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基于动态直觉模糊 VIKOR 群决策的冷链供应商选择研究

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摘要:冷链物流下游企业(客户)选择高质量的供应商是一个复杂的动态决策过程。该动态决策过程针对有限的潜在供应商,在多个阶段基于动态直觉模糊理论和多准则折衷排序解法(VIKOR),构建多专家参与的群决策模型。文章首先介绍了直觉模糊集的相关理论、算子及距离测度公式,接着结合 VIKOR 决策方法构建了基于动态直觉模糊 VIKOR 群决策模型,并对冷链物流供应商选择的决策流程进行规划,然后通过实证及文献研究,选取响应能力、运输水平、客户服务等指标构建冷链物流供应商选择的评价指标体系,最后通过算例对某冷链物流供应商进行决策评价。

关键词:直觉模糊;多准则折衷排序解法(VIKOR);冷链物流;供应商选择;多属性群决策
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随着物流行业的深入发展和人们生活水平的不断提升,高附加值的冷链物流在流通领域扮演着越来越重要的作用。所谓冷链物流[1],是指冷藏冷冻类物品在生产、储存、运输、再加工以及销售的全过程中始终处于规定的低温环境下,以保证物品质量和性能的供应链系统。供应商选择是冷链物流中下游企业(客户)采购流程的重要环节。能否全面客观地对其进行选择评价,并与之建立稳定的联盟伙伴关系,关系到下游企业(客户)的采购效用,也关系到冷链物流的运营效率。

目前,国内外学者对供应商选择进行了大量的研究,主要集中在两个方面:一是供应商选择的指标选取;二是供应商评价的模型方法[2]。在供应商选择的指标体系中,比较集中的指标主要有供应商的质量、价格、服务能力、财务水平、关系管理、选址及文化适应[3-5]等;供应商选择的评价方法则集中于数据包络分析法(DEA)、网络层次分析法(ANP)、模糊评价法、理想点决策法(TOPSIS),以及这些方法的有效结合[6-9]等。然而,针对冷链物流供应商选择的文献鲜见。本文借鉴并改进已有的研究成果,构建冷链物流供应商选择的评价指标体系,并采用动态直觉模糊 VIKOR 群决策模型对其进行研究分析,为冷链物流供应商选择提供一种新的算法。一方面,决策评价过程引入动态直觉模糊数,将传统的静态评价升级为动态评价,同时考虑了决策过程中的不确定性和决策专家打分的犹豫度水平,使属性评价值合理性增强,更加符合实际工作需求;另一方面,使用 VIKOR 决策方法进行综合评价,该方法是一种基于理想点的决策方法,它的基本思想是以群体效用最大化及个体遗憾最小化为出发点,根据各评估方案与理想方案的接近程度来排列方案的优先顺序并进行方案优选,同时兼顾了决策者的偏好影响,从而得到更合理的决策效果。

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1 基于动态直觉模糊 VIKOR 群决策模型基础理论

1.1 直觉模糊集及运算

定义 1[10] 设 X 是一个非空集合，则论域 X 上的直觉模糊集 A 可表示为

$$A=\{[x,\mu_A(x),v_A(x)]\}x\in X \tag{1}$$

其中，$\mu_A(x)$和 $v_A(x)$分别为 X 元素中 x 属于 A 的隶属度和非隶属度，即 $\mu_A:X\to[0,1],x\in X\to\mu_A(x)\in[0,1]$，$v_A:X\to[0,1],x\in X\to v_A(x)\in[0,1]$。同时，满足 $0\leqslant\mu_A(x)+v_A(x)\leqslant 1$；则 $\pi_A=1-\mu_A(x)-v_A(x)$为 X 元素中 x 属于 A 的犹豫度或不确定度。显然，对于任意的 $x\in X$，都有 $0\leqslant\pi_A(x)\leqslant 1$。

