Notes on Intuitionistic Fuzzy Sets
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Application of the InterCriteria Analysis to the universities rankings system in the Republic of Korea

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Abstract: In this paper, an application of the InterCriteria Analysis approach to data on the evaluation of 184 universities in the Republic of Korea is presented. The evaluation criteria consist of 51 indicators, grouped into six thematic areas. The aim of the study is to identify the interdependencies among the individual evaluation criteria. The results are interpreted through the intuitionistic fuzzy triangle, which allows for a deeper understanding of the correlation among the criteria and their influence on the overall assessment of the universities.
Keywords: InterCriteria Analysis, University rankings, Multicriteria decision making.
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1 Introduction to InterCriteria Analysis method

The InterCriteria Analysis (ICA) is a new approach introduced by K. Atanassov, D. Mavrov and V. Atanassova in 2014 [5]. It is a multicriteria decision-making approach based on the mathematical apparatus of Index Matrices (IMs) [2] and Intuitionistic Fuzzy Sets (IFSs) [1, 12]. The method aims to identify the degree of consonance or dissonance between evaluation criteria by analyzing the consistency in the pairwise comparison of objects with respect to these criteria.

In this study, a dataset for the comparative analysis and evaluation of universities in the Republic of Korea is investigated. For the assessment of the universities, intuitionistic fuzzy pairs (IFPs; see [6]) are used. An IFP is an ordered pair $\langle \mu, \nu \rangle$, where:

- $\mu \in [0, 1]$ is the degree of membership,
- $\nu \in [0, 1]$ is the degree of non-membership,
- $0 \leq \mu + \nu \leq 1$.

The last condition gives rise to a third, complementary, degree of uncertainty π, where $\pi = 1 - \mu - \nu$.

The n universities $U_1, U_2, \ldots, U_n$ ($r = 1, 2, \ldots, n$) are evaluated according to a set of m criteria $C_1, C_2, \ldots, C_m$, ($j = 1, 2, \ldots m$). For every t and r ($1 \leq t \leq m$, $1 \leq r \leq n$), U_r is an evaluated university, C_t is an evaluation criterion, and a_{C_t,U_r} is the evaluation of the r-th university against the t-th criterion, defined as a real number (or another object like a linguistic variable, as long as one that maintains natural ordering).

After applying the ICA, an index matrix with IFPs is obtained, representing an intuitionistic fuzzy assessment of the relations between every pair of criteria C_k and C_l. Interpretable as correlations between the criteria within this intuitionistic fuzzy setting, the positive / negative consonance and dissonance can be determined by the following scale of threshold values: "Strong Positive Consonance" – [0.95; 1], "Positive Consonance" – [0.85; 0.95), "Weak Positive Consonance" – [0.75; 0.85), "Weak Dissonance" – [0.67; 0.75), "Dissonance" – [0.57; 0.67), "Strong Dissonance" – [0.43; 0.57), "Dissonance" – [0.33; 0.43), "Weak Dissonance" – [0.25; 0.33), "Weak Negative Consonance" – [0.15; 0.25), "Negative Consonance" – [0.05; 0.15) or "Strong Negative Consonance" – [0.00; 0.05).

The theoretical background of the applied ICA, including its extensions from pairs to higher-order structures, follows the framework developed in Atanassova *et al*. [8]. Other relevant approaches to determining the threshold values separating the various categories of intercriteria relations are given in [7, 13] and most recently [3], and other algorithms for calculation of the InterCriteria relations as implemented in the software ICrAData [14] are given in [17, 18].

In this investigation the ICA is applied over the evaluation criteria of the education institutions in the Republic of Korea. University rankings in different countries have been studied with ICA in previous works, both as a general formulation of the problem [19] and as an application to specific datasets for universities in Bulgaria [10, 11], Australia [20], Poland [15], Slovakia [9], the United Kingdom [21], and India [16], using the results from [4].

2 Presentation of the input data set

The dataset [22] covers 184 higher education institutions, which can be classified into the

following groups: Private (156 in number), Establishment (25 in number), National University (2 in number), and Corporation Public (1). This classification reflects the diversity of ownership and governance models within the Korean higher education system.

The evaluation framework consists of 51 indicators, grouped into six thematic areas, reflecting key aspects of institutional performance (Figure 1). The distribution of the indicators across the groups is presented in Table 1.

