Supplemental material

Evaluating the Barriers to Industrial Symbiosis Using a Group AHP-TOPSIS Model

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Supplementary Materials File S1. Main calculation steps of Group AHP-TOPSIS Decision Model

AHP and TOPSIS are common and independent methodologies documented in many research papers. Here, we will mainly introduce the interaction and integration between the two methodologies.

(1) AHP method

After making pairwise comparisons, the synthesis of the priorities could be achieved by calculating the eigenvalues and eigenvectors of the pairwise comparison matrix [1]. Verified by consistency check, each pairwise comparison matrix can yield a weight vector. There are 8 weight vectors for each expert. One represents the relative importance of 7 generic barriers under the overall objective, while the others represent the relative importance of 23 specific barriers under 7 generic barriers. Each set of weight vectors can be organized as matrix *C*:

$$C = \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \\ \vdots & \vdots & & \vdots \\ c_{p1} & c_{p2} & \cdots & c_{pn} \end{bmatrix} \quad (1\text{-}1)$$

In Equation 1-1, one of the element c_{kj} ($k=1,2,\cdots,p; j=1,2,\cdots,n$) in matrix *C* refers to the relative weight of barrier *i* evaluated by expert *k*.

(2) Preferential differences integration

According to Huang and Li [2], in our study, we defined the weighted difference between alternatives *i* and *j* by expert *k* as:

$$\alpha_{kij} = \left|c_{ki} - c_{kj}\right|, i \neq j \quad (1\text{-}2)$$

It should be noted that α_{kij} only means the preferential differences for expert *k*, so the mean differences for the *p* (the amount of the experts) experts can be normalized as [2]:

$$\alpha_k = \frac{\sum_{j<j} \alpha_{kij}}{\sum_{k=1}^{p} \sum_{i<j} \alpha_{kij}}, 0 < \alpha_k < 1, i \neq j, 1 \leq i < j \leq n \quad (1\text{-}3)$$

If p=2 n=3, we can obtain:

$$\alpha_1 = \frac{\alpha_{112} + \alpha_{113} + \alpha_{123}}{\alpha_{112} + \alpha_{113} + \alpha_{123} + \alpha_{212} + \alpha_{213} + \alpha_{223}}$$

$$\alpha_2 = \frac{\alpha_{212} + \alpha_{213} + \alpha_{223}}{\alpha_{112} + \alpha_{113} + \alpha_{123} + \alpha_{212} + \alpha_{213} + \alpha_{223}}$$

"If α_k is a small value, the preferential difference for expert *k* is also small, which means he/she is unable to or has no interest in decisively discriminating these alternatives, and thus may have similar preferences for all of them" [2].

(3) Preferential priorities integration

Based on Huang and Li [2], the preference ranking is defined as φ_{ki}, which represents the weight ranking of criteria *i* by expert *k*. It should be noted that "if some alternatives are tied with the same rank, they are all assigned the rank which is the average of their original ranking positions" [2].

For example, in our study, if the weight given by the expert *k* is [0.2 0.2 0.1 0.3], then:

$$\varphi_{k1} = 2.5,\ \varphi_{k2} = 2.5,\ \varphi_{k3} = 1,\ \varphi_{k4} = 4$$

The preference priority of criteria *i* can be defined as:

$$\beta_i = \sum_{k=1}^{p} \frac{n}{\varphi_{ki}} \tag{1-4}$$

Then β_i is normalized as:

$$\beta_i = \frac{\beta_i}{\sum_{k=1}^{p} \beta_i} \tag{1-5}$$

Using the preference priority can emphasize "the importance of the best-ranked alternative which is often much more important than other alternatives" [2]. In this study, this means that the larger the β_i is, the higher the score the expert gives to the barrier *i*, indicating that the barrier *i* should be more important.