设 $\alpha=(\mu_a,v_a)$为直觉模糊数，且设 Θ 为全体直觉模糊数的集合[11]。显然，$\alpha^+=(1,0)$为最大的直觉模糊数，$\alpha^-=(0,1)$为最小的直觉模糊数。

直觉模糊集的一些基本运算法则如定义 2 所示：

定义 2[12] 若 $\alpha_1=(\mu_{a1},v_{a1})$和 $\alpha_2=(\mu_{a2},v_{a2})$均为直觉模糊数，则

1）$\alpha^-=(v_a,\mu_a)$；

2）$\alpha_1\wedge\alpha_2=\{\min(\mu_{a1},\mu_{a2}),\max(v_{a1},v_{a2})\}$；

3）$\alpha_1\vee\alpha_2=\{\max(\mu_{a1},\mu_{a2}),\min(v_{a1},v_{a2})\}$；

4）$\alpha_1\oplus\alpha_2=(\mu_{a1}+\mu_{a2}-\mu_{a1}\mu_{a2},v_{a1}v_{a2})$；

5）$\alpha_1\otimes\alpha_2=(\mu_{a1}\mu_{a2},v_{a1}+v_{a2}-v_{a1}v_{a2})$；

6）$\lambda\alpha=(1-(1-\mu_a)^\lambda,v_\alpha^\lambda,\lambda>0)$；

7）$\alpha^\lambda=(\mu_a^\lambda,1-(1-v_a)^\lambda,\lambda>0)$。

1.2 直觉模糊集成算子[11]

定义 3[13] 设 $\alpha_j=(\mu_{aj},v_{aj})(j=1,2,\cdots,n)$是直觉模糊数，且设 $IFWA:\Theta^n\to\Theta$，若

$$IFWA_{\varpi}(\alpha_1,\alpha_2,\cdots,\alpha_n)=\omega_1\alpha_1\oplus\omega_2\alpha_2\oplus\cdots\oplus\omega_n\alpha_n \tag{2}$$

则称 IFWA 为直觉模糊加权平均算子，其中 $\omega=(\omega_1,\omega_2,\cdots,\omega_n)^T$ 为 $\alpha_j(j=1,2,\cdots,n)$的权重向量，$\omega_j\in[0,1]$ $(j=1,2,\cdots,n)$，$\sum_{j=1}^{n}\omega_j=1$。

定理 1[13] 设 $a_j=(\mu_{aj},v_{aj})(j=1,2,\cdots,n)$，则有

$$IFWA_{\varpi}(\alpha_1,\alpha_2,\cdots,\alpha_n)=(1-\prod_{j=1}^{n}(1-\mu_{aj})^{\omega j},\prod_{j=1}^{n}v_{\alpha j}^{\omega j}) \tag{3}$$

且由 IFWA 算子集成所得到的值也是直觉模糊数。

若 $\omega=(\frac{1}{n},\frac{1}{n},\cdots,\frac{1}{n})^T$，则直觉模糊加权平均算子(IFWA)会退化为直觉模糊平均算子(IFA)

$$IFA_{1/n}(\alpha_1,\alpha_2,\cdots,\alpha_n)=(1-\prod_{j=1}^{n}(1-\mu_{aj})^{\frac{1}{n}},\prod_{j=1}^{n}v_{\alpha j}^{\frac{1}{n}}) \tag{4}$$

1.3 直觉模糊数的距离测度公式

若 $a_1=(\mu_{a1},v_{a1})$和 $a_2=(\mu_{a2},v_{a2})$为两个直觉模糊数，则

$$d(a_1,a_2)=\frac{1}{2}(|\mu_{a1}-\mu_{a2}|+|v_{a1}-v_{a2}|+|\pi_{a1}-\pi_{a2}|) \tag{5}$$

