Notes on Intuitionistic Fuzzy Sets
Print ISSN 1310–4926, Online ISSN 2367–8283
Vol. 23, 2017, No. 3, 54–68

Intercriteria analysis and comparison of innovation-driven and efficiency-to-innovation-driven economies in the European Union

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Received: 19 June 2017 **Accepted:** 20 July 2017

Abstract: Intercriteria analysis is applied here to data from the World Economic Forum's Global Competitiveness Reports about the 28 member states of the European Union, divided and compared according to their stage of development from efficiency-driven to innovation-driven economies. On the basis of our previous research of the interrelations between the twelve pillars of competitiveness across all the countries in the EU as a whole union, we are interested here to analyze and compare the interrelations between the twelve pillars using separately the data about the 21 innovation-driven economies in the union, and the rest 7 which are in the efficiency-driven or the efficiency-to-innovation-driven transition state of development. Specific findings are outlined and commented. As a perspective next step of research, this analysis can be extended to a global level comparing the performance of the countries in each of these three stages of development and the two transition ones.

Keywords: Intercriteria analysis, Intuitionistic fuzzy sets, Correlation, Competitiveness, Global competitiveness report, Efficiency-driven economy, Innovation-driven economy.
AMS Classification: 03E72.

To our good friend and colleague
Prof. Janusz Kacprzyk
for his 70th anniversary!

1 Introduction

The World Economic Forum defines competitiveness as the set of institutions, policies, and factors that determine the level of productivity of a country. The level of productivity, in turn, sets the level of prosperity that can be reached by an economy, and defines the rates of return obtained by investments in an economy, which in turn are the fundamental drivers of its growth rates. This said, the more competitive economies are those that are likely to grow faster over time. The Global Competitiveness Index captures these trends by including a weighted average of many different components, each measuring a different aspect of competitiveness. The components are grouped into 12 categories, called "pillars of competitiveness": 1. Institutions; 2. Infrastructure; 3. Macroeconomic environment; 4. Health and primary education; 5. Higher education and training; 6. Goods market efficiency; 7. Labor market efficiency; 8. Financial market development; 9. Technological readiness; 10. Market size; 11. Business sophistication; 12. Innovation.

Although all of the pillars matter to a certain extent for all economies, they affect different economies in different ways. In line with well-known economic theory of stages of development, the GCI assumes that, in the first stage, the economy is *factor-driven* and countries compete based on their factor endowments — primarily unskilled labor and natural resources. Competitiveness at this stage of development is primarily maintained due to well-functioning institutions (1st pillar), a well-developed infrastructure (2nd pillar), a stable macroeconomic environment (3rd pillar), and a healthy workforce that has received at least a basic education (4th pillar).

As a country becomes more competitive, with increased productivity and wages, it moves into the *efficiency-driven* stage of development, when it must begin to develop more-efficient production processes and increase product quality. At this point, competitiveness is increasingly driven by higher education and training (5th pillar), efficient goods markets (6th pillar), well-functioning labor markets (7th pillar), developed financial markets (8th pillar), the ability to harness the benefits of existing technologies (9th pillar), and a large domestic or foreign market (10th pillar).

Finally, as countries move into the *innovation-driven* stage, the ability to sustain higher wages and the associated standard of living is only possible if their businesses are able to compete using the most sophisticated production processes (11th pillar) and by developing new and innovative ones (12th pillar).

The GCI takes the stages of development into account by attributing higher relative weights to those pillars that are more relevant for an economy given its particular stage of development. To implement this concept, the pillars are organized into three subindexes (groups), each critical to a particular stage of development. Any countries falling between two of the three stages are considered to be "in transition." For these countries, the weights change

smoothly as a country develops, reflecting the smooth transition from one stage of development to another, [14, p.37].

