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A quantitative evaluating method of the effectiveness of hi-tech industrial cluster policies based on the fuzzy QFD

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ABSTRACT

Based on fuzzy Quality Function Deployment (QFD), an evaluating method of the effectiveness of hi-tech industry cluster policies is proposed in this paper. Firstly, the evaluating system of the effectiveness is constructed according to the evaluation criteria and indexes. The evaluating base of hi-tech industry cluster policies is based on the linguistic variables and triangular fuzzy numbers (TFNs). Secondly, the expert authority degree is obtained by the expert's judgment and expert's familiarity of the cluster policies. Then by introducing expert authority degree with fuzzy expected value operator, the fuzzy weighted average method is proposed to determine and rank the weights of evaluation indexes of cluster policies. Finally, the weights of evaluation indexes are utilized to calculate the comprehensive evaluation value. The empirical study of Shanghai integrate circuit (IC) industry cluster policies is given to demonstrate the feasibility and practicability of the proposed method.

KEYWORDS

Hi-tech industry cluster; Evaluating method of cluster policies; Expert authority degree; Fuzzy QFD.

INTRODUCTION

Technological innovations and business environments are changing rapidly nowadays[1] and with the continuous spill-over effect of the hi-tech industry cluster[2], each country is increasingly taking hi-tech industry clusters seriously. The government policies can't be ignored in the guidance and support role in the economic development all along. Nowadays, the hi-tech industry clusters are becoming more and more important. The government has infiltrated more and more into the intervention behavior in the development process of the cluster. And the government has exerted profound influence on the development of cluster. Galbraith et al. concluded that local cluster policies would affect the competition strategies of small and middle enterprises (SMEs)[3]. Different high-tech industrial cluster policies have different effects on cluster growth. Inappropriate policies intervention can hinder the development of the cluster. Therefore, the evaluation of the effectiveness of the cluster policies is necessary to improve the actual utility of cluster policies[4]. In another words, establishing an effective evaluation system is the key for the cluster policies.

It is well know that there are huge literatures reported on industrial clusters, industrial policies. But there are few literatures on the cluster policies. The literatures on the evaluation of the effectiveness of cluster policies are particular emphasis on qualitative analysis and empirical research, but much less on the quantitative analysis.

QFD (Quality Function Deployment) engineering technique is one of the typically deployed to achieve the target cost reduction objectives[5]. And QFD is also an analysis tool that could translate customer requirements (CR) into the technical attributes (TA) of a product. The existing studies have shown that QFD can used to analyze policy of the effectiveness evaluation for government behavior, but there are very few relatively researches. For example, Yu, Chang-His et al. developed a revised QFD technique to meet the needs of multiple-customer groups in public policy analysis[6]. Hong and Chung studied the user-oriented service and policy innovation by the QFD and Kano's model[7].

As we know, the framework of MCDM model provides an effective way for the evaluation with multiple attributes[8]. Due to the functions of cluster policies and the evaluation indexes in the decision making process, the effectiveness evaluation of hi-tech industrial cluster policies can be considered as a complex multi-criteria decision-making (MCDM). We introduce the approach of QFD to judge hi-tech industrial cluster policies as a "product". The functions of the "product"(F) are denoted as Customer Requirements (CR) of cluster policies, and the evaluation indexes of the "product" (I) are denoted as Technical Attributes (TA). At the same time, the effectiveness evaluation of hi-tech industrial cluster policies is also a group decision-making, as it requires multiple experts to participate in the evaluating process. In addition, the importance of the functions and the relevancy between the functions and the evaluation indexes are difficult to express in some certain numbers, so it is suitable to depict them by fuzzy numbers. Based on the fuzzy QFD integration of fuzzy thought and QFD method, the effectiveness evaluating method of hi-tech industrial cluster policies in the context would provide scientific decision basis for hi-tech industrial cluster development.

The remaining parts of this paper are organized as follows. Section 2 presents a brief description of the effectiveness evaluating system. Section 3 constructs the effectiveness evaluating method of cluster policies. Section 4 analyzes Shanghai integrated circuit industry cluster by using the proposed method empirically. Section 5 presents conclusions.