(4) TOPSIS aggregation

First, the original *C* matrix is modified by preferential differences and preferential priorities:

$$v_{ki} = \alpha_k \cdot c_{ki} \cdot \beta_i \tag{1-6}$$

G represents the modified *C* matrix:

$$G = \begin{bmatrix} v_{11} & v_{12} & \cdots & v_{1n} \\ v_{21} & v_{22} & \cdots & v_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ v_{p1} & v_{p2} & \cdots & v_{pn} \end{bmatrix} \tag{1-7}$$

The group positive and negative ideal solutions are defined as follows:

$$v_{Gk}^{*} = \left\{ \max_{i}\ v_{ki} | i = 1,2,\cdots,n \right\} \tag{1-8}$$

$$v_{Gk}^{-} = \left\{ \min_{i} \; v_{ki} \middle| i = 1,2,\cdots,n \right\} \tag{1-9}$$

$$A_{G}^{*} = \left\{ v_{G1}^{*}, v_{G2}^{*}, \cdots, v_{Gk}^{*}, \cdots, v_{Gp}^{*} \right\} \tag{1-10}$$

$$A_{G}^{-} = \left\{ v_{G1}^{-}, v_{G2}^{-}, \cdots, v_{Gk}^{-}, \cdots, v_{Gp}^{-} \right\} \tag{1-11}$$

The distances of alternative *i* to the group positive ideal solution (S_{Gi}^{*}) and the group negative ideal solution (S_{Gi}^{-}) can be defined as:

$$S_{Gi}^{*} = \sqrt{\sum_{k=1}^{p} (v_{ki} - v_{Gk}^{*})^2} \tag{1-12}$$

$$S_{Gi}^{-} = \sqrt{\sum_{k=1}^{p} (v_{ki} - v_{Gk}^{-})^2} \tag{1-13}$$

The relative closeness of alternative *i* by the group, C_{Gi}, can thus be derived as:

$$C_{Gi} = \frac{S_{Gi}^{*}}{S_{Gi}^{*} + S_{Gi}^{-}} \tag{1-14}$$

Then C_{Gi} can be normalized as:

$$C_{Gi} = \frac{C_{Gi}}{\sum_{i=1}^{n} C_{Gi}} \tag{1-15}$$

The larger C_{Gi} is, the more important the barrier *i* is, i.e., the weightage value of generic barriers under overall objective and specific barriers under generic barriers can be achieved. The weightage value of the generic barriers under the overall objective can be obtained by multiplying the weightage values of generic barriers with the weightage value of each specific barrier [3].

Supplementary Materials File S2. Results of AHP procedure in case study

The weights of both generic barriers and specific barriers given by each expert are shown in Tables S1–S3.

Table S1. Relative weights of generic barriers.

Expert	B1	B2	B3	B4	B5	B6	B7
1	0.1653	0.0701	0.0599	0.1339	0.0394	0.0395	0.4920
2	0.0282	0.0599	0.0541	0.1253	0.4268	0.1560	0.1496
3	0.0831	0.1894	0.2819	0.0745	0.0641	0.1604	0.1465
4	0.1314	0.1389	0.1872	0.1098	0.1872	0.1227	0.1227
5	0.0535	0.0764	0.0891	0.3386	0.1392	0.1910	0.1122
6	0.0291	0.0686	0.2042	0.0937	0.0937	0.1142	0.3964
7	0.2633	0.0930	0.1100	0.1907	0.1165	0.0930	0.1334
8	0.0406	0.1982	0.1003	0.1057	0.1905	0.1531	0.2117
9	0.0850	0.2347	0.1813	0.1008	0.2331	0.1329	0.0322
10	0.0109	0.4968	0.2350	0.1464	0.0421	0.0386	0.0302
11	0.1427	0.0728	0.1236	0.1998	0.0613	0.1347	0.2650
12	0.0988	0.1358	0.0604	0.1723	0.1380	0.0763	0.3183
13	0.0880	0.0655	0.1273	0.4778	0.0135	0.2048	0.0232
14	0.1421	0.4262	0.0701	0.0633	0.0703	0.0859	0.1421
15	0.1289	0.1304	0.3005	0.0724	0.0630	0.1923	0.1127
16	0.3427	0.0763	0.0705	0.1438	0.1160	0.0862	0.1646
17	0.1522	0.0872	0.3468	0.1403	0.1005	0.0786	0.0945
18	0.1247	0.1247	0.3330	0.0619	0.1566	0.1149	0.0843
19	0.0975	0.1173	0.2530	0.2546	0.1045	0.0557	0.1173
20	0.1682	0.1574	0.0899	0.1375	0.1279	0.1682	0.1509
21	0.1317	0.0546	0.0615	0.0186	0.5361	0.1703	0.0273
22	0.1172	0.3062	0.2113	0.1243	0.1264	0.0654	0.0493
23	0.0903	0.0757	0.4077	0.2271	0.0875	0.0559	0.0559
24	0.3322	0.0325	0.0890	0.1272	0.0456	0.0745	0.2990
25	0.0955	0.2612	0.0331	0.0842	0.3614	0.0739	0.0907