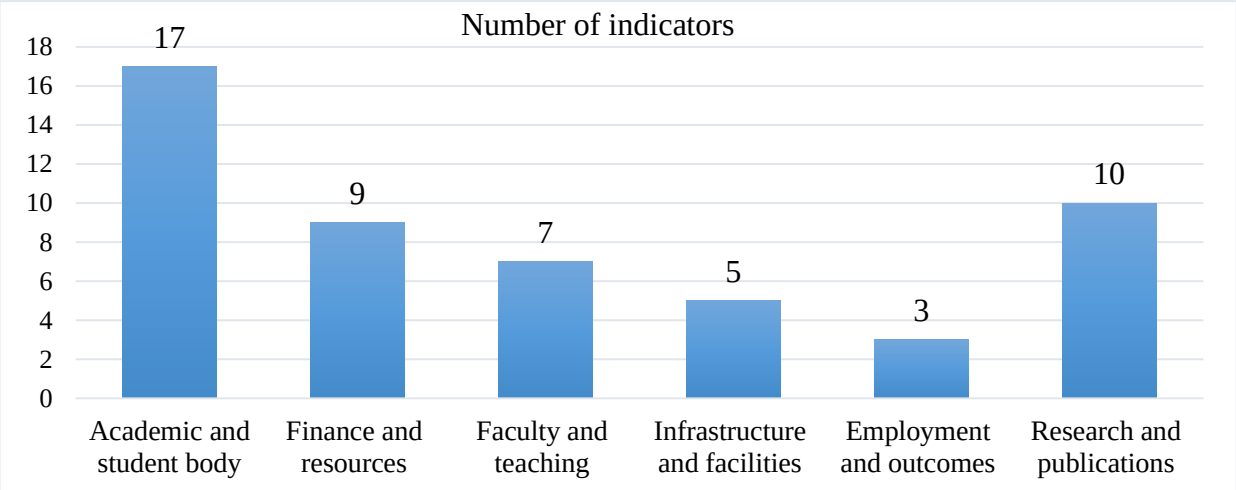


Figure 1. Distribution of the indicators across the thematic areas

Table 1. Distribution of the indicators across the thematic areas

1). *Academic and Student Body*:	
A1. Establishment classification **A2.** Region **A3.** Number of students enrolled in the undergraduate program **A4.** Number of students enrolled within and outside the undergraduate program **A5.** Number of undergraduate and graduate students **A6.** Capacity (number of people) **A7.** Number of enrolled students **A8.** Number of admitted students (within quota)	**A9.** Total number of admitted students (within quota + outside quota) **A10.** Freshman Enrollment Rate (within quota) **A11.** Student quota – Number of students suspended from recruitment **A12.** Enrollment Rate (within quota) **A13.** Number of employees **A14.** Number of students per staff member **A15.** Authorized Faculty Quota **A16.** Number of students **A17.** Number of Enrolled Students (within quota)
2). *Finance and Resources:*	
F1. Tuition (KRW) **F2.** Operating income (total revenue won) **F3.** Donation (won) **F4.** Proportion of donations to revenue **F5.** Material purchase cost (KRW)	**F6.** Annual material purchase cost per student (settlement) **F7.** Instructor fee (won) **F8.** Tuition fee ratio in revenue **F9.** Instructor's tuition

3). ***Faculty and Teaching:***	
T1. Number of full-time faculty members **T2.** Total number of lecture hours (hours) **T3.** Full-time faculty retention rate	**T4.** Teacher retention rate **T5.** Scholarship (won) **T6.** Scholarship ratio **T7.** Tuition
4). ***Infrastructure and facilities:***	
I1. Facility area (m^2) **I2.** Dormitory occupancy rate **I3.** Number of library staff	**I4.** Number of library staff per 1000 students **I5.** Standard area (m^2)
5). ***Employment and outcomes:***	
E1. Employed persons **E2.** Graduates	**E3.** Graduate employment rate
6). ***Research and publications:***	
R1. Number of papers in listed (candidate) journals **R2.** Number of papers published (or submitted) per full-time faculty member **R3.** Number of SCI-level papers **R4.** SCI-level papers per full-time faculty member **R5.** Performance of low-level books per full-time faculty member	**R6.** On-campus research expenses (in thousands won) **R7.** Off-campus research expenses (in thousands won) **R8.** Research expenses per full-time faculty member **R9.** Performance compared to research performance standards **R10.** Off-campus research expenses per full-time faculty member

3 Application of InterCriteria Analysis over the criterial system of higher education institutions in the Republic of Korea

The analyzed data examined cover the full spectrum of the Korean university system – from large research-intensive universities with an international focus to regional and specialized institutions, ensuring representativeness and enabling the analysis of systemic relationships among the different groups of universities.