THE CONSTRUCTION OF EVALUATING SYSTEM OF THE EFFECTIVENESS

The evaluation criteria

The evaluation of cluster policies aims to evaluate the cluster policies for the realization of various functions. There are four major functions for the hi-tech industry cluster concluded by relative papers[9-12]. They are 'solving market failure', 'neutralizing system failure', 'completing dynamic mechanism' and 'improving cluster environment', respectively. Therefore, these four functions of cluster policies are set as evaluation criteria.

The evaluation indexes

According to the cluster policies as the government behaviours and the functions of cluster policies and *The Cluster Polices White book*[10], the effectiveness evaluation in hi-tech industry cluster can be classified into five indexes. Details are illustrated in TABLE 1.

TABLE 1: The effectiveness evaluation indexes of cluster policies

Indexes	Definition
Initiating Dialogues and Cooperation	Evaluating the role of cluster policies in enhancing dialogue and cooperation among various stakeholders in the cluster
expanding demand	Evaluating the role of cluster policies in expanding target market and developing supply chain
Providing Intellectual Guarantee	Evaluating the role of cluster policies in infusing talents, providing skill training service, and promoting the formation of cluster knowledge network
Prompting International Connections	Evaluating the role of cluster policies in elimination of trade barriers, enhancing transportation and communication ability, and stimulating the mobility of international capital and technology.
Improving Cluster Framework	Evaluating the role of cluster policies in optimizing cluster development, completing technological infrastructure and market environment

The evaluation base with triangular fuzzy numbers

The fuzzy set theory has the capability to deal with subjectivity and uncertainty existing in human preference[13]. Therefore, it is suitable to depict the weight of criteria and the relative importance between evaluation criteria and the evaluation indexes with fuzzy numbers. So, the linguistic variables for weighting criteria with the triangular fuzzy numbers (TFNs) are given in TABLE 2. Similarly, the linguistic variables for the relative importance between the functions of clusters (evaluation criteria) and the evaluation indexes with TFNs are given in TABLE 3.

TABLE 2: Linguistic variables for rating criteria importance

Variable	Symbol	Fuzzy Scale
Very important	VI	(0.8, 1, 1)
important	I	(0.6, 0.8, 1)
Moderately important	MI	(0.5, 0.65, 0.8)
slightly important	SI	(0.3, 0.5, 0.7)
slightly unimportant	SU	(0.2, 0.35, 0.5)
unimportant	U	(0, 0.2, 0.4)
Very unimportant	VU	(0, 0, 0.2)

TABLE 3: Linguistic variables for the relative importance between the *CRi* and the *TAj*

Variable	Symbol	Fuzzy Scale
Outstanding	O	(0.7, 1, 1)
Good	G	(0.5, 0.75, 1)
Moderate	M	(0.3, 0.5, 0.7)
Poor	P	(0, 0.25, 0.5)
Negligible	N	(0, 0, 0.3)

Construction of HoQ

QFD also knows as the " house of quality"(HoQ), originated in 1972 at Mitsubishi's Kobe shipyard site[14]. The HoQ of the evaluation system in the paper is shown in Figure 1: the left wall expresses customer requirements which are denoted as the functions of clusters. Ceiling expresses technical attributes which are denoted as the effectiveness evaluation indexes of cluster policies. Room expresses the relationship matrix which is the core of the HoQ, and it describes the relationship between the functions of clusters and the evaluation indexes. Roof expresses technical inter-relationships which represents the inter-relationship of evaluation indexes. The right wall expresses the effectiveness evaluation of cluster policies. The floor expresses the actual score of the evaluation indexes which is the output of the HoQ (Figure 1). The crucial step in the implementation of QFD is to derive the ranking of the technical attributes from input variables. When the input variables cannot be measured with ordinary number, the fuzzy numbers is the best way to descried them.

However, the endogenous fuzziness of fuzzy QFD challenges the effective calculation and ranking the importance of technical attributes. In this paper, the importance of evaluation indexes are ranked by adopting an integrated method which is based on fuzzy weighted average method[15] and fuzzy expected value operator[16] put forward by Yizeng Chen et.al[17]. With the aid of questionnaire results, the importance of effectiveness evaluation indexes of cluster policies is calculated through introducing expert authority degree (C_k) and using the fuzzy weight average method and the fuzzy expected value operator. The steps of this method are proposed in Section 3.

