solution, and can achieve effective control for non-dominated solutions obtained by other methods. Moreover, more non-dominated solutions can be obtained by using the agile supply chain to analyze the inventory level, and its dispersion is also very good, showing an extension arc.

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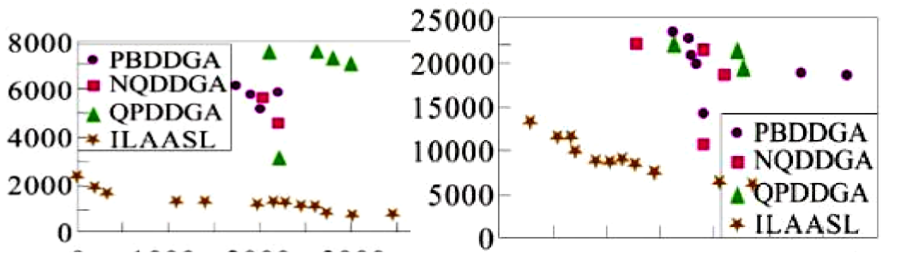
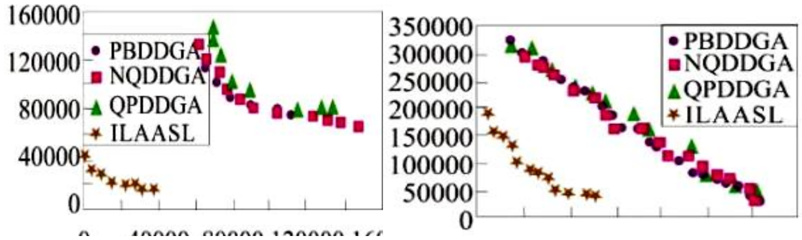


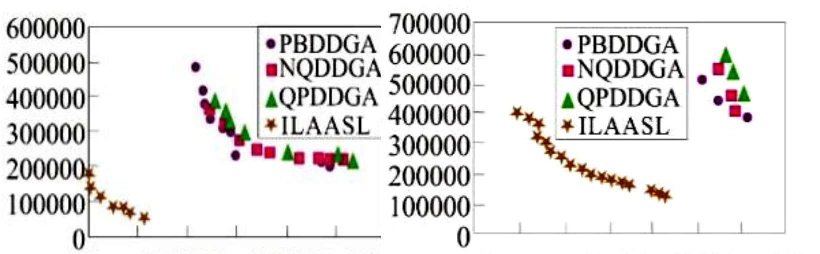
(a) (b)



(c) (d)

Fig 4: The corresponding non-dominated solution of each method under the different inventory supply (10, 20, 40, 60, 80, 100)

Figure 5(a)~Figure 5(d) represents that the corresponding non-dominated solutions of each method when the inventory supply is 100, and the axis corresponds to the local coordination target of the inventory level. The analysis of Figure 5 shows that no matter which example, the solution obtained by using agile supply chain to analyze the inventory level is superior, which not only can completely control the solution obtained by other methods, but also has advantages in terms of quantity and dispersion.



(a) (b)

Fig 5: The corresponding non-dominated solutions of each method when the inventory supply is 100

V. CONCLUSION

The existing analysis that about the analysis on inventory level based on supply chain demand is not much considered for the situation of the demand process obeys. On the basis of this, in the inventory level system, this paper analyzes the coordination problem between supply chain and inventory level, and proposes the analysis on the inventory level based on the agile supply chain whose demand process subjected to first-order autoregressive, which effectively solves the coordination problem between inventory level and supply chain and inventory level. Then how to carry out coordination is analyzed to effectively improve the coordination of each inventory level while ensuring that the supply chain is not damaged. The method proposed in this paper not only fully considers the collaboration between inventory level and supply chain, but also takes into full consideration the respective autonomy of both sides, which is consistent with the actual operation of inventory level, and has practical guiding significance. Applying the method of coordination, the optimized supply chain will be efficient in allocating resources, benefiting the resource-profit environment.

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