为 a_1和 a_2的距离。

1.4　动态直觉模糊多属性群决策问题描述

动态直觉模糊多属性群决策问题可以描述为：在 $t_k(k=1,2,\cdots,r)$ 个时段中，由 p 人组成的决策专家团 $D_l(l=1,2,\cdots,p)$ 从一系列备选方案 $A_i(i=1,2,\cdots,m)$ 中，依据评价准则 $C_j(j=1,2,\cdots,n)$，给出含有直觉模糊数形式的评价信息，并对方案进行决策优选。设 ω^k 表示各个时段 t_k 的权重，λ^k_l 表示 t_k 时段决策者 D_l 的权重，ζ^k_l 表示 t_k 时段指标 C_j 的权重。则 t_k 时段决策者 D_l 的决策矩阵可以表示为

表 1　t_k 时段决策者 D_l 的直觉模糊决策矩阵

Tab.1　Intuitionistic fuzzy decision-making matrix of D_l in period t_k

备选方案	t_k 时段决策者 D_i 的评价值			
	C_1	C_2	…	C_n
A_1	(μ^k_{l11},v^k_{l11})	(μ^k_{l12},v^k_{l12})	…	(μ^k_{l1n},v^k_{l1n})
A_2	(μ^k_{l21},v^k_{l21})	(μ^k_{l22},v^k_{l22})	…	(μ^k_{l2n},v^k_{l2n})
⋮	⋮	⋮	…	⋮
A_m	(μ^k_{lm1},v^k_{lm1})	(μ^k_{lm2},v^k_{lm2})	…	(μ^k_{lmn},v^k_{lmn})

其中，(μ^k_{lmn},v^k_{lmn}) 表示 t_k 时段决策者 D_l 给出的 A_i 方案在 C_j 指标下的直觉模糊评价值，μ^k_{lmn} 和 v^k_{lmn} 分别表示评价值的隶属度和非隶属度，且 $\mu^k_{lmn}\in[0,1]$，$v^k_{lmn}\in[0,1]$；$\sum_{k=1}^{r}\omega^k=1$，$\sum_{l=1}^{p}\lambda_l^k=1$，$\sum_{j=1}^{n}\zeta_j^k=1$。

1.5　动态直觉模糊数的加权平均 DIFWA 算子[14]

将公式（2）和（3）加以推广，形成动态直觉模糊数的加权平均算子 DIFWA，设 $\alpha^1,\alpha^2,\cdots,\alpha^r$ 为 r 个不同时段 $t_k(k=1,2,\cdots,r)$ 状态下的直觉模糊数，且 ω^k 为各个时段 t_k 的权重，$\omega^k>0$，$\sum_{k=1}^{r}\omega^k=1$，则称

$$DIFWA_{\omega^t}(\alpha^1,\alpha^2,\cdots,\alpha^r)=\omega^1\alpha^1\oplus\omega^2\alpha^2\oplus\cdots,\oplus\omega^r\alpha^r=(1-\prod_{k=1}^{r}(1-\mu_{\alpha^k})^{\omega^k},\prod_{k=1}^{r}v_{\alpha^k}^{\omega^k}) \tag{6}$$

为动态直觉模糊数的加权平均 DIFWA 算子。

2　动态直觉模糊 VIKOR 群决策模型的构建

首先，组织决策专家小组分阶段采集冷链物流供应商的信息并根据指标内容对其进行打分，接着根据 IFWA 算子将各个时段专家打分的直觉模糊信息与其权重信息集结，得到每个时段的群评价信息矩阵，再根据 DIFWA 算子将各个时段的群评价信息与指标权重信息集结，得到综合评价的直觉模糊矩阵。在此基础上，将 VIKOR 决策方法[15]引入到模型中，构建动态直觉模糊 VIKOR 群决策模型。具体步骤：