3.1 Application of InterCriteria Analysis to the data on the Academic and Student Body

Applying ICA to the data on the academic and student body yields the following results, presenting the correlations between the different parameter for the 184 higher education institutions in the Republic of Korea: Table 2(a), (b), Figure 2.

Table 2. ICA analysis of the academic and student body, based on the data for 17 criteria

(a) Membership part of IFPs

μ	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17
A1	1.00	0.19	0.19	0.18	0.19	0.21	0.19	0.19	0.19	0.20	0.19	0.18	0.23	0.05	0.19	0.19	0.19
A2	0.19	1.00	0.37	0.37	0.36	0.41	0.36	0.38	0.38	0.41	0.37	0.36	0.38	0.44	0.37	0.37	0.37
A3	0.19	0.37	1.00	0.98	0.96	0.82	0.97	0.98	0.97	0.54	0.96	0.68	0.87	0.59	0.95	0.96	1.00
A4	0.18	0.37	0.98	1.00	0.97	0.82	0.98	0.96	0.95	0.54	0.95	0.69	0.87	0.60	0.95	0.97	0.98
A5	0.19	0.36	0.96	0.97	1.00	0.82	0.99	0.95	0.94	0.54	0.94	0.69	0.88	0.59	0.97	0.99	0.96
A6	0.21	0.41	0.82	0.82	0.82	1.00	0.83	0.82	0.82	0.51	0.82	0.65	0.84	0.52	0.83	0.83	0.82
A7	0.19	0.36	0.97	0.98	0.99	0.83	1.00	0.96	0.95	0.54	0.94	0.69	0.88	0.59	0.97	0.98	0.97
A8	0.19	0.38	0.98	0.96	0.95	0.82	0.96	1.00	0.98	0.54	0.97	0.67	0.87	0.59	0.94	0.95	0.98
A9	0.19	0.38	0.97	0.95	0.94	0.82	0.95	0.98	1.00	0.52	0.98	0.66	0.86	0.59	0.94	0.94	0.97
A10	0.20	0.41	0.54	0.54	0.54	0.51	0.54	0.54	0.52	1.00	0.51	0.67	0.54	0.49	0.53	0.54	0.54
A11	0.19	0.37	0.96	0.95	0.94	0.82	0.94	0.97	0.98	0.51	1.00	0.65	0.86	0.59	0.94	0.94	0.96
A12	0.18	0.36	0.68	0.69	0.69	0.65	0.69	0.67	0.66	0.67	0.65	1.00	0.70	0.50	0.68	0.69	0.68
A13	0.23	0.38	0.87	0.87	0.88	0.84	0.88	0.87	0.86	0.54	0.86	0.70	1.00	0.47	0.89	0.88	0.87
A14	0.05	0.44	0.59	0.60	0.59	0.52	0.59	0.59	0.59	0.49	0.59	0.50	0.47	1.00	0.58	0.59	0.59
A15	0.19	0.37	0.95	0.95	0.97	0.83	0.97	0.94	0.94	0.53	0.94	0.68	0.89	0.58	1.00	0.97	0.95
A16	0.19	0.37	0.96	0.97	0.99	0.83	0.98	0.95	0.94	0.54	0.94	0.69	0.88	0.59	0.97	1.00	0.96
A17	0.19	0.37	1.00	0.98	0.96	0.82	0.97	0.98	0.97	0.54	0.96	0.68	0.87	0.59	0.95	0.96	1.00

