Supplementary Material 1

1. Analytic hierarchy process method

1.1. Comparative judgment matrix

According to AHP method, the comparative judgment matrix of green innovation risk identification criteria of manufacturing industry under the GVC is constructed as follow:

$$A=\begin{bmatrix} a_{11} & a_{12} & a_{13} & L & a_{1n} \\ a_{21} & a_{22} & a_{23} & L & a_{2n} \\ a_{31} & a_{32} & a_{33} & L & a_{3n} \\ M & M & M & M & M \\ a_{n1} & a_{n2} & a_{n3} & L & a_{nn} \end{bmatrix}=\left\{a_{ij}\right\}$$

where a_{ij} ($a_{ij} > 0$) is the relative importance of row i and column j in the identification criteria system of green innovation risk assessment of manufacturing industry in China under the GVC, and obviously $a_{ii} = 1$ and $a_{ij} = a_{ji}^{-1}$ $\left(i = 1, 2, \cdots, n; j = 1, 2, \cdots, n\right)$. As for the value in the comparison judgment matrix, Saaty1-9 contrast scale is used to measure the significance of the comparison among indicators. Contrast rulers is shown in Table 1.

Table S1. Saaty's contrast ruler.

Contrast scale	Denotation and connotation
1	Identification criterion C_i is of equal importance to identification criterion C_j.
3	Identification criterion C_i is slightly more important than identification criterion C_j.
5	Identification criterion C_i is obviously more important than identification criterion C_j.
7	Identification criterion C_i is more important than identification criterion C_j.
9	Identification criterion C_i is absolutely more important than identification criterion C_j.
2, 4, 6, 8	The result of the comparison of the importance of identification criterion C_i and identification criterion C_j is in the middle position above.
Reciprocal	The result of the importance comparison between identification criterion C_i and identification criterion C_j is the reciprocal of identification criterion C_j and identification criterion C_i.

1.2. Weight set and consistency test

The weight set is calculated through the weight judgment matrix of green innovation risk assessment, and the consistency test is conducted. The specific steps are as follows.

(i) Each row element of the comparison judgment matrix is multiplied separately, and the calculation formula is as follow:

$$M_i = \prod_{j=1}^{n} a_{ij}\ ,\ i = 1, 2, \cdots, n$$

where a_{ij} is the element in row i and column j in the weight comparison judgment matrix of green innovation risk identification criteria.

(ii) Taking the n-TH root of M_i, and the calculation formula is as follow:

$$\overline{W_i} = \sqrt[n]{M_i}, \quad i = 1, 2, \cdots, n$$

(iii) Performing consistency processing on $\overline{W_i}$, and the calculation formula is as follow:

$$w_i = \frac{\overline{W_i}}{\sum_{i=1}^{n} \overline{W_i}}, \quad i = 1, 2, \cdots, n$$

where w_i is the weight of criterion i in the green innovation risk assessment system of manufacturing industry in China under the GVC to the criterion at the next higher level. It is concluded that $W = (w_1, w_2, \cdots, w_n)$ is the relative importance of the next layer to the previous layer.

(iv) Consistency test.

$$\lambda_{\max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i}$$

where $\lambda_{\max}$ is the largest characteristic root of green innovation risk judgment matrix.

$$CI = \frac{(\lambda_{\max} - n)}{(n-1)}$$

where CI is the consistency criterion. Under n certain condition, the greater CI is, the worse the consistency will be; otherwise, the better the consistency will be. Since CI is the error caused by randomness, it should be compared with random consistency criterion RI.

$$CR = \frac{CI}{RI}$$

where CR is the random consistency ratio. RI values are shown in Table 2.

Table S2. *RI* values.

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0.58	0.96	1.12	1.24	1.32	1.41	1.45	1.49

The basis of consistency test is as follows. When $CR<0.1$, the judgment matrix of green innovation risk assessment is consistent. Otherwise, the judgment matrix should be re-adjured.

(v) Combined weights. The combination weight is the importance of the element layer to the target layer, and can be obtained through the weight of the element layer to the criterion layer and the weight of the criterion layer to the target layer. The consistency test steps of combined weights are as follows:

$$CI = \sum_{j=1}^{m} W_j CI_j$$

where W_j is the weight set of the $j-th$ criterion layer in the green innovation risk assessment system of manufacturing industry in China under the GVC. CI_j is the CI of the comparison judgment matrix corresponding to the index of the $j-th$ criterion layer.

$$RI = \sum_{j=1}^{m} W_j RI_j$$

where RI_j is the random consistency criterion corresponding to the $j-th$ criterion layer in the green innovation risk identification system of manufacturing industry in China under GVC. If CR<0.1 is obtained from this equation, it means that the overall identification of green innovation risk is consistent. Otherwise, the judgment matrix should be re-adjured to meet the requirement of CR<0.1.

