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Transformation and Upgrading of Chemical Enterprise under the Environment of Internet and Big Data

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With the development of our country, especially after the reform and opening-up policy, chemical industry is developed rapidly and thus forms a relative integrated chemical industrial system. Chemical industry as a capital and technology intensive industry has attracted much attention. However, economic crisis in 2008 leads to the decrease of performance of chemical industry. In order to copy with this problem, transformation and upgrading of chemical enterprise is necessary. After analysing the existing studies of transformation and upgrading of Chinese enterprises, we find the first and an important step is to evaluate the efficient of transformation and upgrading of the enterprise. Thus, in this paper, a set called interval-valued intuitionistic fuzzy set is introduced and thus used toconstruct a decision matrix to express the assessments provided by the decision maker. Then, attribtue weights are obtained by using the idea of maximum deviation degree. After that, a weighted averaging operator with consideration ofinterval-valued intuitionistic fuzzy sets is proposed to combine attribute weights with assessments to form collective assessment. Finally, score function is developed to generate evaluation result or compare each alternative.

1. Introduction

Chemical industry is a capital and technology intensive industry. With the development of our country, especially after the reform and opening-up policy, chemical industry is developed rapidly and thus forms a relative integrated chemical industrial system. However, since economic crisis has appeared in 2008, chemical industry undertakes serious influence. On the one hand, the increase of the cost of labour, land and other factors leads to the rapid decrease of the traditional comparative advantage. On the other hand, constrains of the resource and environmental protection are increasing. More importantly, there is excess production capacity in many chemical enterprises. These phenomena provide serious challenge for the existing chemical enterprises. Thus, in order to copy with this challenge, transformation and upgrading of chemical enterprise is necessary.

In general, the concepts of transformation and upgrading are closely related to those of innovation and rebirth. The transformation of an enterprise denotes a big change of operation strategy and organization structure in order to improve performance of the enterprise. The upgrading of an enterprise denotes the improvement and enhancement of operation criteria and production of the enterprise. Innovation is a tool to help enterprise achieve transformation and upgrading in order to obtain rebirth. The purpose of transformation and upgrading is to help the enterprise survival in the competitive market.

Zhao and Xu (2013) provides an investigation of the transformation and upgrading of Chinese enterprises since the international financial crisis. They pointed out that the loss of research input is the best reason to impact on the transformation and upgrading of Chinese enterprises. Zhang and Dong (2012) investigates the transformation and upgrading of medium and small enterprises, Development of small and medium-sized enterprises. Jiang (2014) thinks that industrial transformation and upgrading is a system engineering and is composed of transformation and upgrading of the industrial chain, that of value chain and that of combination of production factors. Liu (2016) analyzed the existing features of the transformation and upgrading of small medium-sized enterprises to develop new strategy the transformation and upgrading of an enterprise. In order to help enterprise complete transformation and upgrading successfully, the first step is to evaluate the efficient of the enterprise.

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There are plent of methods which have been studied to deal with this evaluation problem for example DEA, multiple-attribute decision making method. Now, we focus on the last one. In general, a multiple-attribute decision making method including four steps (Chen 2014; Wei and Wang 2011): (1) construct a decision matrix to express the assessments provided by the decision maker; (2) Calculate attribute weights of all attributes to measure their relative importance; (3) Combine attribute weights with assessments to form collective assessment of each alternative (Dilev and Yager 1998; Olson 2004); (4) Generate the result or compare each enterprise or alternative to obtain the ranking order or the best solution to the evaluation problem.

Tan (2011) developed a TOPSIS based multiple attribute decision making method with consideration of Choquet integral under the interval-valued intuitionistic fuzzy environment. Meng et al., (2013) introduced Shapely function to develop induced generalized operators of aggregating interval-value intuitionistic fuzzy sets. Wan and Dong (2014) proposed a possibility degree based ranking method for comparing interval-value intuitionistic fuzzy sets to handle multiple-attribute decision making problem from the perspectives of probability.

From the above analysis, interval-valued intuitionistic fuzzy set is a hot research topic (Xu and Chen 2007; Wei et al. 2011) and will be introduced in this paper to build a decision matrix to express the assessments provided by the decision maker which is the first step in the multiple attribute decision making method. Then, attribute weights are obtained by using the idea of maximum deviation degree. After that, a weighted averaging operator of interval-valued intuitionistic fuzzy sets is proposed to combine attribute weights with assessments to form collective assessment. Finally, score function and corresponding accuracy function is developed to generate evaluation result or compare each alternative.

