InterCriteria Analysis of the Most Problematic Factors for Doing Business in the European Union, 2017–2018

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Abstract. In this paper, we use the method of the InterCriteria Analysis, based on the concepts of intuitionistic fuzzy sets and index matrices, to analyze a dataset extracted from the Global Competitiveness Index, concerning the most problematic factors for doing business in the European Union member states. The method is applied on the data of these 28 countries extracted from the Global Competitiveness Report 2017–2018.

Keywords: InterCriteria Analysis, Global Competitiveness Index, Problematic factors for doing business, Intuitionistic fuzzy sets, Decision making, Uncertainty.

1   Introduction

Every year, the World Economic Forum (WEF) releases its Global Competitiveness Index report (GCI), which aims to be one of the most in-depth looks into the financial health and risks of nearly 140 countries around the world. It integrates twelve macroeconomic and the micro/business aspects of competitiveness into a single index, based on more than 100 subindicators that capture concepts that matter for productivity and long-term prosperity. GCI defines its purpose as a common framework populated with comparable data that allows national policy makers to monitor their annual progress along some long-term determinants of productivity, growth, income levels, and well-being.

In the reports produced until 2018 [15], in addition to the countries' performance along these twelve 'pillars of competitiveness', charts were provided summarizing those factors seen by business executives as the most problematic for doing business in their economy. The information was drawn from the World Economic Forum's Executive Opinion Survey, where respondents were asked to select the five most problematic of a list of 16 factors, and rank them from 1 (most problematic) to 5. The results were then tabulated and weighted according to the ranking assigned by respondents

[15]. As of the end of 2018, WEF restructured the methodology of the GCI, now labeled '4.0' [16], which does not include the charts of most problematic factors for doing business. Nevertheless, the availability and relevance of these data has motivated us to explore the relations between these sixteen factors, and for this purpose we used the instrumentation of the InterCriteria Analysis (ICA), which is based on the two underlying concepts of intuitionistic fuzzy sets and of index matrices, [1, 2]. It is noteworthy that ICA has been used in a series of research of data from the GCI [5, 7, 9] aimed at detecting relations between the twelve pillars of competitiveness of national economies, with some interesting and consistent results obtained over time. This is in line with the WEF's traditional appeal to policy makers to identify priorities based on the nation's economic performance, while also understanding the drivers of competitiveness and the underlying relations between them.

This paper is structured as follows. In Section 2, we describe shortly the intuitionistic fuzzy sets and the ICA method. In Section 3, we present the input data that will be analyzed with the proposed method. Section 4 contains the result of the application of ICA onto the presented input data, as well as discussion on the findings. The last section draws some conclusions and ideas of further research.

2 Presentation of the method

InterCriteria Analysis (ICA) was originally introduced in 2014 as a method for detecting existing patterns and dependencies similar to correlation, between a set of criteria based on the evaluations of a set of objects against these criteria. A detailed presentation of the method is given in [2, 10]. The original motivation behind the method was derived from an problem from the field of industrial petro-chemistry, where some of the criteria were slower and/or more expensive to evaluate than others, and the decision maker's aim was to accelerate or lower the cost of the overall decision making process by eliminating the costly criteria on the basis of some detected correlations between them and the cheaper and faster ones. The method is based on intuitionistic fuzzy sets in order to render account of uncertainty, and returns as output a table of detected dependencies between any pair of criteria in the form of intuitionistic fuzzy pairs [3], i.e. tuples of numbers in the [0, 1]-interval, whose sum belongs to that interval as well and stay respectively for the intuitionistic fuzzy functions of membership and the non-membership. These tuples are then interpreted as presence of pairwise correlation between the respective pair of criteria (termed 'positive consonance'), or lack of correlation (termed 'negative consonance'), or uncertainty (termed 'dissonance'). Based on the decision maker's expertise and/or an algorithm (see [10]), the thresholds for the membership and the non-membership are set as two numbers in the [0, 1]-interval, and these are a problem-specific. Equipped with these thresholds and the method's ability to render account of the uncertainty, the decision maker can now decide if the pairwise positive consonances between the targeted criteria are high enough and whether the 'expensive' criteria can be eliminated from the further decision making process without compromising precision.