Table S2. Relative weights of specific barriers under B1,B2,B3

Expert	C1 (B1)	C2 (B1)	C3 (B1)	C4 (B1)	C5 (B2)	C6 (B2)	C7 (B2)	C8 (B3)	C9 (B3)	C10 (B3)	C11 (B3)
1	0.6250	0.1250	0.1250	0.1250	0.4600	0.2211	0.3189	0.1513	0.5848	0.1320	0.1320
2	0.0990	0.0864	0.4319	0.3827	0.0909	0.4545	0.4545	0.0678	0.1318	0.1318	0.6685
3	0.1034	0.5485	0.2048	0.1433	0.2808	0.5842	0.1350	0.2321	0.2321	0.1340	0.4019
4	0.2500	0.2500	0.2500	0.2500	0.7007	0.2021	0.0972	0.4755	0.2745	0.1585	0.0915
5	0.6808	0.1616	0.0279	0.1297	0.3090	0.1095	0.5816	0.2089	0.2795	0.4360	0.0755
6	0.2224	0.1165	0.2677	0.3934	0.3333	0.3333	0.3333	0.1328	0.2000	0.1004	0.5668
7	0.4874	0.1625	0.2234	0.1266	0.3189	0.4600	0.2211	0.4073	0.2951	0.1791	0.1185
8	0.1864	0.1627	0.2458	0.4051	0.2000	0.2000	0.6000	0.1182	0.1182	0.2762	0.4874
9	0.4114	0.4114	0.0641	0.1131	0.5842	0.1350	0.2808	0.3750	0.3750	0.1250	0.1250
10	0.2087	0.6428	0.0512	0.0972	0.0980	0.0196	0.8824	0.1461	0.2575	0.0665	0.5300
11	0.0607	0.5467	0.1420	0.2506	0.1429	0.1429	0.7143	0.1976	0.2224	0.1258	0.4542
12	0.1182	0.1851	0.1362	0.5605	0.4806	0.4054	0.1140	0.1898	0.1502	0.1205	0.5395
13	0.0739	0.6615	0.1143	0.1503	0.2000	0.2000	0.6000	0.6631	0.0265	0.0925	0.2179
14	0.1000	0.3000	0.3000	0.3000	0.6000	0.2000	0.2000	0.2500	0.2500	0.2500	0.2500
15	0.1850	0.2229	0.3368	0.2553	0.4286	0.4286	0.1429	0.2559	0.1375	0.5160	0.0906
16	0.0141	0.0959	0.7878	0.1022	0.2583	0.6370	0.1047	0.2321	0.4019	0.2321	0.1340
17	0.0420	0.3333	0.3124	0.3124	0.7143	0.1429	0.1429	0.3936	0.4373	0.0466	0.1225
18	0.2500	0.2500	0.2500	0.2500	0.4545	0.4545	0.0909	0.3598	0.4309	0.1516	0.0577
19	0.1414	0.5311	0.2369	0.0906	0.2000	0.2000	0.6000	0.2072	0.3210	0.0754	0.3965
20	0.4051	0.2458	0.1864	0.1627	0.2000	0.6000	0.2000	0.2500	0.2500	0.2500	0.2500
21	0.5631	0.1428	0.0880	0.2061	0.0909	0.4545	0.4545	0.2127	0.0286	0.0992	0.6595
22	0.2085	0.4874	0.2085	0.0956	0.6370	0.1047	0.2583	0.2626	0.1158	0.5229	0.0988
23	0.1026	0.1026	0.3974	0.3974	0.2000	0.2000	0.6000	0.2820	0.4246	0.0802	0.2132
24	0.0374	0.5603	0.1455	0.2568	0.0769	0.6923	0.2308	0.1484	0.0797	0.4727	0.2992
25	0.0833	0.7500	0.0833	0.0833	0.6586	0.1852	0.1562	0.0917	0.0665	0.1210	0.7208