步骤 1　根据决策专家的打分矩阵，利用 IFWA 算子（3），计算每个时段的群评价信息矩阵；

步骤 2　根据 DIFWA 算子（6），将各个时段的群评价信息与指标权重信息集结，得到综合评价的直觉模糊矩阵；

步骤 3　分别定义直觉模糊正理想解 x^+ 和负理想解 x^-，即

$$x^+=(\alpha^+_1,\alpha^+_2,\cdots,\alpha^+_n) \tag{7}$$

$$x^-=(\alpha^-_1,\alpha^-_2,\cdots,\alpha^-_n) \tag{8}$$

其中，$\alpha^+=(1,0)$，$\alpha^-=(0,1)$。

步骤 4　根据直觉模糊距离测度公式（5），计算各供应商的群体效益值 S_i 和个体遗憾度 R_i，公式：

$$S_i=\sum_{j=1}^{n}\left\{\omega_j\left(\frac{d(a^+_j,a_{ij})}{d(a^+_j,a^-)}\right)\right\},(i=1,2,\cdots,m) \tag{9}$$

$$R_i=\max_j\left\{\omega_j\left(\frac{d(a_j^+,a_{ij})}{d(a_j^+,a^-)}\right)\right\},(i=1,2,\cdots,m), \tag{10}$$

步骤 5　计算各待评价供应商的折衷排序值

$$Q_i=\varepsilon\left(\frac{S^+-S_i}{S^+-S^-}\right)+(1-\varepsilon)\left(\frac{R^+-R_i}{R^+-R^-}\right),(i=1,2,\cdots,m) \tag{11}$$

式中，ε 为折衷排序系数，$\varepsilon\in[0,1]$，若 $\varepsilon>0.5$，则表示方案群体效益的比重高于个体遗憾度的比重；反之亦然。通常情况下，取 $\varepsilon=0.5$。

步骤 6　按照 VIKOR 决策法的决策准则对备选供应商进行排序，Q_i 值越大，说明方案越差；Q_i 值越小，说明方案更优。同时，若存在 $Q'-Q_{\min}\geqslant 1/(m-1)$，则说明最小解所对应的方案为最优，其中 Q' 为次小解，$Q_{\min}$ 为最小解，m 为对比方案个数。

3　冷链物流供应商选择指标体系的建立

供应商选择是企业与其供应商建立和保持长期合作关系的基础。一般来说，传统供应商的选择是通过供应商供货的产品价格、产品质量、供货及时性、交货期的稳定性及客户服务等各项评定指标进行综合分析的。冷链物流供应商选择更是在这基础上把供应商的冷链能力和水平作为首要因素而提出的。通过选择合适的冷链供应商，并与之建立紧密长久的合作关系，不仅可以降低下游企业（客户）成本、减少库存、提高现金流量、提升物流专业化水平，更能满足冷链商品消费者对于产品高品质享受的预期。

通过归纳梳理大量文献，并结合冷链物流的发展现状，综合专家意见，最终确立了冷链物流供应商选择的 18 项指标，并将其整合为 5 项指标（C_1~C_5）。由于指标数量较多，为了便于专家快速、准确、全面打分，设计了冷链物流供应商选择评价指标的体系图，如图 1 所示。