3   Presentation of the input data

The input data comes in the form of a matrix of 28 labeled rows staying for the analyzed European Union member states and 16 labeled columns with the most problematic factors for doing business (MPFDB) in these countries, namely, 'Access to financing' (ATF), 'Corruption' (COR), 'Crime and theft' (CAT), 'Foreign currency regulations' (FCR), 'Government instability/coups' (GIC), 'Inadequate supply of infrastructure' (ISI), 'Inadequately educated workforce' (IEW), 'Inefficient government bureaucracy' (IGB), 'Inflation' (INF), 'Insufficient capacity to innovate' (ICI), 'Policy instability' (PIN), 'Poor public health' (PPH), 'Poor work ethic in national labor force' (PWE), 'Restrictive labor regulations' (RLR), 'Tax rates' (TRA), 'Tax regulations' (TRE). We note that some of these factors are closely related to the defined twelve pillars of competitivess in the 2017–2018 GCI, for instance Pillar 1 'Institutions', Pillar 7 'Labor market efficiency' or Pillar 12 'Innovation'.

Table 1 shows the input dataset, which is condition-ally formatted in a way to show the intensity of the problematic factor, as identified by the survey respondents. While the EU comprise member states in different stages of economic development (with one Stage 2 'Efficiency-driven' economy, Bulgaria, twenty Stage 3 'Innovation-driven' economies and seven transition Stage 2 to Stage 3 economies), the rather harmonized legislation of the 28 and their union political and economic union explains the relatively homogeneous performance with respect to the least and the most problematic factors, as seen on the average. The least problematic factors for the EU member states in 2017–2018 were 'Foreign currency regulations', 'Crime and theft', 'Poor public health' and 'Inflation' with 0.73% to 1.12% of average weight, and the most problematic factors were 'Tax regulations', 'Restrictive labor regulations', 'Inefficient government bureaucracy' and 'Tax rates', with 10.21% to 14.88% of average weight. This information will serve when analyzing the results of the application of ICA on the data, as the least problematic factors will be excluded from the discussion.

Table 1. ICA input with data for the 28 EU member states in 2017–2018 (objects) against the 16 most problematic factors for doing business (criteria), in %, as sorted by 'Average'