Table S3. Relative weights of specific barriers under B4,B5,B6,B7

Expert	C12 (B4)	C13 (B4)	C14 (B4)	C15 (B4)	C16 (B4)	C17 (B5)	C18 (B5)	C19 (B6)	C20 (B6)	C21 (B6)	C22 (B7)	C23 (B7)
1	0.0716	0.3779	0.3746	0.1178	0.0581	0.5000	0.5000	0.2000	0.6000	0.2000	0.5000	0.5000
2	0.0687	0.0686	0.6009	0.0830	0.1789	0.5000	0.5000	0.1140	0.4806	0.4054	0.5000	0.5000
3	0.3553	0.2122	0.2122	0.0618	0.1585	0.7500	0.2500	0.3333	0.3333	0.3333	0.1667	0.8333
4	0.0305	0.0860	0.4370	0.2232	0.2232	0.8333	0.1667	0.4286	0.4286	0.1429	0.5000	0.5000
5	0.0696	0.0902	0.4203	0.1559	0.2640	0.7500	0.2500	0.2211	0.3189	0.4600	0.5000	0.5000
6	0.2676	0.3097	0.2676	0.1100	0.0451	0.5000	0.5000	0.5842	0.2808	0.1350	0.7500	0.2500
7	0.1690	0.0955	0.1461	0.1875	0.4020	0.7500	0.2500	0.1429	0.4286	0.4286	0.2500	0.7500
8	0.1058	0.1058	0.1058	0.2631	0.4195	0.5000	0.5000	0.1429	0.4286	0.4286	0.5000	0.5000
9	0.5966	0.0303	0.1742	0.0820	0.1169	0.5000	0.5000	0.4600	0.3189	0.2211	0.5000	0.5000
10	0.1412	0.3882	0.0925	0.3417	0.0365	0.2500	0.7500	0.0769	0.2308	0.6923	0.5000	0.5000
11	0.0743	0.2690	0.2690	0.1185	0.2690	0.2500	0.7500	0.1429	0.4286	0.4286	0.5000	0.5000
12	0.0625	0.2111	0.2987	0.0547	0.3730	0.5000	0.5000	0.1350	0.2808	0.5842	0.2500	0.7500
13	0.0769	0.2347	0.1296	0.0484	0.5104	0.2500	0.7500	0.1429	0.1429	0.7143	0.5000	0.5000
14	0.2300	0.1587	0.1514	0.2300	0.2300	0.5000	0.5000	0.3333	0.3333	0.3333	0.5000	0.5000
15	0.1439	0.1747	0.3098	0.0865	0.2850	0.5000	0.5000	0.4600	0.3189	0.2211	0.7500	0.2500
16	0.1939	0.0728	0.0728	0.1939	0.4665	0.5000	0.5000	0.2000	0.6000	0.2000	0.2500	0.7500
17	0.2000	0.2000	0.2000	0.2000	0.2000	0.7500	0.2500	0.3333	0.3333	0.3333	0.2500	0.7500
18	0.0769	0.2308	0.2308	0.2308	0.2308	0.8333	0.1667	0.1350	0.2808	0.5842	0.5000	0.5000
19	0.0743	0.1849	0.2948	0.2230	0.2230	0.5000	0.5000	0.3333	0.3333	0.3333	0.5000	0.5000
20	0.1508	0.3635	0.2736	0.1061	0.1061	0.5000	0.5000	0.3333	0.3333	0.3333	0.5000	0.5000
21	0.0589	0.1430	0.1245	0.6205	0.0531	0.8750	0.1250	0.7147	0.2185	0.0668	0.5000	0.5000
22	0.2000	0.2000	0.2000	0.2000	0.2000	0.5000	0.5000	0.3333	0.3333	0.3333	0.5000	0.5000
23	0.1118	0.1767	0.3995	0.2279	0.0842	0.5000	0.5000	0.3333	0.3333	0.3333	0.5000	0.5000
24	0.1149	0.1750	0.3859	0.0952	0.2290	0.5000	0.5000	0.2211	0.3189	0.4600	0.2500	0.7500
25	0.0155	0.0958	0.0811	0.0114	0.7963	0.5000	0.5000	0.3333	0.3333	0.3333	0.5000	0.5000