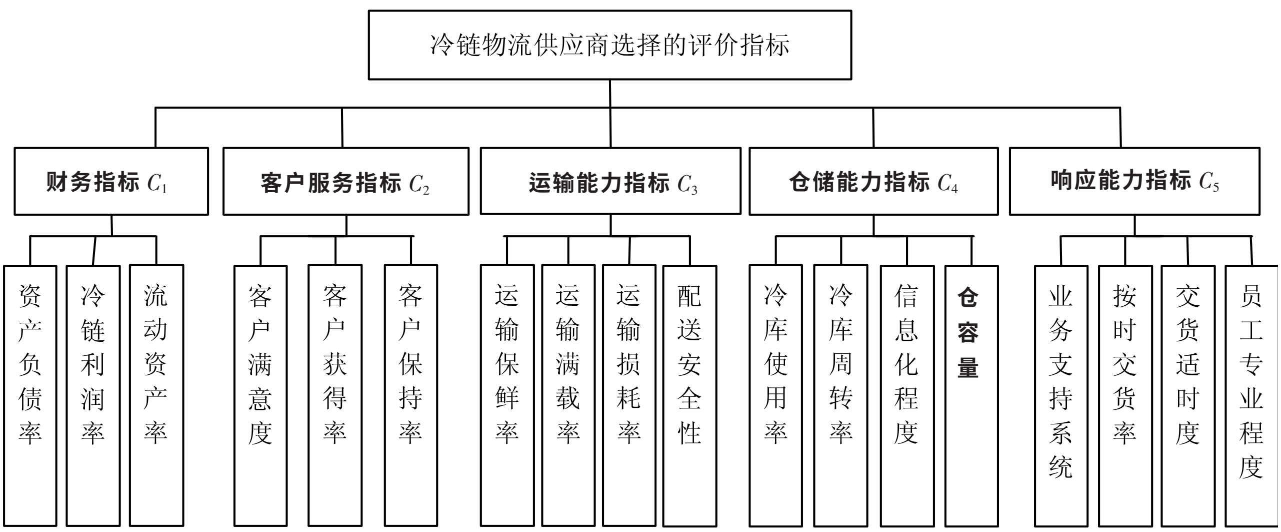

图 1　冷链物流供应商选择的评价指标体系

Fig.1　Evaluation index system of cold logistics supplier selection

4　算例分析

某冷链物流企业对 5 个潜在的供应商（$A_1,A_2,\cdots A_5$）分资格审查 t_1，初步沟通 t_2，和深入调研 t_3，3 个阶段进行优选，3 个决策专家小组（D_1,D_2,D_3）分别从财务指标（C_1）、客户服务指标（C_2）、运输能力指标（C_3）、仓储能力指标（C_4）及响应能力指标（C_5）等 5 个维度对其进行评价。评价值均为直觉模糊数，且设 ω^k 表示各个时段 t_k 的权重，$\omega^3=[0.20,0.30,0.50]$；$\lambda^k_l$ 表示 t_k 时段决策者 D_l 的权重，$\lambda^1=[0.40,0.28,0.32]$，$\lambda^2=$

[0.30,0.35,0.35],λ^3 = [0.40,0.30,0.30]; ζ^{k}_{l} 表示 t_k 时段指标 C_j 的权重, ζ = [0.30,0.17,0.13,0.26,0.14]。专家决策小组在各阶段对 5 个供应商的评价值如表 2~表 4 所示。

下面利用本文所建模型进行求解。

首先,根据决策专家的打分矩阵,利用 IFWA 算子(3),计算每个时段的群评价信息矩阵,如表 5 所示。

表 2　专家决策小组在 t_1 阶段对 5 个供应商的评价值

Tab.2　Evaluation values for the five suppliers made by expert decision group in t_1 stage

评价	t_1/D_1					t_1/D_2					t_1/D_3				
	C_1	C_2	C_3	C_4	C_5	C_1	C_2	C_3	C_4	C_5	C_1	C_2	C_3	C_4	C_5
A_1	(0.61,0.01)	(0.72,0.15)	(0.82,0.01)	(0.75,0.07)	(0.64,0.05)	(0.97,0.01)	(0.80,0.19)	(0.84,0.04)	(0.82,0.01)	(0.67,0.12)	(0.80,0.01)	(0.76,0.01)	(0.65,0.34)	(0.94,0.06)	(0.66,0.27)
A_2	(0.78,0.11)	(0.97,0.01)	(0.94,0.03)	(0.99,0.00)	(0.90,0.06)	(0.76,0.23)	(0.94,0.03)	(0.90,0.08)	(0.92,0.03)	(0.82,0.03)	(0.97,0.02)	(0.81,0.15)	(0.74,0.17)	(0.77,0.13)	(0.58,0.13)
A_3	(0.64,0.02)	(0.84,0.01)	(0.70,0.15)	(0.79,0.11)	(0.70,0.18)	(0.70,0.09)	(0.96,0.03)	(0.85,0.12)	(0.79,0.08)	(0.63,0.05)	(0.97,0.01)	(0.82,0.10)	(0.75,0.08)	(0.83,0.01)	(0.57,0.38)
A_4	(0.67,0.13)	(0.86,0.06)	(0.74,0.07)	(0.88,0.09)	(0.80,0.19)	(0.87,0.10)	(0.92,0.05)	(0.90,0.09)	(0.81,0.10)	(0.70,0.26)	(0.93,0.06)	(0.98,0.00)	(0.70,0.07)	(0.81,0.17)	(0.62,0.21)
A_5	(0.76,0.24)	(0.80,0.15)	(0.77,0.17)	(0.84,0.13)	(0.99,0.00)	(0.92,0.08)	(0.99,0.00)	(0.70,0.25)	(0.86,0.07)	(0.84,0.16)	(0.77,0.06)	(0.80,0.10)	(0.66,0.32)	(0.70,0.28)	(0.78,0.01)