The construction of the contents is shown in the following. Section 2 provides the process of evaluation of transformation efficient of chemical enterprises including concepts of interval-valued intuitionistic fuzzy sets, the generation of attribute weights and corresponding operators. Section 3 demonstrates a case study by the evaluation transformation method. Section 4 concludes the whole paper.

2. Process of evaluating transformation efficient

In order to help a chemical enterprise transform into a new chemical enterprise successfully, an intuitionistic fuzzy evaluation method is developed to study transformation efficient of a chemical enterprise in the process of transformation and upgrading.

2.1 Type font and type size

First of all, a concept of INF set is introduced in the following.

Definition 1. Given a universe of discourse denoted by Z = {Z_1, Z_2, ..., Z_n}, INF set can be defined as.

$$INF=\left\{\left\langle z,p_I(z),q_I(z)\right\rangle\middle|z\in Z\right\} \tag{1}$$

where p $p_I(z)\to[0,1]$ and $q_I(z)\to[0,1]$ denote some membership degrees and possible non-membership degrees which satisfy that $0\le p_I(z)+q_I(z)\le 1$. In particular,

$$\pi_I(z)=1-p_I(z)-q_I(z),\forall z\in Z \tag{2}$$

It represents the uncertain degree of INF number *a* to A.

Definition 2. Suppose Z = {Z_1, Z_2, ..., Z_n} denotes a universe of discourse, an interval-valued INF set can be defined as

$$IVINF=\left\{\left\langle z,\tilde{p}_I(z),\tilde{q}_I(z)\right\rangle\middle|z\in Z\right\} \tag{3}$$

where $\tilde{p}_I(z)\to[0,1],\tilde{q}_I(z)\to[0,1]$ denote interval-valued possible membership degree and interval-valued non-membership degree which satisfy that $0\le\sup(\tilde{p}_I(z))+\sup(\tilde{q}_I(z))\le 1$. Here, an interval-valued INF set can be rewritten as

$$IVINF=\left\{\left\langle a,[p_{IL}(z),p_{IU}(z)],[q_{IL}(z),q_{IU}(z)]\right\rangle\middle|z\in Z\right\} \tag{4}$$

where

$$\tilde{\pi}_I(z)=1-\tilde{p}_I(z)-\tilde{q}_I(z)=[1-p_{IL}(z)-p_{IU}(z),1-q_{IL}(z)-q_{IU}(z)] \tag{5}$$

In order to aggregate interval-valued INF information in evaluation problem, the important step is to develop the operational law of interval-valued INF set.

Definition 3. Let *M* and *N* denote two interval-valued INF sets, the operations of interval-valued INF sets *M* and *N* can be obtained in the following.

(1) $M \cap N =$

$$\{\left[\min\left(p_{MIL}(z), p_{NIL}(z)\right), \min\left(p_{MIU}(z), p_{NIU}(z)\right)\right], \left[\max\left(q_{MIL}(z), q_{NIL}(z)\right), \max\left(q_{MIU}(z), q_{NIU}(z)\right)\right]\};$$

(2) $M \cup N =$

$$\{\left[\max\left(p_{MIL}(z), p_{NIL}(z)\right), \max\left(p_{MIU}(z), p_{NIU}(z)\right)\right], \left[\min\left(q_{MIL}(z), q_{NIL}(z)\right), \min\left(q_{MIU}(z), q_{NIU}(z)\right)\right]\}$$

(3) $M \oplus N = \{\left[p_{MIL}(z) + p_{NIL}(z) - p_{MIL}(z) \times p_{NIL}(z), p_{MIU}(z) + p_{NIU}(z) - p_{MIU}(z) \times p_{NIU}(z)\right],$

$$\left[q_{MIL}(z) \times q_{NIL}(z), q_{MIU}(z) \times q_{NIU}(z)\right]\}$$

(4) $M \otimes N = \{\left[p_{MIL}(z) \times p_{NIL}(z), p_{MIU}(z) \times p_{NIU}(z)\right],$

$$\left[q_{MIL}(z) + q_{NIL}(z) - q_{MIL}(z) \times q_{NIL}(z), q_{MIU}(z) + q_{NIU}(z) - q_{MIU}(z) \times q_{NIU}(z)\right]\};$$