2. Fuzzy base definition

Definition 1. [1] If $a=(a^L,a^M,a^U)$, where $0<a^L \le a^M \le a^U$, a is called triangular fuzzy numbers (TFNs). a^L and a^U are the lower and upper bounds, whose function can be expressed as:

$$\mu_a(x) = \begin{cases} \dfrac{x-a^L}{a^M-a^L}, a^L \le x \le a^M \\ \dfrac{x-a^U}{a^M-a^U}, a^M \le x \le a^U \\ 0 \quad , \quad else \end{cases}$$

Meanwhile, TFNs a can be represented as Figure 1.

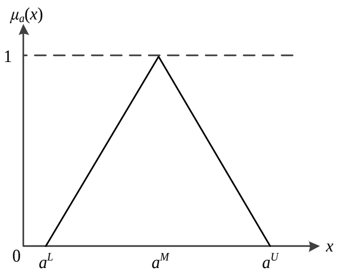

Figure S1. TFNs.

Definition 2. [1] Assuming that there are two TFN $a=\left(a^L,a^M,a^U\right)$ and $b=\left(b^L,b^M,b^U\right)$, the basic algorithm for defining TFNs is as follows:

(i) $a \oplus b = \left(a^L+b^L, a^M+b^M, a^U+b^U\right)$

(ii) $a \otimes b = \left(a^L b^L, a^M b^M, a^U b^U\right)$

(iii) $\forall \lambda \in R, \lambda a = \left(\lambda a^L, \lambda a^M, \lambda a^U\right)$

Definition 3. [2] Each TFN corresponds to a certain value. In this paper, mean area method is adopted for fuzzy resolution. The fuzzy resolution value of TFN is as follows:

$$D(a) = \frac{1}{6}\left(a^L + a^M + a^U\right) \tag{11}$$

3. Deviation maximization method

The idea of deviation maximization is an idea that maximizes the distance between objects as far as possible. Some scholars applied it as an evaluation method in many scientific fields to achieve good evaluation effect. Let $v_{ij}(i = 1,2,\cdots, \ n; \ j = 1,2,\cdots, \ m)$ represents the normalized value of the j criterion of the sub-industry of the i manufacturing industry. Let w_j be the weight of criterion j, and $w_j \geq 0$. $E_{ij}(w)$ represents the total deviation between the sub-industries and the green innovation risk level of manufacturing industry, and can be donated as follows:

$$E_{ij}(w) = \sum_{j=1}^{m}\left|v_{ij}w_j - v_{ik}w_j\right| \tag{12}$$

The green innovation risk identification value of manufacturing industry under the criteria j, which can be expressed as:

$$E_j(w) = \sum_{i=1}^{n} E_{ij}(w) = \sum_{i=1}^{n}\sum_{k=1}^{n}\left|v_{ij} - v_{ik}\right|w_j \tag{13}$$

Under the condition of the maximum total deviation, the objective function about the weighted vector w_j is constructed as follows:

$$\begin{aligned} &maxE(w) = \sum_{j=1}^{m}\sum_{i=1}^{n}\sum_{k=1}^{n}\left|v_{ij} - v_{ik}\right|w_j \\ &s.t. \quad \sum_{j=1}^{m} w_j = 1, w_j \geq 0 \end{aligned} \tag{14}$$

Lagrange function is performed for the above optimization model, and its partial derivative is calculated. Hence, weight vector can be obtained:

$$w_j = \frac{\sum_{i=1}^{n}\sum_{k=1}^{n}\left|v_{ij} - v_{ik}\right|}{\sum_{j=1}^{m}\sum_{i=1}^{n}\sum_{k=1}^{n}\left|v_{ij} - v_{ik}\right|} \tag{15}$$

Let V_i represents the comprehensive score of green innovation risk of manufacturing industry in China under the GVC, and the calculation formula is as follows:

$$V_i = \sum_{j=1}^{m} w_j v_{ij} \tag{16}$$

4. Average method

The average value method is a method that uses the average value to solve problems. For some mathematical problems, if the average value method can be used to solve them skillfully, the result can be changed from complex to simple [3]. The calculation formula of the average value method is as follows:

$$\overline{X}_t = \sum_{j=1,t=1}^{m} w_{jt} v_{ijt} \Big/ n \tag{17}$$

where $i = 1,2,\cdots, n$, $j = 1,2,\cdots, m$, and $T = 1,2,\cdots, t$.

Supplementary Material 2

Table S3. Notation definition.