(b) Non-membership part of IFPs

ν	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17
A1	0.00	0.14	0.07	0.08	0.08	0.06	0.08	0.07	0.07	0.11	0.08	0.09	0.04	0.21	0.07	0.08	0.07
A2	0.14	0.00	0.53	0.53	0.53	0.49	0.53	0.52	0.52	0.44	0.52	0.53	0.51	0.45	0.53	0.53	0.53
A3	0.07	0.53	0.00	0.02	0.04	0.18	0.03	0.02	0.03	0.40	0.04	0.32	0.13	0.41	0.05	0.04	0.00
A4	0.08	0.53	0.02	0.00	0.03	0.18	0.02	0.04	0.04	0.40	0.05	0.31	0.13	0.40	0.05	0.03	0.02
A5	0.08	0.53	0.04	0.03	0.00	0.17	0.01	0.05	0.06	0.40	0.06	0.31	0.12	0.41	0.03	0.01	0.04
A6	0.06	0.49	0.18	0.18	0.17	0.00	0.17	0.18	0.18	0.43	0.18	0.35	0.16	0.48	0.17	0.17	0.18
A7	0.08	0.53	0.03	0.02	0.01	0.17	0.00	0.04	0.05	0.40	0.06	0.31	0.12	0.41	0.03	0.02	0.03
A8	0.07	0.52	0.02	0.04	0.05	0.18	0.04	0.00	0.02	0.40	0.03	0.33	0.13	0.41	0.06	0.05	0.02
A9	0.07	0.52	0.03	0.04	0.06	0.18	0.05	0.02	0.00	0.42	0.02	0.34	0.14	0.41	0.05	0.06	0.03
A10	0.11	0.44	0.40	0.40	0.40	0.43	0.40	0.40	0.42	0.00	0.42	0.27	0.40	0.44	0.41	0.40	0.40
A11	0.08	0.52	0.04	0.05	0.06	0.18	0.06	0.03	0.02	0.42	0.00	0.35	0.14	0.41	0.06	0.06	0.04
A12	0.09	0.53	0.32	0.31	0.31	0.35	0.31	0.33	0.34	0.27	0.35	0.00	0.29	0.50	0.32	0.31	0.32
A13	0.04	0.51	0.13	0.13	0.12	0.16	0.12	0.13	0.14	0.40	0.14	0.29	0.00	0.53	0.11	0.12	0.13
A14	0.21	0.45	0.41	0.40	0.41	0.48	0.41	0.41	0.41	0.44	0.41	0.50	0.53	0.00	0.42	0.41	0.41
A15	0.07	0.53	0.05	0.05	0.03	0.17	0.03	0.06	0.05	0.41	0.06	0.32	0.11	0.42	0.00	0.03	0.05
A16	0.08	0.53	0.04	0.03	0.01	0.17	0.02	0.05	0.06	0.40	0.06	0.31	0.12	0.41	0.03	0.00	0.04
A17	0.07	0.53	0.00	0.02	0.04	0.18	0.03	0.02	0.03	0.40	0.04	0.32	0.13	0.41	0.05	0.04	0.00

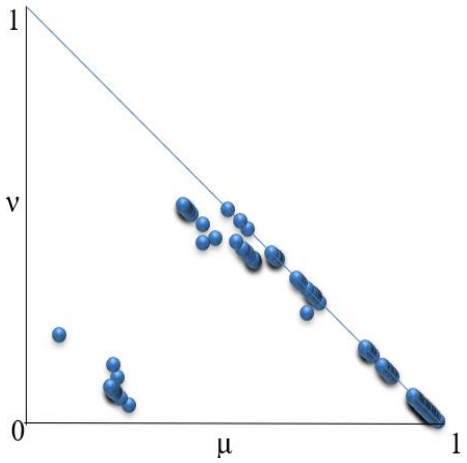


Figure 2. Distribution of the IFPs plotted as points onto the intuitionistic fuzzy triangle

After applying the ICA method, a total of 136 intuitionistic fuzzy pairs are obtained, distributed as follows:

- 31 in “strong positive consonance”,
- 25 in “positive consonance”,
- 10 in “weak positive consonance”,
- 10 in “weak dissonance”,
- 27 in “dissonance”,
- 17 in “strong dissonance”,
- 15 in “weak negative consonance”, and
- 1 in “negative consonance”.

Discussion: The fact that 31 criteria are into the “strong positive consonance” indicates that there is strong internal coherence and a high degree of mutual correlation between them. This means that these indicators measure similar or overlapping aspects of institutional activity (mainly A3 to A17). It is therefore possible to reduce the number of measured criteria by excluding highly correlated indicators without significant loss of accuracy or informativeness. This creates the prerequisites for a more efficient, simplified and less resource-intensive assessment process, without compromising the quality of the conclusions drawn.