Supplementary Materials File S3. Results of Group-TOPSIS Decision model in case study

The weights derived by AHP should be aggregated by Group TOPSIS Decision Model, including preferential differences integration, preferential priorities integration, and TOPSIS aggregation.

For preferential differences integration and preferential priorities integration, α_k and β_i can be calculated by Equation 1-3 and Equation 1-5 in the supporting information. There are 8 sets of relative weights from AHP. One represents the relative importance of 7 generic barriers under the overall objective, while the others represent the relative importance of 23 specific barriers under 7 generic barriers. Each set of relative weights should be processed to obtain both a set of α_k and a set of β_i. The results are shown in Table S4 and Table S5.

Based on α_k and β_i, relative weights are modified by Equation 1-6 in the supporting information. Through the remaining steps in the supporting information, C_{Gi} could be calculated. According to the descending order of C_{Gi}, the degrees of importance of IS barriers have been quantitatively evaluated, i.e., weights of generic barriers (Table 5 and Figure 3), specific barriers (Table 6 and Figure 4), and the specific barriers' degrees of importance corresponding to their generic barriers (Table 6).

Table S4. Preferential differences for the experts

Expert	α_k (generic barriers)	α_k (under B1)	α_k (under B2)	α_k (under B3)	α_k (under B4)	α_k (under B5)	α_k (under B6)	α_k (under B7)
1	0.0581	0.0484	0.0221	0.0446	0.0499	0.0000	0.0620	0.0000
2	0.0514	0.0426	0.0337	0.0584	0.0622	0.0000	0.0569	0.0000
3	0.0331	0.0451	0.0417	0.0260	0.0339	0.0896	0.0000	0.1600
4	0.0130	0.0000	0.0560	0.0411	0.0503	0.1194	0.0443	0.0000
5	0.0391	0.0642	0.0438	0.0373	0.0463	0.0896	0.0370	0.0000
6	0.0481	0.0283	0.0000	0.0475	0.0364	0.0000	0.0697	0.1200
7	0.0252	0.0369	0.0221	0.0318	0.0346	0.0896	0.0443	0.1200
8	0.0274	0.0254	0.0371	0.0410	0.0416	0.0000	0.0443	0.0000
9	0.0340	0.0432	0.0417	0.0324	0.0649	0.0000	0.0370	0.0000
10	0.0681	0.0609	0.0800	0.0487	0.0504	0.0896	0.0955	0.0000
11	0.0305	0.0505	0.0530	0.0327	0.0286	0.0896	0.0443	0.0000
12	0.0347	0.0444	0.0340	0.0420	0.0462	0.0000	0.0697	0.1200
13	0.0627	0.0580	0.0371	0.0660	0.0573	0.0896	0.0886	0.0000
14	0.0450	0.0194	0.0371	0.0000	0.0121	0.0000	0.0000	0.0000
15	0.0335	0.0157	0.0265	0.0452	0.0311	0.0000	0.0370	0.1200
16	0.0363	0.0751	0.0494	0.0260	0.0481	0.0000	0.0620	0.1200
17	0.0338	0.0282	0.0530	0.0468	0.0000	0.0896	0.0000	0.1200
18	0.0334	0.0000	0.0337	0.0430	0.0163	0.1194	0.0697	0.0000
19	0.0317	0.0457	0.0371	0.0349	0.0254	0.0000	0.0000	0.0000
20	0.0116	0.0254	0.0371	0.0000	0.0361	0.0000	0.0000	0.0000
21	0.0661	0.0480	0.0337	0.0650	0.0645	0.1343	0.1005	0.0000
22	0.0370	0.0379	0.0494	0.0460	0.0000	0.0000	0.0000	0.0000
23	0.0487	0.0380	0.0371	0.0357	0.0395	0.0000	0.0000	0.0000
24	0.0503	0.0542	0.0571	0.0431	0.0368	0.0000	0.0370	0.1200
25	0.0473	0.0645	0.0466	0.0646	0.0874	0.0000	0.0000	0.0000