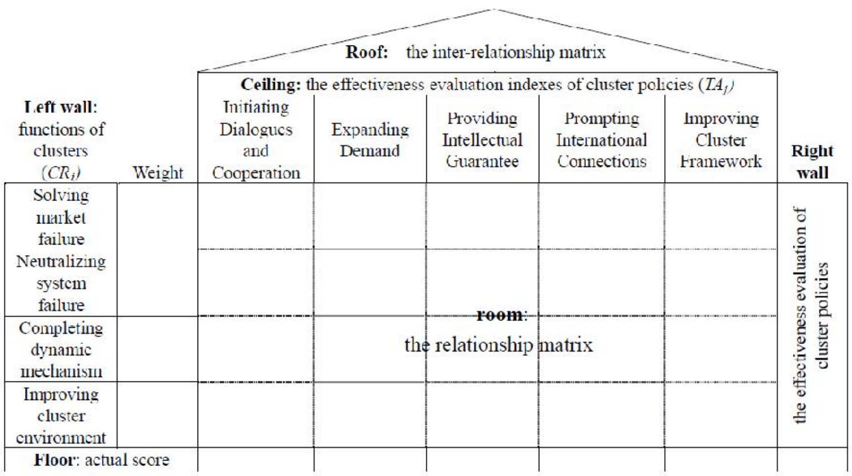

Figure 1: The HoQ of the effectiveness evaluating system for cluster policies

THE QUANTITATIVE EVALUATING METHOD OF THE EFFECTIVENESS

The expert authority degree C_k

Each expert has a degree of authority C_k according to his/her differences in judgment and familiarity level with the cluster government behavior and cluster policies. The expert authority degree C_k is shown in Equation (1).

$$C_k = (C_{ak} + C_{sk})/2 \quad \textbf{(1)}$$

where C_{ak} represents the kth expert's judgment in accordance with four aspects including 'theoretical analysis', 'practical experience', 'understanding of relevant research at home and abroad', 'intuition'. These four aspects use a scale with the values 0.3, 0.3, 0.3, 0.1 respectively. Each expert provides the judgment values according to these four aspects respectively. C_{ak} is the sum of the four judgment values. The degree of expert' s familiar level with the research object is divided into six different levels including 'Not familiar', 'A little familiar', 'Moderate', 'familiar', 'Fairly familiar', 'Very familiar'. These six different levels use a scale with the values 0, 0.2, 0.4, 0.6, 0.8, 0.1 respectively. Each expert provides the familiar level C_{sk} according to their own familiarity with the cluster government behavior and cluster policies.

Obviously, the expert authority degree is higher when the value of C_k is larger. And the corresponding data has more reference value. So the weight of C_k should be higher. C_k can avoid the deviation of results effectively. The deviation is caused by the inconsistency of expert understanding same problem.

Data acquisition and synthesis

Questionnaire survey helps to obtain the fuzzy preference degree of experts on the functions of cluster policies and the fuzzy relationship between functions of cluster policies with evaluation indexes. CR_i denotes the fuzzy preference degree of experts. p represents the development stage of cluster including sprout stage, agglomeration forming stage, cluster developing stage, or cluster expanding stage. The relative weight of cluster functions $CR_i$is denoted by $\widetilde{W}_{ip}$. The fuzzy relationship degree between $CR_i$and TA_j is denoted by $\widetilde{D}_{ijp}$. The expert k on the fuzzy preference degree of $CR_i$is denoted by $\widetilde{W}_{ip}^{k}$. The expert k on the fuzzy relationship degree between CR_i and $TA_j$of is denoted by $\widetilde{D}_{ijp}^{k}$. Then expert opinions can be calculated by Equation (2).

$$\widetilde{W}_{ip} = \frac{\sum_{k=1}^{n} c_k \widetilde{W}_{ip}^{k}}{\sum_{k=1}^{n} c_k}, \widetilde{D}_{ijp} = \frac{\sum_{k=1}^{n} c_k \widetilde{D}_{ijp}^{k}}{\sum_{k=1}^{n} c_k} \quad \textbf{(2)}$$

where i indicates functions, j indicates indexes. $\widetilde{W}_{ip}^{k}$ and $\widetilde{D}_{ijp}^{k}$are the pre-defined TFNs (for *i*=1,2,3,4; *j*=1,2,..,5; *p*=1,2,..,5) shown in TABLES 2 and 3. n is the number of experts. It is worth to note that the relative weight of each CR_i is different in different stages. But the fuzzy relationship degree $\widetilde{D}_{ijp}^{k}$ is consistent in different stages.