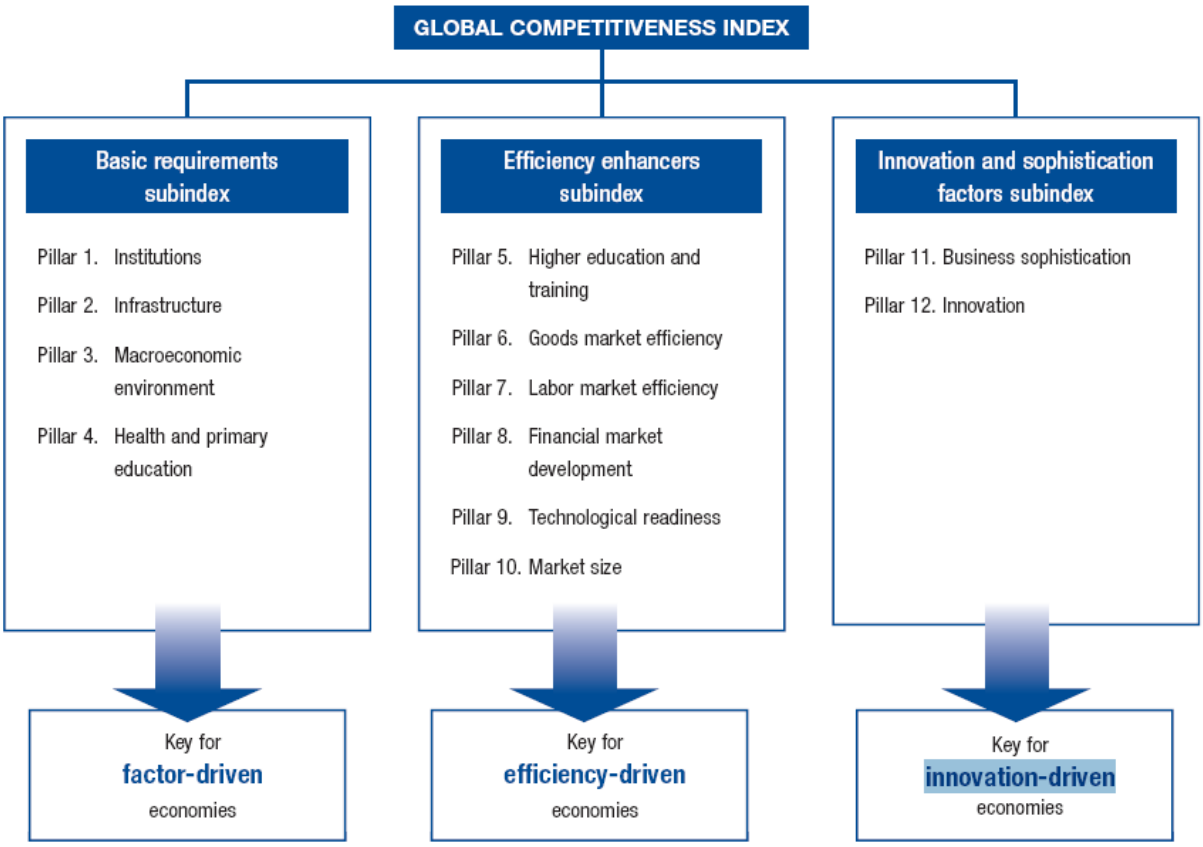

Figure. The Global Competitiveness Index framework, [14, p. 6]

In the 2015–2016 GCR we read: "*Although we report the results of the 12 pillars of competitiveness separately, it is important to keep in mind that they are not independent: they tend to reinforce each other, and a weakness in one area often has a negative impact in others.*" [14, p. 37]. This is an evidence that it is worth researching the interrelation of the 12 pillars, since it can give us better understanding and knowledge of the processes, driving economies forward, and as an appropriate tool for researching this interrelation, we use the apparatus of Intercriteria Analysis.

2 Problem statement

From the data in The Global Competitiveness Report 2015–2016 [14, p. 38] there are 35 countries in the world in stage 1 "Factor-driven economies"; 16 countries are in the transition from stage 1 to stage 2; 31 countries are in stage 2 "Efficiency-driven economies"; 20 countries are in the transition from stage 2 to stage 3; and 38 countries are in the stage 3 "Innovation-driven economies".

In the European Union, which is a political and economic union of 28 member states, 21 countries are in the innovation-driven stage, and 7 (i.e., one-fourth) are currently in either the efficiency-driven stage or in the transition between both stages.

This difference in the EU members profile and stage of development raises the question about how the twelve pillars of competitiveness vary among the innovation-driven economies and the efficiency-driven and transition ones, and formulated a particular problem for investigation with the apparatus of InterCriteria Analysis (ICA, [1]). Moreover, with this problem statement we are motivated here for the first time to show how the intercriteria pairs, plotted as points on the intuitionistic fuzzy triangle [3] can be grouped per criterion, and analyse and compare the clusters they form.

3 Input datasets

While in previous legs of the ICA research over datasets of the EU member states' competitiveness (e.g. [4, 5, 6]), we have been interested in the annual performance of the EU as a whole political and economic union, here we divide the set in two disjoint subsets of countries and analyze them separately in order to compare the results of the application of ICA over each of them separately. In order to achieve better representability and precision, we use data from the last 3 years, extracted from the World Economic Forum's Global Competitiveness Reports for the 28 EU members, [13, 14, 15].

The subset of 21 innovation-driven economies in the EU comprises: Austria, Belgium, Cyprus, Czech Rep., Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, Netherlands, Portugal, Slovak Rep., Slovenia, Spain, Sweden, UK (Table 1).