	Austria	Belgium	Bulgaria	Croatia	Cyprus	Czech Rep.	Denmark	Estonia	Finland	France	Germany	Greece	Hungary	Ireland	Italy	Latvia	Lithuania	Luxembourg	Malta	Netherlands	Poland	Portugal	Romania	Slovak Rep.	Slovenia	Spain	Sweden	UK	Average
FCR	0.4	0.1	0.3	0.3	1.7	0.3	0.3	0.0	1.2	1.1	4.0	0.5	0.7	2.5	0.0	0.0	0.0	0.2	2.0	0.8	0.8	0.3	0.0	0.5	0.7	0.1	1.0	0.6	0.7
CAT	0.0	0.0	2.5	2.4	0.3	0.8	1.8	0.5	0.0	0.0	3.8	0.1	2.0	0.7	1.3	0.8	0.3	0.0	0.0	2.7	0.7	0.0	1.1	0.6	0.0	0.0	1.4	1.2	0.8
PPH	0.2	0.3	0.8	0.0	2.3	0.0	1.5	0.3	0.0	0.0	3.1	0.7	4.3	2.9	0.1	1.8	0.0	0.1	0.2	1.5	0.1	1.0	0.3	0.6	0.9	1.0	1.0	1.0	1.0
INF	0.7	0.4	3.3	0.0	0.5	0.2	0.9	1.9	0.3	0.2	4.5	0.0	1.0	2.1	0.0	0.5	1.6	3.9	0.7	0.7	0.6	0.5	1.7	0.1	0.3	1.0	2.8	0.9	1.1
GIC	0.7	1.7	5.9	3.3	0.7	2.6	3.1	9.4	2.0	2.1	4.7	10.8	0.4	8.8	3.8	3.5	4.7	0.0	2.3	1.6	6.5	2.8	4.3	1.6	2.1	3.4	5.2	3.5	3.6
PWE	3.6	1.6	8.8	3.2	3.4	1.8	6.0	7.5	0.6	2.6	5.8	0.8	7.2	1.2	1.6	4.6	3.2	3.9	9.8	2.6	3.3	1.2	6.5	4.3	4.9	3.2	3.8	5.6	4.0
ISI	1.4	4.4	3.4	1.4	10.9	4.6	5.1	5.7	0.8	0.9	5.4	2.0	3.0	17.7	5.5	2.6	2.6	9.8	11.7	2.0	4.0	1.2	10.1	6.9	2.3	2.0	4.9	9.3	5.0
COR	0.1	0.4	17.8	11.5	7.7	9.6	0.5	2.2	0.0	1.8	3.2	5.5	14.9	0.0	4.6	8.0	4.6	0.9	7.9	0.6	1.5	3.2	11.7	19.1	5.4	5.0	1.6	0.0	5.3
ICI	5.1	6.4	2.9	5.2	11.1	6.7	4.6	7.9	8.9	5.9	6.4	1.4	5.7	7.5	5.3	2.8	3.7	8.7	12.4	8.8	3.3	4.8	2.8	3.9	3.8	11.3	3.5	8.4	6.0
PIN	3.5	5.2	6.7	13.4	2.8	9.8	3.2	4.3	6.1	7.7	4.8	13.8	4.3	8.2	7.2	5.2	0.0	3.0	3.2	11.5	13.1	6.1	5.2	8.4	7.4	3.0	11.3	9.2	6.7
ATF	2.1	5.0	8.5	5.0	19.5	2.8	9.3	5.4	7.7	6.5	3.9	10.0	7.9	9.7	9.6	7.1	5.3	6.1	11.7	8.6	6.9	10.2	11.9	0.8	7.7	9.6	4.9	8.6	7.6
IEW	5.8	4.1	8.2	3.7	5.1	7.3	9.5	17.9	1.7	3.1	8.1	0.5	15.2	3.6	3.4	7.5	9.7	23.5	11.2	11.3	7.0	4.5	11.9	8.5	4.4	6.9	9.3	10.3	8.0
TRE	11.3	16.0	5.3	12.4	2.8	17.6	13.3	3.6	11.7	17.6	10.7	14.1	9.8	3.6	13.0	11.7	8.3	3.7	10.2	17.6	6.5	3.1	10.1	10.8	5.4	13.4	11.9	10.1	10.2
RLR	23.2	16.1	4.3	5.0	10.2	8.3	10.3	5.6	27.3	19.1	10.5	1.2	3.2	7.0	11.0	4.4	13.2	18.9	5.0	18.0	12.5	13.8	1.8	8.8	13.9	13.5	14.8	6.3	11.0
IGB	21.3	14.6	12.0	21.8	19.4	16.9	10.9	8.5	9.8	11.8	9.0	18.1	6.3	11.9	17.6	18.2	15.6	11.1	14.6	15.5	8.4	19.1	12.9	15.7	16.5	15.2	6.9	10.5	13.9
TRA	20.4	23.7	9.3	11.0	1.7	10.9	20.5	18.1	21.5	19.6	12.1	20.3	10.4	16.7	17.3	17.9	17.6	4.8	4.0	13.1	13.8	18.7	13.0	13.6	18.2	15.1	22.6	10.6	14.9