Calculation of the fuzzy importance of evaluation indexes

Using the fuzzy weighted average method, the fuzzy importance of effectiveness evaluation indexes of cluster policies at the pth stage can be obtained by following equation.

$$\tilde{Z}_{jp} = \frac{\sum_{i=4}^{4} \widetilde{W}_{ip} \widetilde{D}_{ijp}}{\sum_{i=1}^{4} \widetilde{W}_{ip}} \quad \textbf{(3)}$$

The triangular fuzzy number $\tilde{Z}_{jp}$can't directly rank the importance of evaluation indexes yet. Furthermore, h-cuts weighted fuzzy linear programming method proposed by Kao et.al[15] can solve out the problem. The h-cuts of $\widetilde{W}_{ip}$ is $(W_{ip})_h$. The h-cuts of $\widetilde{D}_{ijp}$ is $(D_{ijp})_h$. $(W_{ip})_h$ and $(D_{ijp})_h$ can be calculated by following equations.

$$\begin{cases} (W_{ip})_h = \left\{ w_{ip} \in W_i | \mu_{\widetilde{W}_{ip}}(w_i) \geq h, 0 \leq h \leq 1 \right\} \\ (D_{ijp})_h = \left\{ d_{ijp} \in D_{ij} | \mu_{\widetilde{D}_{ijp}}(d_{ij}) \geq h, 0 \leq h \leq 1 \right\} \end{cases} \quad \textbf{(4)}$$

The upper bond of the *h*-cut of $\tilde{Z}_{jp}$is $(\tilde{Z}_{jp})_h^U$. $(\tilde{Z}_{jp})_h^U$can be obtained by the following non-linear programming (5).

$$(Z_{jp})_h^U = max \frac{\sum_{i=1}^{4} w_{ip} d_{ijp}}{\sum_{i=1}^{4} w_{ip}}$$

$$s.t. \begin{cases} (W_{ip})_h^L \leq w_{ip} \leq (W_{ip})_h^U \\ (D_{ijp})_h^L \leq d_{ijp} \leq (D_{ijp})_h^U \\ w_{ip}, d_{ijp} \geq 0 \\ i=1,2,...4; j=1,2,...,5; p=1,2,...5 \end{cases} \quad \textbf{(5)}$$

The lower bond of the *h*-cut of $\tilde{Z}_{jp}$ is $(\tilde{Z}_{jp})_h^L$. $(\tilde{Z}_{jp})_h^L$ can be obtained by the following non-linear programming (6).

$$(Z_{jp})_h^L = min\frac{\sum_{i=1}^{4} w_{ip}d_{ijp}}{\sum_{i=1}^{4} w_{ip}}$$
$$s.t.\begin{cases}(W_{ip})_h^L \le w_{ip} \le (W_{ip})_h^U\\(D_{ijp})_h^L \le d_{ijp} \le (D_{ijp})_h^U\\w_{ip}, d_{ijp} \ge 0\\i=1,2,\ldots 4; j=1,2,\ldots,5; p=1,2,\ldots 5\end{cases} \quad (6)$$

The denominators of the objective functions of (5) and (6) are nonnegative. Supposing $t = \frac{1}{\sum_{i=1}^{4} w_{ip}}$, $v_{ip} = tw_{ip}$, so the non-linear programming can be transformed into two separate linear programming, i.e. (7) and (8).

$$(Z_{jp})_h^U = max\sum_{i=4}^{4} v_{ip}(D_{ijp})_h^U$$
$$s.t.\begin{cases}t(W_{ip})_h^L \le v_{ip} \le t(W_{ip})_h^U\\\sum_{i=1}^{4} v_{ip} = 1\\t, v_{ip} \ge 0\\i=1,2,\ldots 4; p=1,2,\ldots 5\end{cases} \quad (7)$$

$$(Z_{jp})_h^L = min\sum_{i=4}^{4} v_{ip}(D_{ijp})_h^L$$
$$s.t.\begin{cases}t(W_{ip})_h^L \le v_{ip} \le t(W_{ip})_h^U\\\sum_{i=1}^{4} v_{ip} = 1\\t, v_{ip} \ge 0\\i=1,2,\ldots 4; p=1,2,\ldots 5\end{cases} \quad (8)$$

