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Optimal Model on Petroleum Products Dispatching Mode

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Abstract: Optimization has been done to reduce cost of petroleum products dispatching. Definitions, stochastic mode, stochastic decision-making model and theorems were proposed, which weren't mentioned by anyone previously. Accordingly, the final result was obtained, considering that the stochastic mode not only reducing cost but also lowering wasting resources. Therefore, a new dispatching mode of petroleum products came out.

Keywords: dispatching mode; stochastic mode; stochastic model; petroleum product

1 Introduction

Along with the development of social economy and the improvement of humans living, consumption of petroleum products has increased rapidly, for which a high price was paid. For joining the WTO, China has loosened the oil retail market in 2004 and the whole sale business in 2006, facing a severe situation of global oil business.

At present, many studies have been done in fields of oil dispatching. Gomes MHR and Saraiva JT introduced SLP into research on power dispatching in Portugal in 2007 [1]. HB Gooi introduced a linear programming description model in Singapore in 2006 [2]. Vasile B and Ling L introduced a nonlinear mathematical model into power dispatching research in America in 2002 [3]. Poorna PR, Robert DG and John SC introduced discrete analog simulation technology into study on oil storage and transport in America in 2007 [4]. From 2002 to 2006, Liu SD, Jiang HM, Shi JJ, Guo ZP, Zhang LZ, Yin Q, Dong LM (etc.) in China have done research on theory of traditional mode and regional mode, of which characteristics and problems were analyzed [5-8].

As well as definitions and analysis about stochastic dispatching mode, theorems and analysis about stochastic decision-making model would be proposed in the paper, the topic is not only of the realism sense but also of the theory value.

2 Stochastic mode

Based on [9-11], let ρ_i be weight of a_i in the factors set $A = \{a_1, a_2, \cdots a_n\}$, so $\rho(A) = (\rho_i)_{1\times n}$. Similarly, let $R(A) = (r_{ij})_{n\times m}$ be weight of A, which is relative to the goals set $U = \{u_1, u_2\}$. We express the traditional mode and the regional mode as M_O and M_N. Inside A, while some factors belong to $U(u_1)$ and the other factors belong to $U(u_2)$, thereinto, $U(u_1) \cap U(u_2) = \varnothing$ and $U(u_1) \cup U(u_2) = A$, and consider the dispatching mode at the time as stochastic mode and express it as M_R.

There is a random factor C_{kl} in A, $R_{kl} = (\ u_{kl,1} \quad u_{kl,2}\ )$ is weight of C_{kl} relative to U, thereinto, $u_{kl,1} + u_{kl,2} = 1$. If $u_{kl,1} \geq u_{kl,2}$, consider that C_{kl} shows significant of u_1 and express that as $C_{kl} \in U(u_1)$, and its significant extent is $u_{kl,1} - 0.5$. Otherwise, consider that $C_{kl}\bar{\in}U(u_1)$. The weight of M_R is $B_R = (\ u_{A,1} \quad u_{A,2}\ )$ which is relative to U, thereinto, $u_{A,1} + u_{A,2} = 1$.
While $u_{A,1} \geq u_{A,2}$, consider that M_R shows significant of u_1 and express that as $M_R \propto U(u_1)$, and its significant extent is $u_{A,1} - 0.5$. Otherwise, consider $M_R\bar{\propto}U(u_1)$. M_O and M_N can be referred to $M_R = M_O \Leftrightarrow U(u_1) = \varnothing$ and $M_R = M_N \Leftrightarrow U(u_2) = \varnothing$.

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Theorem 2.1 *It is supposed that the factors set A is realigned into* $\{a^{(1)}, a^{(2)}, \cdots, a^{(n)}\}$ *as* $\rho(a^{(i)})$ *descends,* $a^{(k)}, a^{(k+1)}, \cdots, a^{(k+p)} \in U(u_1), a^{(l)}, a^{(l+1)}, \cdots, a^{(l+p)} \in U(u_1)$*, if* $\rho(a^{(k)}) \geq \rho(a^{(l)})$*,* $u_{A,1}^{(k)} \geq u_{A,1}^{(l)}$.