The criterion A2 “Region” is in dissonance or strong dissonance with the other indicators. This means that criterion A2 provides unique information that is not captured by the remaining indicators.

The results from applying ICA method show that the criterion A1 “Establishment classification” is in “weak negative consonance” with all other criteria. In addition, it exhibits a very high uncertainty values across all criteria – over 0.67 for Criterion A2 and Criterion A10, and above 0.73 for all remaining ones. This indicates that Criterion A1 has a more specific, typological nature and should be interpreted separately or with particular caution when analyzing systemic relationships.

3.2 Application of InterCriteria Analysis to the data on Finance and Resources

From the application of ICA to the data on “Finance and resources”, we obtain the following output which presents the correlations between the different parameters for the investigated higher education institutions in the Republic of Korea: Table 3(a), (b), Figure 3.

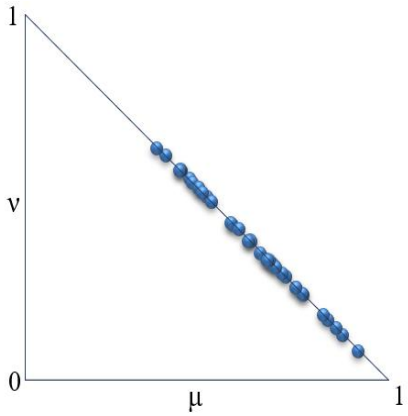
Table 3. ICA analysis of the Finance and resources, based on the data for 9 criteria

(a) Membership part of IFPs

μ	F1	F2	F3	F4	F5	F6	F7	F8	F9
F1	1.00	0.88	0.72	0.45	0.86	0.62	0.77	0.62	0.57
F2	0.88	1.00	0.75	0.43	0.92	0.69	0.84	0.50	0.67
F3	0.72	0.75	1.00	0.68	0.77	0.71	0.69	0.48	0.57
F4	0.45	0.43	0.68	1.00	0.46	0.59	0.43	0.48	0.43
F5	0.86	0.92	0.77	0.46	1.00	0.75	0.82	0.52	0.65
F6	0.62	0.69	0.71	0.59	0.75	1.00	0.67	0.39	0.62
F7	0.77	0.84	0.69	0.43	0.82	0.67	1.00	0.49	0.67
F8	0.62	0.50	0.48	0.48	0.52	0.39	0.49	1.00	0.36
F9	0.57	0.67	0.57	0.43	0.65	0.62	0.67	0.36	1.00

(b) Non-membership part of IFPs

ν	F1	F2	F3	F4	F5	F6	F7	F8	F9
F1	0.00	0.12	0.28	0.55	0.14	0.38	0.23	0.38	0.42
F2	0.12	0.00	0.25	0.57	0.08	0.31	0.16	0.50	0.33
F3	0.28	0.25	0.00	0.32	0.23	0.29	0.31	0.52	0.43
F4	0.55	0.57	0.32	0.00	0.54	0.41	0.57	0.52	0.57
F5	0.14	0.08	0.23	0.54	0.00	0.25	0.18	0.48	0.34
F6	0.38	0.31	0.29	0.41	0.25	0.00	0.32	0.61	0.38
F7	0.23	0.16	0.31	0.57	0.18	0.33	0.00	0.51	0.32
F8	0.38	0.50	0.52	0.52	0.48	0.61	0.51	0.00	0.63
F9	0.42	0.33	0.43	0.57	0.34	0.38	0.33	0.63	0.00



After applying the ICA method, 36 IFPs are obtained, distributed as follows:

- 3 in “positive consonance”,
- 13 in “weak positive consonance”,
- 11 in “dissonance”, and
- 9 in “strong dissonance”.

Figure 3. Distribution of the IFPs plotted as points onto the intuitionistic fuzzy triangle

Discussion: Three pairs of criteria are in positive consonance: pair F2. “Operating income (total revenue)” – F5. “Material purchase cost”, pair F1. “Tuition (KRW)” – F2. “Operating income (total revenue) (KRW)”, and pair F1. “Tuition (KRW)” – F5. “Material purchase cost (KRW)”. This indicates that tuition fees (F1), total revenue (F2), and material purchase costs (F5) show

the strongest correlations and tend to vary in similar directions. These criteria reflect the core financial flows of the institutions, which logically leads to their similar behavior.