The crisp interval $[(Z_{jp})_h^L, (Z_{jp})_h^U]$of h-level set can be obtained by solving the linear programming (7) and (8). Unfortunately, it is impossible to gain the analytical solution for the most cases. So the numerical solutions for $(Z_{jp})_h^U$and$(Z_{jp})_h^L$ at different possibility level h can be obtained approximately by the shapes of $R(Z_{ip})$ and $L(Z_{ip})$. If $(Z_{jp})_h^U$ and $(Z_{jp})_h^L$ are invertible with respect to h, then a right shape function$(Z_{jp})_h^U$and a left shape function $(Z_{jp})_h^L$ can be obtained. The clear membership function $\mu_{\tilde{Z}_{jp}}(Z_{jp})$ can be constructed by following equation.

$$\mu_{\tilde{Z}_{jp}}(z_{jp}) = \begin{cases}L(z_{jp}),\ (Z_{jp})_{h=0}^L \le z_{jp} \le (Z_{jp})_{h=1}^L\\1,\ (Z_{jp})_{h=1}^L \le y_{jp} \le (Z_{jp})_{h=1}^U\\R(z_{jp}),\ (Z_{jp})_{h=1}^U \le z_{jp} \le (Z_{jp})_{h=0}^U\\j = 1,2, \ldots 5; p = 1,2, \ldots 5\end{cases} \quad (9)$$

Ranking the fuzzy importance of evaluation indexes

Based on the average level set defuzzification method, the fuzzy expected value operator of effectiveness evaluation indexes of cluster policies at the stage p $(E(\tilde{Z}_{jp}))$ can be obtained by following equation.

$$E(\tilde{Z}_{jp}) = \frac{1}{2S}\sum_{l=1}^{S}[(Z_{jp})_{h_l}^U + (Z_{jp})_{h_l}^L] \quad (10)$$

Where $(Z_{jp})_{h_l}^U$ and $(Z_{jp})_{h_l}^L$ are, respectively, the h_l-optimistic value and h_l-pessimistic value of $\tilde{Z}_{jp}$, h_l denotes different level set and $0 = h_1 < \cdots < h_l < \cdots < h_S = 1$, see Figure 2. The fuzzy expected value operator $E(\tilde{Z}_{jp})$is the importance of effectiveness evaluation indexes of cluster policies at the stage p. $E(\tilde{Z}_{jp})$ can determine and rank the index weight of each evaluation index. The above computational process will be realized by MATLAB programming.

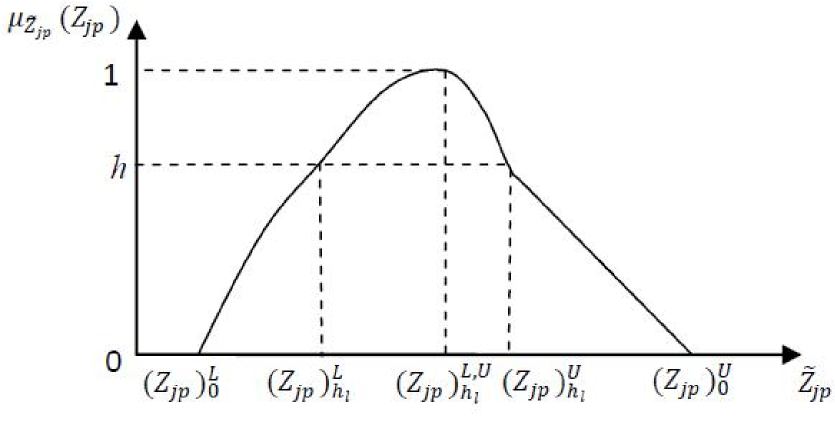

Figure 2: h_l-Pessimistic value and h_l-optimistic value of $\tilde{Z}_{jp}$

The comprehensive evaluation value of cluster policies

Before the calculation of the comprehensive evaluation value, we should make clear clusters' development stage. The index weight w_{jp}at the stage p is determined by equation $E(\tilde{Z}_{jp}) = w_{jp}$. The practical effect of each cluster policy given by the experts is denoted by 5-point Scale. The linguistic variables for the practical effect form low to high are very ineffective, ineffective, uncertain, effective, very effective. The corresponding scale is 1,2,3,4,5.