表 3　专家决策小组在 t_2 阶段对 5 个供应商的评价值

Tab.3　Evaluation values for the five suppliers made by expert decision group in t_2 stage

评价	t_2/D_1					t_2/D_2					t_2/D_3				
	C_1	C_2	C_3	C_4	C_5	C_1	C_2	C_3	C_4	C_5	C_1	C_2	C_3	C_4	C_5
A_1	(0.90,0.08)	(0.64,0.04)	(0.75,0.03)	(0.72,0.06)	(0.77,0.18)	(0.52,0.24)	(0.64,0.05)	(0.80,0.13)	(0.81,0.03)	(0.97,0.01)	(0.79,0.07)	(0.82,0.07)	(0.71,0.08)	(0.60,0.03)	(0.61,0.10)
A_2	(0.63,0.09)	(0.63,0.33)	(0.74,0.09)	(0.95,0.04)	(0.86,0.01)	(0.86,0.08)	(0.83,0.05)	(0.61,0.14)	(0.96,0.02)	(0.90,0.09)	(0.94,0.06)	(0.89,0.11)	(0.69,0.08)	(0.86,0.02)	(0.58,0.40)
A_3	(0.72,0.08)	(0.88,0.10)	(0.88,0.12)	(0.81,0.02)	(0.79,0.16)	(0.51,0.07)	(0.76,0.01)	(0.60,0.36)	(0.88,0.05)	(0.94,0.05)	(0.74,0.08)	(0.71,0.23)	(0.59,0.40)	(0.78,0.10)	(0.97,0.01)
A_4	(0.94,0.03)	(0.85,0.08)	(0.58,0.14)	(0.93,0.04)	(0.82,0.12)	(0.96,0.03)	(0.79,0.20)	(0.69,0.12)	(0.86,0.09)	(0.88,0.04)	(0.88,0.03)	(0.79,0.03)	(0.85,0.05)	(0.77,0.09)	(0.73,0.12)
A_5	(0.85,0.11)	(0.95,0.03)	(0.94,0.03)	(0.76,0.23)	(0.79,0.04)	(0.91,0.04)	(0.79,0.11)	(0.83,0.09)	(0.88,0.08)	(0.84,0.12)	(0.60,0.40)	(0.74,0.01)	(0.81,0.05)	(0.90,0.06)	(0.83,0.14)

表 4　专家决策小组在 t_3 阶段对 5 个供应商的评价值

Tab.4　Evaluation values for the five suppliers made by expert decision group in t_3 stage