Table S5. Preferential priorities for the IS barriers

Generic barriers	β_i	Under B1	β_i	Under B2	β_i	Under B3	β_i	Under B4	β_i	Under B5	β_i	Under B6	β_i	Under B7	β_i
B1	0.137	C1	0.224	C5	0.367	C8	0.233	C12	0.152	C17	0.529	C19	0.290	C22	0.471
B2	0.147	C2	0.312	C6	0.302	C9	0.266	C13	0.201	C18	0.471	C20	0.287	C23	0.529
B3	0.170	C3	0.240	C7	0.331	C10	0.219	C14	0.244			C21	0.423		
B4	0.140	C4	0.224			C11	0.282	C15	0.165						
B5	0.135							C16	0.239						
B6	0.115														
B7	0.156														

Supplementary Materials File S4. Discussion of preferential differences & preferential priorities in case study

In order to discuss the two characteristics of "preferential differences" and "preferential priorities", we take the results of comparison of 7 generic barriers as an example.

Expert	Governmental barriers (B1)	Economic barriers (B2)	Technological barriers (B3)	Organizational barriers (B4)	Informational barriers (B5)	Cognitive & motivational barriers (B6)	Safety barriers (B7)	Range (max-min)	preferencial difference
1	16.53%	7.01%	5.99%	13.39%	3.94%	3.95%	49.20%	0.4525	0.0581
2	2.82%	5.99%	5.41%	12.53%	42.68%	15.60%	14.96%	0.3987	0.0514
3	8.31%	18.94%	28.19%	7.45%	6.41%	16.04%	14.65%	0.2178	0.0331
4	13.14%	13.89%	18.72%	10.98%	18.72%	12.27%	12.27%	0.0774	0.013
5	5.35%	7.64%	8.91%	33.86%	13.92%	19.10%	11.22%	0.2851	0.0391
6	2.91%	6.86%	20.42%	9.37%	9.37%	11.42%	39.64%	0.3673	0.0481
7	26.33%	9.30%	11.00%	19.07%	11.65%	9.30%	13.34%	0.1703	0.0252
8	4.06%	19.82%	10.03%	10.57%	19.05%	15.31%	21.17%	0.1711	0.0274
9	8.50%	23.47%	18.13%	10.08%	23.31%	13.29%	3.22%	0.2025	0.034
10	1.09%	49.68%	23.50%	14.64%	4.21%	3.86%	3.02%	0.4859	0.0681
11	14.27%	7.28%	12.36%	19.98%	6.13%	13.47%	26.50%	0.2037	0.0305
12	9.88%	13.58%	6.04%	17.23%	13.80%	7.63%	31.83%	0.2579	0.0347
13	8.80%	6.55%	12.73%	47.78%	1.35%	20.48%	2.32%	0.4643	0.0627
14	14.21%	42.62%	7.01%	6.33%	7.03%	8.59%	14.21%	0.3629	0.045
15	12.89%	13.04%	30.05%	7.24%	6.30%	19.23%	11.27%	0.2375	0.0335
16	34.27%	7.63%	7.05%	14.38%	11.60%	8.62%	16.46%	0.2722	0.0363
17	15.22%	8.72%	34.68%	14.03%	10.05%	7.86%	9.45%	0.2682	0.0338
18	12.47%	12.47%	33.30%	6.19%	15.66%	11.49%	8.43%	0.2711	0.0334
19	9.75%	11.73%	25.30%	25.46%	10.45%	5.57%	11.73%	0.1989	0.0317
20	16.82%	15.74%	8.99%	13.75%	12.79%	16.82%	15.09%	0.0783	0.0116
21	13.17%	5.46%	6.15%	1.86%	53.61%	17.03%	2.73%	0.5175	0.0661
22	11.72%	30.62%	21.13%	12.43%	12.64%	6.54%	4.93%	0.2569	0.037
23	9.03%	7.57%	40.77%	22.71%	8.75%	5.59%	5.59%	0.3518	0.0487
24	33.22%	3.25%	8.90%	12.72%	4.56%	7.45%	29.90%	0.2997	0.0503
25	9.55%	26.12%	3.31%	8.42%	36.14%	7.39%	9.07%	0.3284	0.0473