On the other hand, the considerable number of pairs falling into the dissonance and strong dissonance categories shows that the remaining financial indicators measure different aspects without clear overlap. This means that the group of F-criteria is structurally diverse, with each subgroup representing specific characteristics-revenues, donations, expenditures, remuneration, proportions, and others.

3.3 Application of InterCriteria Analysis to the data on Faculty and Teaching

From the application of ICA to the data on Faculty and teaching, we obtain the following output which presents the correlations between the different parameters for the investigated higher education institutions in the Republic of Korea: Table 4(a), (b), Figure 4.

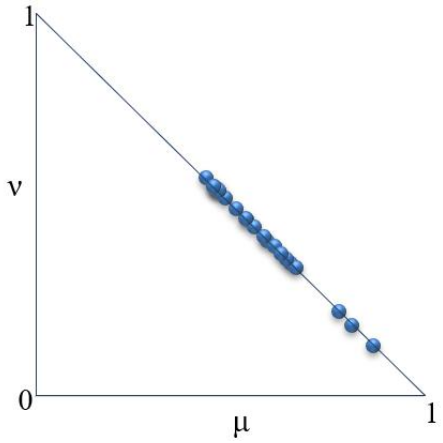
Table 4. ICA analysis of the Faculty and teaching, based on the data for the 7 criteria

(a) Membership part of IFPs

μ	T1	T2	T3	T4	T5	T6	T7
T1	1.00	0.82	0.55	0.47	0.87	0.46	0.60
T2	0.82	1.00	0.57	0.49	0.78	0.47	0.59
T3	0.55	0.57	1.00	0.62	0.47	0.54	0.66
T4	0.47	0.49	0.62	1.00	0.44	0.67	0.65
T5	0.87	0.78	0.47	0.44	1.00	0.46	0.52
T6	0.46	0.47	0.54	0.67	0.46	1.00	0.64
T7	0.61	0.61	0.67	0.66	0.53	0.64	1.00

(b) Non-membership part of IFPs

ν	T1	T2	T3	T4	T5	T6	T7
T1	0.00	0.18	0.45	0.53	0.13	0.54	0.40
T2	0.18	0.00	0.43	0.51	0.22	0.53	0.41
T3	0.45	0.43	0.00	0.38	0.53	0.46	0.34
T4	0.53	0.51	0.38	0.00	0.56	0.33	0.35
T5	0.13	0.22	0.53	0.56	0.00	0.54	0.48
T6	0.54	0.53	0.46	0.33	0.54	0.00	0.36
T7	0.39	0.39	0.33	0.34	0.47	0.36	0.00



After applying the ICA method, 21 IFPs are obtained, distributed as follows:

- 1 in “positive consonance”,
- 2 in “weak positive consonance”,
- 1 in “weak dissonance,
- 6 in “dissonance”, and
- 11 in “strong dissonance”.

Figure 4. Distribution of the IFPs plotted as points onto the intuitionistic fuzzy triangle

Discussion: The results show a clear pattern of correlation among the criteria in this group. The intuitionistic fuzzy pairs that fall into positive consonance indicate a strong positive relationship, meaning that these criteria tend to move in the same direction and capture related aspects of

institutional academic performance. The pair identified in positive consonance, namely, T1. “Number of full-time faculty members (persons)” – T5. “Scholarship (won)”, demonstrates a particularly notable alignment, suggesting that these two indicators reflect closely connected dimensions of the academic environment.

3.4 Application of InterCriteria Analysis to the data on Infrastructure and Facilities and Employment and Outcomes

From the application of ICA to the data on Infrastructure and facilities and Employment and outcomes, we obtain the following output which presents the correlations between the different parameters for the investigated higher education institutions in the Republic of Korea: Table 5(a), (b), Figure 5.