Proof. It can be obtained that $\rho(a^{(1)}) \geq \rho(a^{(2)}) \geq \cdots \geq \rho(a^{(n)})$ and $\rho(a^{(k)}) \geq \rho(a^{(l)})$, so we can make sure that $\rho(a^{(k+i)}) \geq \rho(a^{(l+i)}), 0 \leq i \leq p$.
Suppose that

$$\begin{cases} a^{(k)} \in U(u_1) \Leftrightarrow u_1^{(k)} = x \\ x \in (0.5, 1) \end{cases}.$$

So

$$\begin{cases} u_{A,1}^{(k)} = x \cdot q^{(k)} + (1-x) \cdot (1-q^{(k)}) \\ q^{(k)} = \sum\limits_{i=k}^{k+p} \rho(a^{(i)}) \\ u_{A,1}^{(l)} = x \cdot q^{(l)} + (1-x) \cdot (1-q^{(l)}) \\ q^{(l)} = \sum\limits_{i=l}^{l+p} \rho(a^{(i)}) \end{cases}.$$

It can be also obtained that

$$\begin{cases} u_{A,1}^{(k)} = 1 + 2q^{(k)}(x-0.5) \\ u_{A,1}^{(l)} = 1 + 2q^{(l)}(x-0.5) \end{cases},$$

So

$$u_{A,1}^{(k)} - u_{A,1}^{(l)} = 2(x-0.5)(q^{(k)} - q^{(l)}).$$

Because $x > 0.5$ and $q^{(k)} \geq q^{(l)}$, so it can be made sure that $u_{A,1}^{(k)} - u_{A,1}^{(l)} \geq 0$, therefore $u_{A,1}^{(k)} \geq u_{A,1}^{(l)}$. ■

Adapted to the status, $m = 2$ and $n = 10$ are provided to simplify the problem. $U = \{u_1, u_2\}$, $A = C_1 \cup C_2 \cup C_3 \cup C_4 = \{C_{11}, C_{12}, C_{13}, C_{21}, C_{22}, C_{23}, C_{31}, C_{32}, C_{41}, C_{42}\} = \{$circulation links, liquidity, sales cycle, security risks, distribution services, management, inventory costs, circulation costs, economic benefits and social benefits$\}$, $\rho(A) = (\rho_i)_{1\times 10}, R(A) = (r_{ij})_{10\times 2}$. Here randomness of the problem can be explained by $R(A)$, for there are random factors in $U(u_1)$, number of which is also random. So $R(A)$, decided by factors in $U(u_1)$, is random as well.

As analyzed, we know that M_R would spend on C_{kl} while $C_{kl} \in U(u_1)$, so we can consider the minimum expense as the object of decision-making. And while the expense achieve minimum, the number of factors in $U(u_1)$ achieve minimum, too.
With previous analysis, we obtain a model to do decision-making on the basis of stochastic mode.

3 Stochastic model

We obtain a set of judgment matrixes, $U = \begin{bmatrix} 1 & 1/2 & 1/3 & 1/4 \\ 2 & 1 & 2/3 & 2/4 \\ 3 & 3/2 & 1 & 3/4 \\ 4 & 4/2 & 4/3 & 1 \end{bmatrix}$, $B_1 = \begin{bmatrix} 1 & 1/2 & 1/3 \\ 2 & 1 & 2/3 \\ 3 & 3/2 & 1 \end{bmatrix}$, $B_2 = \begin{bmatrix} 1 & 1/4 & 1/5 \\ 4 & 1 & 4/5 \\ 5 & 5/4 & 1 \end{bmatrix}$, $B_3 = \begin{bmatrix} 1 & 1/3 \\ 3 & 1 \end{bmatrix}$, $B_4 = \begin{bmatrix} 1 & 1/4 \\ 4 & 1 \end{bmatrix}$, and by the necessary and sufficient conditions for consistency, we know that these 5 matrixes are consistent [12-13].

By Theorem 2.1, while there are the numbers of factors in $U(u_1)$, The higher the significant extent of factors in $U(u_1)$, the higher the significant extent of M_R. Therefore, object of decision-making can be modified as below.

Under the premise of reflecting on significant u_1 of M_R,
(i) choose the less one while $U(u_1)$ includes different numbers of factors,
(ii) choose factors which has higher significant extent while $U(u_1)$ includes the same numbers of factors.
After finally sorted, we obtain final results. And we realigned A as ρ_i descends, so we get $\rho(A)$=(0.32 0.225 0.1 0.08 0.08 0.075 0.05 0.033 0.02 0.017). And $A = \{C_{42}, C_{32}, C_{23}, C_{41}, C_{22}, C_{31}, C_{13}, C_{12}, C_{21}, C_{11}\}$, which is realigned.

As a result, the stochastic problem can be transformed into a non-random problem. Accordingly, it could be also supposed that

$$\begin{cases} C_{kl} \in U(u_1) \Leftrightarrow u_{kl,1} = x \\ x \in (0.5, 1) \end{cases}.$$

Based on all that were analyzed, the stochastic decision-making model can be obtained as $min : k = [U(u_1)]$, thereinto, $[U(u_1)]$ is the number of factors included in $U(u_1)$.

$$s.t. \begin{cases} \widetilde{B} = \rho(A) \cdot R(A) \\ B = \widetilde{B} \cdot (\sum_{i=1}^{2} \widetilde{b}_i)^{-1} \\ b_1 \geq 0.5 \\ k \in [0, 10] \end{cases},$$

thereinto, $\widetilde{b}_1$ and $\widetilde{b}_2$ are the components of $\widetilde{B}$, b_1 is the first component of B.