Figure S1. Results of preferential differences for each expert (comparison of 7 generic barriers)

In Figure S1, the 1st column refers to the sequence number of the expert. The 2nd to the 8th column refers to the weightage value of generic barriers given by AHP, i.e., quantitative results of the importance of the barriers given by each expert. The 9th column refers to the range of each expert, i.e., the difference between the maximum weightage value and the minimum weightage value given by each expert. The 10th column refers to the results of preferential differences for each expert.

In Section 3.2.2, we assume that if an expert is not able to or shows no interest in decisively distinguishing these alternatives, similar preferences may be chosen for all of them [2]. This means that experts give similar weights to barriers. Thus, there is little difference in weights among these barriers, i.e., the range of the judgment is small (especially the 4th expert and the 20th expert). It also means that they have a lower preferential difference.

Huang et al. [4] argued that "it is reasonable that an individual with greater preferential differences among alternatives would have more influence in a group than those who with less preferential differences, since the individual with greater preferential differences would fight for his/her choices, while the other members may be less insistent because of their similar perceptions of all alternatives". Basak [5] argued that "in any rational consensus, those who know more should, accordingly, influence the consensus more strongly than those who are less knowledgeable".

Therefore, in our study, the preferential differences should be considered. From Equation 1-7 and Equation 1-10, experts' preferential differences are proportional to the weights of his/her judgment in the result. So, experts with lower preferential difference would influence the consensus more weakly. This reflects the selection of experts in final judgement based on whether his/her judgement shows similar preferences.

Table S6. Results of preferential priorities for each barrier (comparison of 7 generic barriers)

Criteria	**Governmental barriers (B1)**	**Economic barriers (B2)**	**Technological barriers (B3)**	**Organizational barriers (B4)**	**Informational barriers (B5)**	**Cognitive & motivational barriers (B6)**	**Safety barriers (B7)**
<=1	3	4	6	3	4	1	5
<=2	6	7	10	7	6	6	8
<=3	12	12	12	12	10	8	11
<=4	15	14	14	15	16	12	15
<=5	18	18	18	19	18	17	18
<=6	20	23	21	21	20	23	23
<=7	25	25	25	25	25	25	25
p-priority	0.137	0.147	0.17	0.14	0.135	0.115	0.156

Table S6 shows a summary of the ranking results of experts. For example, "<=1" shows how many people rank each barrier as No.1 (most important). "<=2" shows how many people rank each barrier as No.1 or No.2. The last row of Table S6 shows results of preferential priorities for each barrier. It can be seen that for B3, B7, and B2, there are many people ranking them as the most important one. Their preferential priorities also rank from the 1st to 3rd, respectively. However, there are 4 experts who rank B5 as the most important one, which is the same as B2. More experts rank B2 as the No.1 or No.2.

So, B3, B7, and B2 should receive greater weightage value relative to the average of the results of AHP. Using the preferential priority assists in emphasizing "the importance of the best ranked alternative which is often much more important than other alternatives" [2], and has been demonstrated by Inti and Tandon [6]. Therefore, from Equation 1-9 and Equation 1-10, the weightage value of barriers is adjusted by multiplying the value of preferential priorities. It reflects an emphasis on the barriers that more experts consider important.