4 Main results and discussion

The input data from Table 1 was analyzed with the software for ICA, developed by D. Mavrov [12, 13], freely available from the website `http://intercriteria.net`, [17]. The output represents two tables, Table 2 (a) and (b), for the membership and the non-membership parts of the IFPs, respectively, that stand collectively for the IF consonance / dissonance between any pair of criteria. While the input is objects (28 countries) against criteria (here, 16 MPFDBs), the output is two 16×16 matrices. Along the main diagonals of the two tables, all elements of the membership table are 1's and all elements of the non-membership table are 0's thus producing ⟨1,0⟩'s as the IFPs, i.e. the intuitionistic fuzzy perfect 'truth', as every criterion correlates perfectly with itself. Also, the two tables are symmetrical according to the main diagonals, since the ICA method mandates that the intercriteria consonance between two criteria C_i and C_j is identical with the intercriteria consonance between C_j and C_i.

Table 2. Results of the InterCriteria Analysis from the input of Table 1: (a) the membership elements of the IF pairs, (b) the non-membership elements of the IF pairs

(a)	Crime and theft	Foreign currency regulations	Poor public health	Inflation	Poor work ethic in national labor force	Government instability/coups	Insufficient capacity to innovate	Policy instability	Tax regulations	Inadequate supply of infrastructure	Corruption	Access to financing	Inefficient government bureaucracy	Inadequately educated workforce	Tax rates	Restrictive labor regulations
CAT	1.000	0.434	0.571	0.526	0.553	0.540	0.365	0.450	0.444	0.503	0.526	0.423	0.376	0.558	0.323	0.288
FCR	0.434	1.000	0.492	0.463	0.442	0.399	0.577	0.397	0.471	0.481	0.397	0.471	0.368	0.405	0.426	0.532
PPH	0.571	0.492	1.000	0.624	0.595	0.627	0.386	0.455	0.402	0.587	0.484	0.521	0.333	0.545	0.431	0.320
INF	0.526	0.463	0.624	1.000	0.661	0.558	0.505	0.283	0.339	0.611	0.407	0.489	0.278	0.722	0.405	0.466
PWE	0.553	0.442	0.595	0.661	1.000	0.492	0.447	0.373	0.368	0.643	0.608	0.481	0.376	0.767	0.339	0.336
GIC	0.540	0.399	0.627	0.558	0.492	1.000	0.344	0.577	0.513	0.542	0.487	0.537	0.413	0.463	0.548	0.328
ICI	0.365	0.577	0.386	0.505	0.447	0.344	1.000	0.352	0.370	0.574	0.376	0.540	0.458	0.519	0.384	0.590
PIN	0.450	0.397	0.455	0.283	0.373	0.577	0.352	1.000	0.630	0.323	0.563	0.503	0.574	0.328	0.511	0.402
TRE	0.444	0.471	0.402	0.339	0.368	0.513	0.370	0.630	1.000	0.323	0.410	0.310	0.492	0.365	0.675	0.579
ISI	0.503	0.481	0.587	0.611	0.643	0.542	0.574	0.323	0.323	1.000	0.516	0.540	0.413	0.669	0.312	0.344
COR	0.526	0.397	0.484	0.407	0.608	0.487	0.376	0.563	0.410	0.516	1.000	0.511	0.601	0.548	0.328	0.262
ATF	0.423	0.471	0.521	0.489	0.481	0.537	0.540	0.503	0.310	0.540	0.511	1.000	0.542	0.476	0.426	0.386
IGB	0.376	0.368	0.333	0.278	0.376	0.413	0.458	0.574	0.492	0.413	0.601	0.542	1.000	0.357	0.505	0.476
IEW	0.558	0.405	0.545	0.722	0.767	0.463	0.519	0.328	0.365	0.669	0.548	0.476	0.357	1.000	0.331	0.399
TRA	0.323	0.426	0.431	0.405	0.339	0.548	0.384	0.511	0.675	0.312	0.328	0.426	0.505	0.331	1.000	0.669
RLR	0.288	0.532	0.320	0.466	0.336	0.328	0.590	0.402	0.579	0.344	0.262	0.386	0.476	0.399	0.669	1.000