评价	t_3/D_1					t_3/D_2					t_3/D_3				
	C_1	C_2	C_3	C_4	C_5	C_1	C_2	C_3	C_4	C_5	C_1	C_2	C_3	C_4	C_5
A_1	(0.96,0.01)	(0.79,0.21)	(0.79,0.02)	(0.98,0.02)	(0.98,0.01)	(0.80,0.07)	(0.90,0.01)	(0.73,0.09)	(0.90,0.07)	(0.63,0.22)	(0.58,0.32)	(0.68,0.22)	(0.60,0.38)	(0.69,0.20)	(0.84,0.11)
A_2	(0.90,0.02)	(0.72,0.18)	(0.96,0.02)	(0.92,0.06)	(0.59,0.40)	(0.82,0.16)	(0.71,0.11)	(0.74,0.25)	(0.97,0.02)	(0.86,0.04)	(0.86,0.14)	(0.96,0.01)	(0.70,0.25)	(0.90,0.09)	(0.86,0.14)
A_3	(0.79,0.11)	(0.91,0.07)	(0.79,0.03)	(0.83,0.12)	(0.62,0.30)	(0.74,0.15)	(0.70,0.01)	(0.80,0.14)	(0.87,0.04)	(0.77,0.08)	(0.92,0.04)	(0.81,0.16)	(0.98,0.01)	(0.84,0.10)	(0.65,0.14)
A_4	(0.84,0.01)	(0.55,0.43)	(0.50,0.29)	(0.88,0.02)	(0.93,0.04)	(0.89,0.09)	(0.94,0.06)	(0.77,0.18)	(0.82,0.09)	(0.91,0.05)	(0.85,0.06)	(0.75,0.07)	(0.63,0.12)	(0.67,0.27)	(0.66,0.23)
A_5	(0.86,0.10)	(0.57,0.38)	(0.62,0.35)	(0.85,0.14)	(0.73,0.02)	(0.90,0.04)	(0.57,0.23)	(0.91,0.04)	(0.82,0.03)	(0.72,0.20)	(0.83,0.07)	(0.87,0.02)	(0.91,0.07)	(0.92,0.03)	(0.61,0.36)

表 5 群评价信息矩阵

Tab.5 Group evaluation matrix

供应商	t_1 时段专家小组的综合评价植					t_2 时段专家小组的综合评价植					t_3 时段专家小组的综合评价植				
	C_1	C_2	C_3	C_4	C_5	C_1	C_2	C_3	C_4	C_5	C_1	C_2	C_3	C_4	C_5
A_1	(0.52,0.41)	(0.75,0.23)	(0.71,0.21)	(0.61,0.30)	(0.62,0.29)	(0.60,0.36)	(0.64,0.32)	(0.64,0.30)	(0.59,0.37)	(0.58,0.42)	(0.52,0.25)	(0.50,0.24)	(0.59,0.37)	(0.46,0.27)	(0.54,0.39)
A_2	(0.69,0.23)	(0.64,0.36)	(0.57,0.38)	(0.47,0.10)	(0.69,0.26)	(0.62,0.37)	(0.55,0.45)	(0.66,0.32)	(0.42,0.35)	(0.57,0.43)	(0.26,0.20)	(0.32,0.25)	(0.55,0.39)	(0.40,0.25)	(0.56,0.36)
A_3	(0.75,0.23)	(0.63,0.29)	(0.71,0.27)	(0.69,0.27)	(0.77,0.21)	(0.74,0.22)	(0.59,0.30)	(0.67,0.33)	(0.58,0.42)	(0.60,0.35)	(0.31,0.19)	(0.48,0.41)	(0.38,0.29)	(0.44,0.23)	(0.40,0.28)
A_4	(0.67,0.28)	(0.72,0.24)	(0.81,0.15)	(0.61,0.30)	(0.64,0.30)	(0.49,0.46)	(0.53,0.41)	(0.64,0.36)	(0.61,0.32)	(0.58,0.40)	(0.34,0.23)	(0.33,0.00)	(0.51,0.28)	(0.50,0.41)	(0.58,0.42)
A_5	(0.68,0.25)	(0.69,0.24)	(0.70,0.25)	(0.68,0.26)	(0.57,0.10)	(0.51,0.43)	(0.53,0.20)	(0.60,0.32)	(0.55,0.45)	(0.63,0.36)	(0.52,0.36)	(0.45,0.17)	(0.44,0.33)	(0.38,0.29)	(0.50,0.29)