Nomenclature			
i	Element in row	$\mu_a(x)$	Triangular fuzzy numbers (TFNs)
j	Element in column	$D(a)$	The fuzzy resolution value of TFN
a_{ij}	The relative importance of row and column	R_{ij}	The assignment matrix of the initial recognition criterion
M_i	Each row element of the comparison judgment matrix	$\lambda(t)$	The weight vectorof time series
w_i	The weight of criterion	φ	Time degree vector
W	The relative importance of the next layer to the previous layer	$d(\lambda^1, \lambda^2)$	Euclidean distance between two time weight vector
$\lambda_{\max}$	The largest characteristic root of green innovation risk judgment matrix	θ	Degree of subjective and objective balance
CI	Consistency criterion	$\overline{x_j}$	Group comprehensive identification value
RI	Random consistency criterion	S_{C_i}	Comprehensive identification result
CR	Random consistency ratio	$E_{ij}(w)$	Total deviation between the sub-industries and the green innovation risk level
		V_i	Comprehensive score of green innovation risk
		$\overline{X_t}$	Average value

Supplementary Material 3

$$V_{t1} = W_{C_1} \otimes R_{t1}$$

$$= \begin{bmatrix} 0.6125 & 0.5076 & 0.5542 & 0.4734 & 0.4085 & 0.6545 & 0.5068 & 0.4678 & 0.5244 & 0.4817 & 0.5743 & 0.6181 & 0.6933 & 0.5538 & 0.6274 \\ 0.6086 & 0.6631 & 0.6085 & 0.5501 & 0.5326 & 0.3641 & 0.4156 & 0.6118 & 0.3993 & 0.6238 & 0.5700 & 0.5882 & 0.7396 & 0.6649 & 0.5549 \\ 0.4551 & 0.5040 & 0.6616 & 0.6307 & 0.5474 & 0.6825 & 0.4337 & 0.3115 & 0.5768 & 0.6631 & 0.4666 & 0.8380 & 0.6587 & 0.6010 & 0.6486 \end{bmatrix}$$

$$V_{t2} = W_{C_2} \otimes R_{t2}$$

$$= \begin{bmatrix} 0.5497 & 0.5387 & 0.4818 & 0.4525 & 0.4013 & 0.4684 & 0.5402 & 0.5385 & 0.5872 & 0.3993 & 0.6215 & 0.5858 & 0.5407 & 0.7986 & 0.7744 \\ 0.6513 & 0.7190 & 0.6412 & 0.7242 & 0.5737 & 0.4103 & 0.3502 & 0.6457 & 0.3842 & 0.6286 & 0.5831 & 0.5471 & 0.7263 & 0.5952 & 0.6219 \\ 0.4320 & 0.5279 & 0.8065 & 0.5939 & 0.3789 & 0.7389 & 0.4672 & 0.5398 & 0.4744 & 0.6210 & 0.6081 & 0.7713 & 0.6458 & 0.3535 & 0.6850 \end{bmatrix}$$

$$V_{t3} = W_{C_3} \otimes R_{t3}$$

$$= \begin{bmatrix} 0.7004 & 0.7388 & 0.4165 & 0.5806 & 0.4570 & 0.7045 & 0.6118 & 0.6099 & 0.6352 & 0.4707 & 0.6747 & 0.6370 & 0.6270 & 0.8041 & 0.7685 \\ 0.6812 & 0.6919 & 0.7023 & 0.7466 & 0.6025 & 0.6381 & 0.4562 & 0.6832 & 0.5926 & 0.6195 & 0.6471 & 0.5694 & 0.7236 & 0.6817 & 0.6848 \\ 0.7317 & 0.6418 & 0.8075 & 0.7271 & 0.6373 & 0.8024 & 0.5130 & 0.5198 & 0.5205 & 0.6531 & 0.5865 & 0.7105 & 0.6426 & 0.4372 & 0.7408 \end{bmatrix}$$

$$V_{t4} = W_{C_4} \otimes R_{t4}$$

$$= \begin{bmatrix} 0.7389 & 0.7017 & 0.4186 & 0.7649 & 0.5657 & 0.7383 & 0.5959 & 0.4199 & 0.5908 & 0.5917 & 0.6501 & 0.7039 & 0.6358 & 0.8411 & 0.5761 \\ 0.8603 & 0.7842 & 0.6232 & 0.5652 & 0.6219 & 0.5319 & 0.4672 & 0.5506 & 0.6479 & 0.6448 & 0.7310 & 0.5742 & 0.6250 & 0.6411 & 0.5143 \\ 0.7150 & 0.4897 & 0.5919 & 0.8265 & 0.7449 & 0.6751 & 0.3831 & 0.6613 & 0.4511 & 0.8416 & 0.7095 & 0.6819 & 0.5461 & 0.5193 & 0.7581 \end{bmatrix}$$

References

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