(5) $\lambda M = \{\left[1 - (1 - p_{MIL}(z))^{\lambda}, 1 - (1 - p_{MIU}(z))^{\lambda}\right], \left[(q_{MIL}(z))^{\lambda}, (q_{MIU}(z))^{\lambda}\right]\};$

(6) $M^{\lambda} = \{\left[(p_{MIL}(z))^{\lambda}, (p_{MIU}(z))^{\lambda}\right], \left[1 - (1 - q_{MIL}(z))^{\lambda}, 1 - (1 - q_{MIU}(z))^{\lambda}\right]\}.$

2.2 Attribute weights

The weights of attributes means the relative importance of an attributes compared with other attributes (Chen and Li 2011). It is necessary to be considered in the process of aggregating assessments on each attribute. Up to present, there are so many ways to determine attribute weights involving subjective methods and objective methods (Shirland et al., 2003). For example, point allocation, regression analysis, analytic hierarchy process and direct rating. In general, subjective method to obtain weights reflects the judgements provided by the decision maker or attitude and intuition of the decision maker. Differently, another way called objective weights is generated by assessments or decision information in the decision matrix unrelated to the attitude or intuition of the decision maker such as entropy method or the critic method.

First of all, given M enterprises and N attributes, the deviation between different alternatives on each attributes can be obtained as,

$$DIS(a_i) = \frac{1}{(M_{num} - 1) \times (M_{num} - 1)} \sum_{j=1, j \neq k}^{Mnum} \sum_{k=1, j \neq k}^{Mnum} Dis(ent_j, ent_k) \tag{6}$$

where

$Dis(ent_j, ent_k) =$

$$\frac{1}{4}\left|p_{IL}(ent_j) - p_{IL}(ent_k)\right| + \left|p_{IU}(ent_j) - p_{IU}(ent_k)\right| + \left|q_{IL}(ent_j) - q_{IL}(ent_k)\right| + \left|q_{IU}(ent_j) - q_{IU}(ent_k)\right| \tag{7}$$

Then, attribute weight can be generated by

$$W(a_i) = \frac{DIS(z_i)}{\sum_{i=1}^{N} DIS(z_i)} \tag{8}$$

From the above equation, when deviation is bigger on an attribute, it will be given more weights. This idea accords with the maximum deviation method.

2.3 Aggregation operators

Aggregation operators are usual way to aggregate decision information in the decision matrix. Then, the aggregation operator of interval-valued INF information is introduced in this section to aggregate decision information.

Definition 4. Let $Z_j = \{[p_{IL}(z_j), p_{IU}(z_j)], [q_{IL}(z_j), q_{IU}(z_j)]\}$ (*j*=1, ..., N_{num}) denotes a set of interval-valued INF numbers and W_j denotes relative weight of an attribute satisfying $W_j \in [0,1]$ and $\sum_{j=1}^{N_{num}} W_j = 1$. Then, a weighted operator of interval-valued intuitionistic fuzzy set can be defined as follows

$$IVIFA(Z_1, Z_2, ..., Z_N) = \sum_{j=1}^{N_{num}} W_i Z_j$$
$$= \left(\left[1-\prod_{j=1}^{N_{num}}\left(1-p_{IL}\left(Z_j\right)\right)^{W_j}, 1-\prod_{j=1}^{Nnum}\left(1-p_{IU}\left(Z_j\right)\right)^{W_j}\right], \left[\prod_{j=1}^{Nnum}\left(q_{IL}\left(Z_j\right)\right)^{W_j}, \prod_{j=1}^{Nnum}\left(q_{IU}\left(Z_j\right)\right)^{W_j}\right]\right) \quad (9)$$

In particular, when $W = (1/N, 1/N, ..., 1/N)^T$, the above operator could reduce to

$$IVIFA(Z_1, Z_2, ..., Z_N) = \sum_{j=1}^{N_{num}} W_i Z_j$$
$$= \left(\left[1-\prod_{j=1}^{Nnum}\left(1-p_{IL}\left(Z_j\right)\right)^{1/N}, 1-\prod_{j=1}^{Nnum}\left(1-p_{IU}\left(Z_j\right)\right)^{1/N}\right], \left[\prod_{j=1}^{Nnum}\left(q_{IL}\left(Z_j\right)\right)^{1/N}, \prod_{j=1}^{Nnum}\left(q_{IU}\left(Z_j\right)\right)^{1/N}\right]\right) \quad (10)$$

2.4 Comparison and ranking order

For two interval-valued INF sets, it is difficult for the decision maker to directly compare these sets. In order to address this problem, score value and accuracy value of interval-valued INF sets is introduced in this subsection.