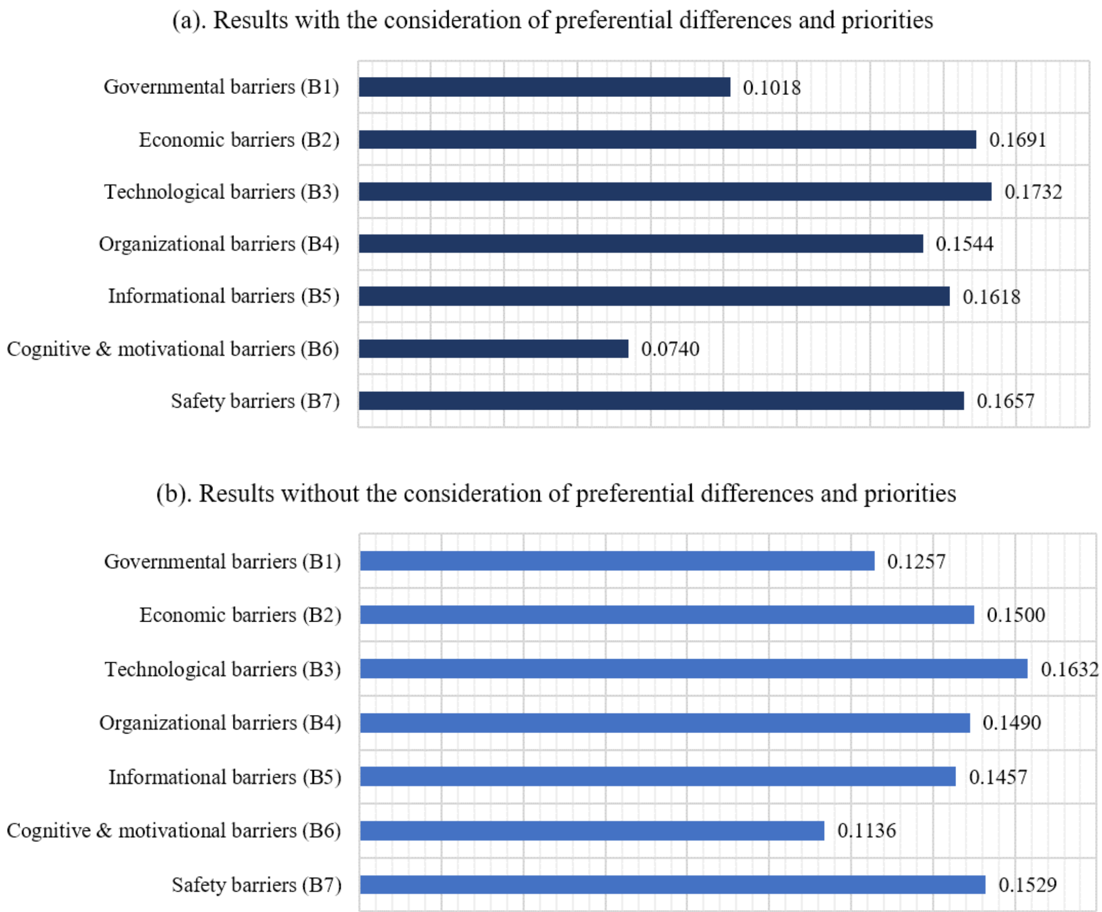

Figure S2. Results with/without the consideration of preferential differences and priorities (comparison of 7 generic barriers)

Figure S2 shows the results with and without (average of the results of AHP) the consideration of differences and preferential priorities. It can be seen that after taking the consideration of the two characteristics, the weightage value of each barrier is distinguished more clearly. Moreover, the weightage value of B3, B7, B2 (0.1732,0.1657,0.1691) became greater (0.1632, 0.1529, 0.1500). Preferential differences reflect the selection of experts in final judgment based on whether his/her judgment shows similar preferences, while the preferential priorities reflect an emphasis on the barriers that more experts consider important. So, the weightage value of each barrier is distinguished more clearly and B3, B7, B2 are emphasized. Thus, the two characteristics of "preferential differences" and "preferential priorities" are suitable for this research because they assist in identifying the more important barriers for the development of the IS.

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