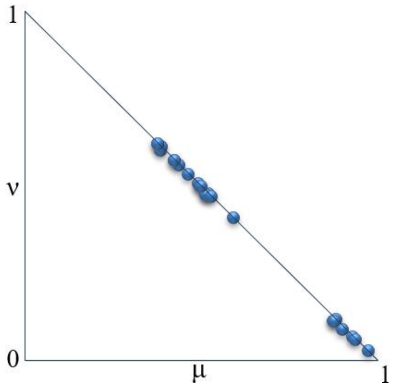
Table 5. ICA analysis of the Infrastructure and Facilities (5 criteria) and Employment and Outcomes (3 criteria)

(a) Membership part of IFPs

μ	I1	I2	I3	I4	I5	E1	E2	E3
I1	1.00	0.43	0.89	0.47	0.92	0.88	0.88	0.52
I2	0.43	1.00	0.38	0.59	0.38	0.37	0.37	0.49
I3	0.89	0.38	1.00	0.51	0.90	0.87	0.87	0.51
I4	0.47	0.59	0.51	1.00	0.44	0.42	0.42	0.46
I5	0.92	0.38	0.90	0.44	1.00	0.93	0.94	0.50
E1	0.88	0.37	0.87	0.42	0.93	1.00	0.97	0.53
E2	0.88	0.37	0.88	0.42	0.94	0.97	1.00	0.50
E3	0.52	0.49	0.51	0.46	0.50	0.53	0.50	1.00

(b) Non-membership part of IFPs

ν	I1	I2	I3	I4	I5	E1	E2	E3
I1	0.00	0.57	0.10	0.53	0.08	0.12	0.12	0.48
I2	0.57	0.00	0.60	0.41	0.61	0.62	0.62	0.51
I3	0.10	0.60	0.00	0.48	0.09	0.11	0.11	0.48
I4	0.53	0.41	0.48	0.00	0.56	0.58	0.58	0.54
I5	0.08	0.61	0.09	0.56	0.00	0.07	0.06	0.50
E1	0.12	0.62	0.11	0.58	0.07	0.00	0.03	0.47
E2	0.12	0.62	0.11	0.58	0.06	0.03	0.00	0.50
E3	0.48	0.51	0.48	0.54	0.50	0.47	0.50	0.00



After applying the ICA method, 28 IFPs are obtained, distributed as follows:

- 1 in “strong positive consonance”,
- 9 in “positive consonance”,
- 7 in “dissonance”, and
- 11 in “strong dissonance”.

Figure 5. Distribution of the IFPs plotted as points onto the intuitionistic fuzzy triangle

Discussion: The IFPs that are in positive consonance indicate strong positive correlation, showing that these criteria tend to move in the same direction and reflect related aspects of institutional performance. The one pair found in strong positive consonance, namely E1. “Employed persons (number of people)” – E2. “Graduates (number of people)”, shows very

high correlation, suggesting that these two indicators capture highly aligned dimensions of the academic environment.

Overall, the distribution of the correlations shows that the infrastructure-related indicators (I1, I3, I5) and the employment-related indicators (E1, E2) exhibit noticeable positive correlations with each other. This suggests that institutions with well-developed facilities and resources also tend to perform better in graduate output and employment.

3.5. Application of InterCriteria Analysis to the data on Research and Publications

From the application of ICA to the data on research and publications, we obtain the following output which presents the correlations between the different parameters for the investigated higher education institutions in the Republic of Korea: Table 6(a), (b), Figure 6.

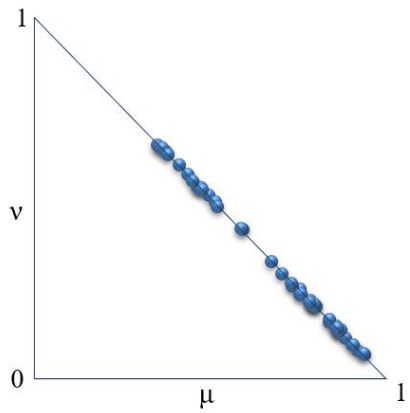
Table 6. ICA analysis of the Faculty and teaching, based on the data for 10 criteria