(b)	Crime and theft	Foreign currency regulations	Poor public health	Inflation	Poor work ethic in national labor force	Government instability/coups	Insufficient capacity to innovate	Policy instability	Tax regulations	Inadequate supply of infrastructure	Corruption	Access to financing	Inefficient government bureaucracy	Inadequately educated workforce	Tax rates	Restrictive labor regulations
CAT	0.000	0.405	0.288	0.347	0.328	0.349	0.526	0.426	0.439	0.381	0.357	0.468	0.524	0.339	0.574	0.606
FCR	0.405	0.000	0.397	0.439	0.479	0.524	0.360	0.519	0.452	0.447	0.532	0.455	0.566	0.532	0.511	0.402
PPH	0.288	0.397	0.000	0.299	0.336	0.307	0.556	0.476	0.537	0.347	0.450	0.421	0.611	0.402	0.516	0.624
INF	0.347	0.439	0.299	0.000	0.288	0.394	0.455	0.661	0.619	0.341	0.545	0.471	0.685	0.243	0.561	0.497
PWE	0.328	0.479	0.336	0.288	0.000	0.479	0.532	0.590	0.603	0.328	0.362	0.492	0.606	0.217	0.646	0.646
GIC	0.349	0.524	0.307	0.394	0.479	0.000	0.638	0.389	0.460	0.431	0.487	0.439	0.571	0.524	0.439	0.656
ICI	0.526	0.360	0.556	0.455	0.532	0.638	0.000	0.622	0.611	0.407	0.606	0.444	0.534	0.476	0.611	0.402
PIN	0.426	0.519	0.476	0.661	0.590	0.389	0.622	0.000	0.341	0.643	0.402	0.466	0.402	0.651	0.468	0.574
TRE	0.439	0.452	0.537	0.619	0.603	0.460	0.611	0.341	0.000	0.651	0.563	0.667	0.492	0.622	0.312	0.405
ISI	0.381	0.447	0.347	0.341	0.328	0.431	0.407	0.643	0.651	0.000	0.458	0.437	0.571	0.317	0.675	0.640
COR	0.357	0.532	0.450	0.545	0.362	0.487	0.606	0.402	0.563	0.458	0.000	0.466	0.384	0.439	0.659	0.722
ATF	0.468	0.455	0.421	0.471	0.492	0.439	0.444	0.466	0.667	0.437	0.466	0.000	0.444	0.513	0.563	0.601
IGB	0.524	0.566	0.611	0.685	0.606	0.571	0.534	0.402	0.492	0.571	0.384	0.444	0.000	0.640	0.492	0.519
IEW	0.339	0.532	0.402	0.243	0.217	0.524	0.476	0.651	0.622	0.317	0.439	0.513	0.640	0.000	0.669	0.598
TRA	0.574	0.511	0.516	0.561	0.646	0.439	0.611	0.468	0.312	0.675	0.659	0.563	0.492	0.669	0.000	0.328
RLR	0.606	0.402	0.624	0.497	0.646	0.656	0.402	0.574	0.405	0.640	0.722	0.601	0.519	0.598	0.328	0.000

We can thus only concentrate on the 120 unique intercriteria pairs. Following the already established practice in the ICA research (see e.g. [5, 7, 9]), we graphically visualise the resultant intercriteria pairs as points on the intuitionistic fuzzy interpretational triangle [4, 8, 11], thus giving perception of what does the respective intuitionistic fuzzy set look like (Figure 1). Many of the points belong to the hypotenuse (intuitionistic fuzzy values flattened to fuzzy), but also some are inside the triangle, i.e. their uncertainty, or hesitation margin is non-zero.
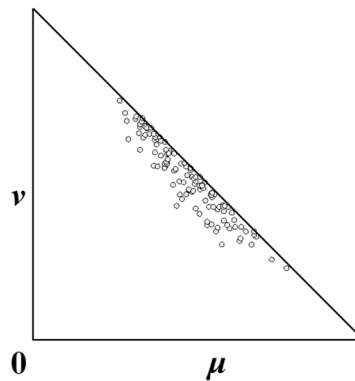

Fig. 1. Results of the InterCriteria Analysis (Table 2 (a, b)) plotted as points on the IF triangle.