4 Analysis on the model

According to the stochastic mode and the stochastic decision-making model, a universality theorem can be advanced.

Theorem 4.1 *According to Theorem 2.1 and the stochastic decision-making model, it is obtained that*

$$\begin{cases} b_{1,k} = x \cdot q_k + (1 - x) \cdot (1 - q_k) \\ q_0 = 0, \quad q_k = \sum_{i=1}^{k} \rho_i \quad k \in \mathrm{Z}, \quad 1 \leq k \leq 10 \end{cases},$$

it is made sure that $b_{1,k}$ would increase as k increases.

Proof. We let $\beta_k = 1 - q_k$ and $\alpha_k = 1 - 2q_k$, it can be simplified as $b_{1,k} = \beta_k - \alpha_k x$. So we can obtain that $b_{1,k} - b_{1,k-1} = (\beta_k - \beta_{k-1}) - (\alpha_k - \alpha_{k-1})x$.
Here we assume that $\Delta_k = q_k - q_{k-1}$, so $\Delta_k > 0$.

We know that

$$\begin{cases} \beta_k - \beta_{k-1} = -\Delta_k \\ \alpha_k - \alpha_{k-1} = -2\Delta_k \end{cases},$$

So we can consider that

$$b_{1,k} - b_{1,k-1} = 2\Delta_k(x - 0.5).$$

Because $0.5 < x < 1$, it is made sure that $b_{1,k} - b_{1,k-1} > 0$. Therefore, $b_{1,k}$ would increase as k increases. ■

In the stochastic model, while $k = 0, 1, 2$, it can be obtained that

$$\begin{cases} b_{1,0} = 1 - x \\ b_{1,1} = 1 - \rho_1 - (1 - 2\rho_1)x \\ b_{1,2} = 1 - \rho_1 - \rho_2 - (1 - 2\rho_1 - 2\rho_2)x \end{cases}.$$

Here, we know that

$$\begin{cases} \rho_1 = 0.32 \\ \rho_2 = 0.225 \\ x > 0.5 \end{cases}.$$

Based on those analyzed above, it is certain that

$$\begin{cases} b_{1,0} < 0.5 \\ b_{1,1} < 0.5 \\ b_{1,2} > 0.5 \end{cases}.$$

By Theorem 4.1, while $k \geq 2$, $b_{1,k} > 0.5$. Therefore, while $k \geq 2$, $M_{R,k} \in U(u_1)$. Accordingly, it can be made sure that $\min : k = 2$. Thus, $\forall x > 0.5$, min: $k \equiv 2$. On the basis of all that were analyzed above, the universality theorem is proved completely.

While the universality theorem is completely proved, the stochastic model is also solved. As a result, whatever the value of x is, $\min : k = 2$.

To simplify description, three cases will be analyzed to examine the universality theorems.

Case 4.1. Research on M_O.

While$M_R = M_O$, $k = 0 < \min : k = 2$, and by the universality theorem, we know that M_O shows no significant of u_1, so $M_O \notin U(u_1)$.

Case 4.2. Research on M_N.

While$M_R = M_N$, $k = 10 > \min : k = 2$, and by the universality theorem, we know that M_N shows significant of u_1, so $M_N \in U(u_1)$.

According to case 6.1 and case 6.2, neither the traditional mode nor the regional mode can be the final result of decision-making on petroleum products dispatching. And it is considered that M_O can not reflects on significant while $k < 2$ and M_N may cause waste of resources while $k > 2$.

Case 4.3. Research on M_R. As described, x is treated as an independent variable and min: k is treated as an induced variable. Accordingly, we let x be some numerical values ($x = \{0.6, 0.7, 0.8, 0.9\}$) to examine case 4.3 and the proof of Theorem 4.1 and Theorem 4.2. According to previous analysis, the relationship between x and min: k can be obtained. As researched, it is certain that x has nothing to do with min: k. The assumption in Theorem 4.1 is right and min: $k \equiv 2$, which means unquestionably $C_{42}, C_{32} \in U(u_1)$.

Therefore, the traditional mode and the regional mode can neither be accepted. And the final result of the model is $C_{42}, C_{32} \in U(u_1)$. Therefore, a complete new dispatching mode of petroleum products comes into the existence.

5 Conclusion

It is made sure that the best mode is neither the traditional one M_O nor the regional one M_N but the restricted stochastic dispatching mode M_R (min:$k \equiv 2$), which is a new dispatching mode of petroleum products. We just have to do well in social benefits and circulation costs, which are expressed as C_{42} and C_{32}.

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