$$x_{jp} = \frac{\sum_{k=1}^{n} c_k x_{jp}^k}{\sum_{k=1}^{n} c_k} \quad \textbf{(11)}$$

Where $x_{jp}(j = 1,2,...5)$ is the practical effect of cluster policy j (the evaluation index j) at the stage p. $x_{jp}^k$is the practical effect of cluster policy j given by the expert $k. C_k$is the degree of expert authority. n indicates the number of experts. Finally, the practical effect of cluster policies at the stage p can be calculated by Equation (12). The comprehensive evaluating value of the effectiveness is the practical effect of cluster policies at the stage.

$$x_p = \frac{\sum_{j=1}^{5} x_{jp} w_{jp}}{\sum_{j=1}^{5} w_{jp}} \quad \textbf{(12)}$$

EMPIRICAL ANALYSIS OF IC INDUSTRY CLUSTER OF SHANGHAI

In this section, IC (integrate circuit) industry cluster of Shanghai city in China is considered as a practical example to apply the proposed method. Shanghai IC industry cluster is currently at the stage of cluster expanding $(p = 3)$.

The expert authority degree C_k of IC industry cluster of Shanghai city

Eight experts from research institutes of universities, development research centre of Shanghai government and relevant consultancies are interviewed to evaluate the cluster policies of Shanghai IC industry cluster. The experts are familiar with Shanghai IC industry cluster. The reliability of The initial data of this empirical study is reliable because of the skillful experts.

It can easy to gain expert authority degree by applying Eq.(1). They are C_1= 0.35, C_2=0.95, C_3=0.45, C_4=0.4, C_5=0.75, C_6=0.85, C_7=0.55, C_8=0.5, respectively.

Data acquisition and synthesis

As mentioned previously, the fuzzy preference degree between functions of cluster policies is obtained by questionnaire survey. The relative weight of cluster functions ($\widetilde{W}_{ip}$) can be calculated from Eq.(2), $\widetilde{W}_{13} = (0.615,0.815,1.000)$, $\widetilde{W}_{23} = (0.555,0.746,0.883)$, $\widetilde{W}_{33} = (0.574,0.759,0.883)$, $\widetilde{W}_{43} = (0.548,0.742,0.887)$. $\widetilde{D}_{ijp}$ can also be calculated from Eq. (3).

The fuzzy relationship degree between cluster functions (CR_i) and evaluation indexes(TA_j) are illustrated in TABLE 4.

TABLE 4: The fuzzy relationship between cluster functions with evaluation indexes

	CR_1	CR_2	CR_3	CR_4
TA_1	(0.195,0.401,0.658)	(0.550,0.785,0.9688)	(0.391,0.621,0.8229)	(0.437,0.685,0.805)
TA_2	(0.263,0.454,0.698)	(0.191,0.431,0.662)	(0.546,0.790,0.938)	(0.174,0.349,0.594)
TA_3	(0.053,0.117,0.394)	(0.149,0.359,0.610)	(0.617,0.883,0.976)	(0.438,0.679,0.865)
TA_4	(0.052,0.115,0.406)	(0.282,0.448,0.723)	(0.409,0.650,0.799)	(0.381,0.588,0.807)
TA_5	(0.414,0.631,0.841)	(0.529,0.754,0.969)	(0.360,0.572,0.756)	(0.669,0.953,1.000)

Calculation of the fuzzy importance of evaluation indexes of IC industry cluster of Shanghai

According to Eq.(3)-(9), the fuzzy importance of effectiveness evaluation indexes of cluster policies at the expanding stage of Shanghai IC industry can be obtained. The h-optimistic value $\widetilde{TA}_{sup}(h)$ is the supremum value that $\widetilde{TA}$ achieves with a possibility h, while the h-pessimistic value $\widetilde{TA}_{inf}(h)$ is the infimum value that $\widetilde{TA}$ achieves with a possibility h. Details are illustrated in TABLE 5.