然后，根据 DIFWA 算子(6)，将各个时段的群评价信息与指标权重信息集结，得到综合评价的直觉模糊矩阵，如表 6 所示。

表 6 直觉模糊矩阵的综合评价

Tab.6 Comprehensive evaluation of intuitionistic fuzzy decision-making matrix

评价	C_1	C_2	C_3	C_4	C_5
A_1	(0.81,0.05)	(0.76,0.06)	(0.73,0.10)	(0.84,0.05)	(0.81,0.09)
A_2	(0.89,0.06)	(0.88,0.06)	(0.79,0.11)	(0.92,0.00)	(0.78,0.11)
A_3	(0.83,0.05)	(0.82,0.06)	(0.82,0.10)	(0.82,0.06)	(0.81,0.09)
A_4	(0.89,0.05)	(0.87,0.00)	(0.74,0.10)	(0.82,0.10)	(0.78,0.12)
A_5	(0.82,0.10)	(0.84,0.00)	(0.82,0.11)	(0.85,0.09)	(0.82,0.00)

接着，根据步骤 3,4,5 分别定义直觉模糊正理想解 x^+和负理想解 x^-，通过直觉模糊距离测度公式(5)，计算各供应商的群体效益值 S_i 和个体遗憾度 R_i，并依据 VIKOR 决策法的决策准则对备选供应商进行排序，Q_i 值越大，说明方案越差；Q_i 值越小，说明方案更优。结果如表 7 所示。

表 7 待选择供应商的 S_i、R_i 及 Q_i 值

Tab.7 S_i,R_i and Q_i of five suppliers

评价	S_i	R_i	Q_i	Rank
A_1	0.202 7	0.064 5	0.000 0	1
A_2	0.132 3	0.038 6	1.000 0	5
A_3	0.177 4	0.052 4	0.413 9	2
A_4	0.167 4	0.052 2	0.489 5	4
A_5	0.169 7	0.051 6	0.483 2	3

最后,进行最优解的判断,$Q'-Q_{min}=0.4139-0.0000=0.4139\geqslant 1/(m-1)=0.250$,故满足最优解判断标准,$A_1$ 为最优冷链物流供应商。

使用 TOPSIS 方法[16]进行供应商优选,结果与本文一致,即 $A_1>A_3>A_5>A_4>A_2$,从而说明了本文所构建方法的可行性和有效性。此外,在决策专家打分的过程中,若存在多种类型的数据,如实数、区间数及直觉模糊数并存的情况,与 TOPSIS 方法相比,选择 VIKOR 决策方法可以有效降低数据间的不可公度性,提高决策的合理性。

5　结束语

本文基于冷链物流供应商选择的评价指标体系,构建了动态直觉模糊 VIKOR 群决策模型,提出了在时间权重、专家权重及指标权重已知的条件下进行动态直觉模糊多属性群决策的方法和步骤,并通过一个算例证明该方法是有效可行的,为物流供应商选择提供了一种新的思路。本决策方法也可推广到人员动态评价、服务质量动态评价及医疗诊断等领域,具有比较广阔的应用前景和实用价值。

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Research on Cold Chain Logistics Supplier Selection Based on Dynamic Intuitionistic Fuzzy VIKOR Group Decision-making Model

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Abstract: The selection of high quality suppliers for downstream enterprises (customers) in cold chain logistics is a complex dynamic decision process, whose main task is to construct a group decision-making model participated by experts based on dynamic intuitionistic fuzzy theory and multi-criteria compromise algorithm (VIKOR) in multi- periods for finite potential suppliers. This paper firstly introduces the related theory of intuitionistic fuzzy sets, operators and distance measurement formula. Then, it constructs group decision-making model combined with VIKOR decision-making method and designs the decision-making process for the selection of cold chain logistics suppliers. After choosing some indicators such as responsiveness, transportation, customer service level to establish the evaluation indicator system for cold chain logistics supplier selection, it finally presents the decision-making evaluation process for some cold chain logistics supplier with illustrative examples and literature review.

Key words: intuitionistic fuzzy set; VIKOR; cold chain; supplier selection; group decision-making

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