Definition 5. Given two interval-valued INF sets

$Z_1 = \{[p_{IL}(Z_1), P_{IU}(Z_1)], [q_{IL}(Z_1), q_{IU}(Z_1)]\}$ and $Z_2 = \{[p_{IL}(Z_2), P_{IU}(Z_2)], [q_{IL}(Z_2), q_{IU}(Z_2)]\}$, score values *SV*($A_1$) and *SV*($A_1$) can be obtained and accuracy value *AV*(A_1) and *AV*(A_1) can be further obtained as

(1) If *SV*(A_1) >*SV*(A_1), two interval-valued INF set A_1will be bigger than A_2.

(2) If *SV*(A_1) =*SV*(A_1),

1) If *AV*(A_1) >*AV*(A_1), two interval-valued INF set A_1will be bigger than A_2.

2) If *AV*(A_1) =*AV*(A_1), two interval-valued INFA_1will be equal to A_2.

2.5 Process of the problem

Firstly, we should develop the decision making matrix $\mathrm{DEC} = [A_{ij}]_{M\times N}$. Hereinto, all the assessments $A_{ij}(i = 1,2,\cdots,M_{num}; j = 1,2,\cdots,N_{num})$ are interval-valued INF numbers provided by the decision maker. The decision maker is invited to provide or express his/her evaluations, preferences or judgements based on each attribute $ATT_j(j = 1,2,\cdots,N)$ by an interval-valued INF assessment $A_{ij} = \{[p_{IL}(A_{ij}), p_{IU}(A_{ij})], [q_{IL}(A_{ij}), q_{IU}(A_{ij})]\}$, Then a decision making matrix is generated as follow:

$$Dec = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1N} \\ A_{21} & A_{22} & \cdots & A_{2N} \\ \vdots & \vdots & \ddots & \vdots \\ A_{M1} & \cdots & \cdots & A_{MN} \end{pmatrix}$$

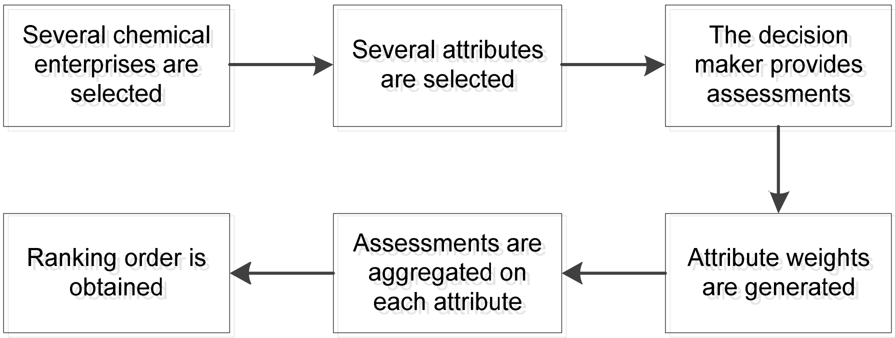

Figure 1: The process of evaluating transformation efficient

3. Case study

In this subsection, we applied the proposed process to evaluate the transformation efficient of some chemical enterprises to help them improve their transformation and upgrading.

3.1 Explanation of transformation and upgrading

Transformation and upgrading is a continue process including some stages such as automation, enhancement and redefinition. Different stage may face different challenges. Many researchers summarized the important factors that may influence the transformation and upgrading of an enterprise including the leadership of the leaders, vision communication, enterprise scale, social network, human resource condition, competitive situation and so on. In particular, with the development of big data and internet, information technology and the modern competition bring new chance and challenge for the chemical enterprises. How to catch this chance and deal with this challenge is very important for the transformation and upgrading of chemical enterprises. In this paper, we attempt to find a new way to help chemical enterprise realize their transformation efficient in order to improve their performance by an evaluation method.

3.2 The result of this evaluation problem

Firstly, according to the above relationship, the decision maker provides assessments of the given three enterprises on five attributes as illustrated in Table 1.