TABLE 5: *h*-cuts of fuzzy importance of effectiveness evaluation indexes at different h values

		h										
		0	**0.1**	**0.2**	**0.3**	**0.4**	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**	**1.0**
TA_1	Inf	0.360	0.386	0.412	0.438	0.463	0.489	0.515	0.541	0.567	0.592	0.618
	Sup	0.830	0.808	0.787	0.766	0.745	0.725	0.704	0.682	0.661	0.640	0.618
TA_2	Inf	0.268	0.292	0.315	0.338	0.362	0.386	0.410	0.434	0.458	0.482	0.506
	Sup	0.748	0.724	0.700	0.676	0.652	0.628	0.603	0.580	0.555	0.530	0.506
TA_3	Inf	0.259	0.282	0.305	0.329	0.353	0.377	0.402	0.426	0.452	0.477	0.502
	Sup	0.749	0.726	0.702	0.6774	0.653	0.628	0.604	0.579	0.553	0.528	0.502
TA_4	Inf	0.244	0.263	0.282	0.302	0.321	0.341	0.361	0.382	0.402	0.423	0.443
	Sup	0.706	0.680	0.655	0.629	0.603	0.577	0.550	0.524	0.497	0.470	0.443
TA_5	Inf	0.467	0.493	0.518	0.544	0.569	0.595	0.621	0.646	0.672	0.698	0.725
	Sup	0.910	0.892	0.874	0.856	0.837	0.819	0.800	0.782	0.763	0.744	0.725

Ranking the importance of evaluation indexes of IC industry cluster of Shanghai

According to Eq. (10), the fuzzy expected value operator $E(\check{Z}_{j3})$ can be obtained. The fuzzy expected value operator $E(\tilde{Z}_{j3})$is the importance of effectiveness evaluation indexes of cluster policies at the cluster expanding ($p = 3$).

TABLE 6: Weight and ranking of evaluation indexes

Index (TA_j)	Weight ($E(\check{Z}_{j3})$)	Ranking
Initiating Dialogues and Cooperation (TA_1)	0.607	2
Expanding Demand (TA_2)	0.507	3
Providing Intellectual Guarantee (TA_3)	0.503	4
Prompting International Connections (TA_4)	0.459	5
Improving Cluster Framework (TA_5)	0.707	1

According to the above TABLE 6, the ranking of the evaluation indexes can thus be obtained as: $I_5 \succ I_1 \succ I_2 \succ I_3 \succ I_4$.

The comprehensive evaluation value of IC industry cluster of Shanghai

The index weight w_{jp} at the expanding stage of Shanghai IC industry is acquired by $(\check{Z}_{jp}) = w_{jp}$. Shown TABLE 7 in the comprehensive evaluation score of Shanghai IC industry cluster policies can be obtained by Eq. (11) and (12).

TABLE 7: The comprehensive evaluation of Shanghai IC industry cluster policies

Index (TA_j)	w_{jp}	The practical effect of cluster policy j ($\tilde{x}_{jp}$)
Initiating Dialogues and Cooperation	0.218	3.282
Expanding Demand	0.182	2.458
Providing Intellectual Guarantee	0.181	3.229
Prompting International Connections	0.164	2.635
Improving Cluster Framework	0.254	3.656
comprehensive evaluation score (x_p)	3.108	

According to the TABLE 7, the final evaluation result is 3.108 points. And the effective rate is 62.2%. Hence, the formulation and implementation of cluster policies are in good consistency in IC industry cluster of Shanghai.

CONCLUSIONS

The cluster policies can't be ignored in the guidance and supporting role in the development of hi-tech industry clusters. How to measure the effectiveness of policies is an urgent need for governments. The existing literatures on the evaluation of the effectiveness of the cluster policies only stress on the qualitative research. This paper focuses on quantitative research, which proposes a quantitative evaluating method of the effectiveness of hi-tech industrial cluster policies based on fuzzy QFD. Comparing with the previous literature about cluster policies evaluation, the integrated evaluation methodology in this paper is capable of capturing the evaluators' judgment preference and familiar level with the evaluation object. And it provides a more accurate and systematic evaluation tool. Furthermore, the method is applied in Shanghai IC industry policies. Through the proposed method, it is easy to obtain the effectiveness of industry cluster policies for decision-makers. In the next research, it is important to research the sensitivity with different cluster policies reflect evaluation result. And we think that we can further discuss the feasibility of application in other fields with the proposed method.

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