(a) Membership part of IFPs

μ	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
R1	1.00	0.59	0.83	0.78	0.41	0.85	0.83	0.75	0.67	0.78
R2	0.59	1.00	0.47	0.46	0.59	0.49	0.47	0.51	0.52	0.48
R3	0.83	0.47	1.00	0.93	0.35	0.90	0.91	0.79	0.73	0.86
R4	0.78	0.46	0.93	1.00	0.35	0.86	0.88	0.79	0.75	0.86
R5	0.41	0.59	0.35	0.35	1.00	0.37	0.36	0.43	0.45	0.38
R6	0.85	0.49	0.90	0.86	0.37	1.00	0.90	0.87	0.73	0.85
R7	0.84	0.48	0.91	0.88	0.36	0.90	1.00	0.80	0.75	0.93
R8	0.75	0.51	0.79	0.79	0.43	0.87	0.80	1.00	0.70	0.79
R9	0.67	0.52	0.73	0.75	0.45	0.73	0.75	0.70	1.00	0.78
R10	0.78	0.48	0.86	0.86	0.38	0.85	0.93	0.79	0.78	1.00

(b) Non-membership part of IFPs

ν	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
R1	0.00	0.41	0.16	0.21	0.59	0.15	0.16	0.25	0.32	0.22
R2	0.41	0.00	0.53	0.53	0.41	0.50	0.52	0.49	0.47	0.52
R3	0.16	0.53	0.00	0.07	0.64	0.09	0.08	0.20	0.25	0.13
R4	0.21	0.53	0.07	0.00	0.64	0.13	0.11	0.20	0.23	0.13
R5	0.59	0.41	0.64	0.64	0.00	0.62	0.63	0.56	0.54	0.62
R6	0.15	0.50	0.09	0.13	0.62	0.00	0.09	0.13	0.26	0.14
R7	0.16	0.52	0.08	0.11	0.63	0.09	0.00	0.20	0.23	0.07
R8	0.25	0.49	0.20	0.20	0.56	0.13	0.20	0.00	0.29	0.20
R9	0.32	0.47	0.25	0.23	0.54	0.26	0.23	0.29	0.00	0.21
R10	0.22	0.52	0.13	0.13	0.62	0.14	0.07	0.20	0.21	0.00



After applying the ICA method, 45 IFPs are obtained, distributed as follows:

- 12 in “positive consonance”,
- 12 in “weak positive consonance”,
- 3 in “weak dissonance”,
- 9 in “dissonance”, and
- 9 in “strong dissonance”.

Figure 6. Distribution of the IFPs plotted as points onto the intuitionistic fuzzy triangle

Discussion: The IFPs in Positive Consonance (R3–R4, R7–R10, R3–R7, R3–R6, R6–R7, R4–R7, R4–R6, R4–R10, R3–R10, R6–R8, R6–R10, R1–R6) show a logical and expected relationship: institutions that publish more typically also have larger research budgets. This suggests a stable and consistent relationship between research activity (criteria (R1–R4)) and the financial support (R6–R10) allocated for research work. Here, it is possible to reduce some of the criteria.

The criteria related to standardized evaluations and low-level publications (R2, R5, R9) exhibit clear independence and distinct behavior compared to the rest. They provide unique information and therefore should not be eliminated.

3.6 Application of InterCriteria Analysis to all data

The analysis of cross-group intuitionistic fuzzy pairs reveals several strong positive correlations between Academic & Student Body indicators (such as A3, A4, A5, A7, A8, A9, A16, A17) and indicators from Infrastructure (I5), Faculty & Teaching (T2), and Employment (E1–E2). These links show that institutions with a larger student population and higher enrollment flows tend to have better infrastructure capacity, higher instructional workload, and stronger graduate employment outcomes. A number of strong relationships also appear between Academic indicators and specific Finance criteria (e.g., F7), suggesting that institutional scale is tightly connected with financial and teaching resources. Overall, cross-group correlations demonstrate that several dimensions of institutional performance-scale, infrastructure, faculty load, and employment-reinforce each other and form a coherent systemic cluster.

4 Conclusion

The application of InterCriteria Analysis to data from the university ranking system in the Republic of Korea reveals consistent patterns of correlation both within and across thematic groups. The results highlight clusters of indicators that change in close correlation and reflect overlapping dimensions of institutional effectiveness, as well as indicators that provide unique and non-overlapping information. On this basis, some groups of highly correlated indicators can be reduced to optimize the rating methodology without compromising interpretive value.

At the same time, indicators such as A1, A2, R2, R5, R9 and others that have a clear independent contribution should be retained as key elements of the evaluation framework. Overall, the study shows that ICA can effectively support the optimization, simplification and improvement of higher education institutions' evaluation systems.

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