Table 1: Value assessments of the decision maker

p,*q**10	1	2	3	4	5
Enterprise 1	{[2, 3], [4, 6]}	{[5, 6], [2, 3]}	{[6, 7], [1, 2]}	{[4, 5], [3, 4]}	{[5, 6], [2, 3]}
Enterprise 2	{[4, 5], [3, 4]}	{[7, 8], [1, 2]}	{[5, 6], [2, 3]}	{[8, 9], [0, 1]}	{[5, 7], [1, 2]}
Enterprise 3	{[4, 5], [2, 3]}	{[2, 3], [6, 7]}	{[1, 2], [7, 8]}	{[3, 4], [5, 6]}	{[3, 5], [4, 5]}
Enterprise 4	{[1, 2], [4, 5]}	{[6, 7], [1, 2]}	{[4, 5], [4, 5]}	{[2, 3], [1, 4]}	{[4, 5], [3, 4]}

After that, weighted operator of interval-valued INF sets developed in Eq. (9) could be introduced to obtain the final result: $A_2 \succ A_1 \succ A_4 \succ A_3$.

4. Conclusions

With the development of big data and internet, information technology and the modern competition bring new chance and challenge for the chemical enterprises. How to catch this chance and deal with this challenge is very important for the development of chemical enterprises. Chemical industry as a capital and technology intensive industry has attracted much attention. However, economic crisis in 2008 leads to the decrease of performance of chemical industry. In order to copy with this problem, transformation and upgrading of chemical enterprise is necessary. After analysing the existing studies of transformation and upgrading of Chinese enterprises, we find the first and an important step is to evaluate the efficient of transformation and upgrading of the enterprise. Thus, in this paper, interval-valued INF set is introduced to construct a decision matrix to express the assessments provided by the decision maker. Then, attribtue weights are obtained by using the idea of maximum deviation degree. After that, a weighted averaging operator of interval-valued INF sets is proposed to combine attribute weights with assessments to form collective assessment. Finally, score function is developed to generate the evaluation result or compare each alternative.

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References

Chen T.Y, Li C.H, 2011, Objective weights with intuitionistic fuzzy entropy measures and computational experiment analysis, Applied Soft Computing, 11, 5411-5423.

Chen T.Y, 2014, Interval-valued intuitionistic fuzzy QUALFLEX method with a likelihood-based comparison approach for multiple criteria decision analysis, Information Sciences, 261, 149-169.

Filev D, Yager R.R, 1998, On the issue of obtaining OWA operator weights, Fuzzy set and Systems, 94m 157-169.

Jiang X.M, 2014, The path of the transformation and upgrading of industry, Development of economic problems, 12, 43-49.

Liu J.H, 2016, A study of transformation and upgrading strtegies for L company, Guangdong University of Foreign Studies.

Meng F.Y, Tang C.Q, Zhang Q, 2013, The induced generalizd interval-valued intuitionistic fuzzy hybrid Shapley averging operator and its application in decision making, Knowledge-based systems, 42, 9-19.

Olson D.L, 2004, Comparison of weights in TOPSIS models, Mathematical and Computer Modelling, 40, 721-724.

Shirland L.E, Jesse R.R, Thompson R.L, Lacovou C.L, 2003, Determining attribute weights using mathematical programming, Omega, 31, 423-437.

Tan C.Q, 2011, A multi-criteria interval-valued intuitionistic fuzzy group decision making with Choquet integral-based TOPSIS, Expert Systems with Applications, 38, 3023-3033.

Wan S.P, Dong J.Y, 2014, A possibility degree method for interval-valued intuitionistic fuzzy multi-attribute group decision making, Journal of Computer and System Sciences, 80, 237-256.

Wei C.P, Wang P, Zhang Y.Z, 2011, Entropy similarity measure of interval-valued intuitionistic fuzzy sets and their applications, Information Sciences, 181, 4273-4286.

Wei G.W, Wang H.J, Lin R, 2011, Application of correlation coefficient to interval-valued intuitionistic fuzzy multiple attribute decision-making with incomplete weight information, Knowledge Information Systems, 26, 337-349.

Xu Z.S, Chen J, 2007, Approach to group decision making based on interval-valued intuitionistic judgment matrices, Systems Engineering-Theory & Practice, 27(4), 126-133.

Zhao C.W, Xu Z.Y, 2013, Investigation of the transformation and upgrading of Chinese enterprises since the international financial crisis, Management World, 4, 8-15.

Zhang J, Dong J, 2012, Investigation of the transformation and upgrading of medium and small enterprises, Development of small and medium-sized enterprises, 3, 28-31.