In the Table 3 below, we will outline the top 10% of the ICA positive consonance pairs from Table 2.

Table 3. Top 10% of ICA positive consonance pairs, sorted according in ascending order to their distance to $\langle 1,0 \rangle$

C_i	C_j	μ	v	d
Poor work ethic in national labor force	Inadequately educated workforce	0.767	0.217	0.318
Inflation	Inadequately educated workforce	0.722	0.243	0.369
Inflation	Poor work ethic in national labor force	0.661	0.288	0.445
Tax regulations	Tax rates	0.675	0.312	0.451
Inadequate supply of infrastructure	Inadequately educated workforce	0.669	0.317	0.458
Tax rates	Restrictive labor regulations	0.669	0.328	0.466
Poor public health	Inflation	0.624	0.299	0.480
Poor public health	Government instability/coups	0.627	0.307	0.483
Poor work ethic in national labor force	Inadequate supply of infrastructure	0.643	0.328	0.485
Policy instability	Tax regulations	0.630	0.341	0.504
Crime and theft	Poor public health	0.571	0.288	0.517
Inflation	Inadequate supply of infrastructure	0.611	0.341	0.517

It is noteworthy that the top three pairs are formed between 3 of the 16 factors, 'Poor work ethic in national labor force', 'Inadequately educated work-force' and 'Inflation' with consonances in the IFPs $\langle 0.767; 0.217 \rangle$, $\langle 0.722; 0.243 \rangle$, $\langle 0.661; 0.288 \rangle$, thus forming and intercriteria correlation triple, as described in [6, 14]. However, as we discussed in the previous section, four of the 16 factors, namely, 'Foreign currency regulations', 'Crime and theft', 'Poor public health' and 'Inflation', at least in the context of EU, have little to no weight. Hence, we remove them from the significant detected ICA consonances. On the other hand, four other factors, 'Tax regulations', 'Restrictive labor regulations', 'Inefficient government bureaucracy' and 'Tax rates' are ranked highest among the EU member states. Thus, the other IFPs in the top 10% are 'Tax regulations' and 'Tax rates' ranking with $\langle 0.675; 0.312 \rangle$; 'Tax rates' and 'Restrictive labor regulations' with $\langle 0.669; 0.328 \rangle$; and 'Tax regulations' and 'Policy instability' with $\langle 0.630; 0.341 \rangle$.

5   Conclusion

In the present paper, we apply the method of Inter-Criteria Analysis on the weighted data about the 16 most problematic factors for doing business, measured in the 28 European Union member states, as derived from the 2017–2018 Global Competitive-ness Index of the World Economic Forum. The aim of the research is to identify, using this novel intuitionistic fuzzy sets-based method how these sixteen factors are related to each other, which can be indicative of what changes EU and its national economies are subject to if they are to foster their competitiveness and innovation, in the light of the

World Economic Forum's traditional appeal to the national policy makers to identify the transformative forces in the national economies and strengthen them to drive future economic growth. While numerous research using the ICA method has been dedicated to the analysis of the twelve pillars of competitiveness in the WEF's methodology over the years, the present leg of research is the first that addresses these most problematic factors for doing business. Although in different annual editions of the Global Competitiveness Index these factors have been formulated with slight variations, and as of the 2018 Global Competitiveness Index v. 4.0, they have been completely dropped out of the report, we consider researching these factors useful and insightful, and encourage the national policy makers to consider the results presented of the detected relations in between them when building the future policies in this regard.

Acknowledgement

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