Table 1: GCI for the 21 innovation-driven economies in EU, years 2014–2017

Countries (ICA objects)	**Year**	**Pillars of competitiveness (ICA Criteria)**											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Austria	**2016/2017**	5.2	5.8	5.5	6.4	5.8	4.9	4.5	4.5	5.7	4.5	5.5	5
Belgium		5.2	5.5	4.8	6.7	6	5.2	4.5	4.7	6	4.7	5.4	5
Cyprus		4	4.4	3.8	6.2	4.6	4.7	4.4	3.2	4.6	2.8	4	3.2
Czech Rep.		4.2	4.7	5.9	6.3	5.2	4.7	4.5	4.7	5.5	4.4	4.5	3.8
Denmark		5.5	5.6	5.9	6.4	5.9	5.1	5.1	4.8	6.1	4.2	5.4	5.1
Estonia		5.1	5	6.1	6.5	5.5	5.1	5	4.8	5.4	3	4.3	4.1
Finland		6.1	5.3	5.1	6.9	6.2	5.1	4.8	5.5	6	4.1	5.3	5.7
France		4.9	6.1	4.7	6.4	5.5	4.7	4.4	4.6	5.9	5.7	5.2	4.9
Germany		5.2	6.1	6	6.5	5.6	5	4.8	4.9	6.1	6	5.6	5.6
Greece		3.8	4.8	2.9	6.1	4.9	4.2	3.8	2.5	5	4.2	3.9	3.3
Ireland		5.6	5.2	5.2	6.5	5.7	5.4	5.1	4	6.1	4.3	5.2	4.8
Italy		3.5	5.4	4.2	6.4	4.9	4.3	3.6	3.1	5	5.6	4.8	3.9
Luxembourg		5.8	5.7	6.2	6.2	4.8	5.5	5	5	6.4	3.2	5.2	4.9
Malta		4.5	4.7	5.8	6.4	5	4.7	4.5	4.4	5.8	2.5	4.3	3.7
Netherlands		5.7	6.4	5.7	6.7	6.1	5.4	5.1	4.5	6.2	5.1	5.6	5.4
Portugal		4.3	5.5	3.7	6.4	5	4.7	4.3	3.3	5.6	4.3	4.2	3.9
Slovak Rep.		3.5	4.2	5.3	6	4.5	4.5	4	4.6	4.8	4	4.1	3.3
Slovenia		4.1	4.8	4.9	6.5	5.4	4.6	4.1	3.2	5.2	3.3	4.2	3.9
Spain		4.1	5.9	4.3	6.3	5.1	4.5	4.2	4	5.6	5.4	4.5	3.8

Sweden		5.9	5.6	6.3	6.4	5.6	5.3	4.9	5.2	6.3	4.6	5.6	5.5
UK		5.5	6	4.4	6.5	5.5	5.3	5.5	4.9	6.3	5.7	5.6	5
Austria	**2015/2016**	5.2	5.7	5.1	6.4	5.6	4.9	4.5	4.2	5.6	4.6	5.4	4.9
Belgium		5.2	5.5	4.8	6.7	5.9	5.1	4.3	4.4	5.9	4.8	5.3	5
Cyprus		4.3	4.5	4.2	6.4	4.9	4.8	4.5	3.4	4.6	2.9	4.2	3.6
Czech Rep.		4.1	4.7	6	6.3	5.1	4.6	4.4	4.6	5.4	4.5	4.5	3.8
Denmark		5.5	5.5	6.3	6.4	5.8	5	5.1	4.6	6.1	4.3	5.4	5.1
Estonia		5	4.9	6.2	6.3	5.5	4.9	5	4.6	5.3	3.1	4.3	4
Finland		6.1	5.4	5.4	6.9	6.1	5	4.7	5.4	6	4.2	5.3	5.7
France		4.8	6	4.7	6.4	5.3	4.6	4.4	4.5	5.9	5.8	5.1	4.9
Germany		5.2	6.1	6	6.5	5.6	4.9	4.6	4.7	6	6	5.7	5.5
Greece		3.7	4.8	3.3	6.1	4.8	4.2	3.7	2.8	4.9	4.3	3.8	3.2
Ireland		5.5	5.3	4.5	6.5	5.6	5.4	5.1	4	6.1	4.2	5.1	4.8
Italy		3.4	5.4	4.1	6.3	4.8	4.3	3.5	3.2	4.9	5.6	4.8	3.9
Luxembourg		5.8	5.7	6.2	6.2	4.9	5.5	4.9	5	6.4	3.2	5.1	5
Malta		4.5	4.7	5.2	6.3	4.8	4.6	4.3	4.4	5.6	2.6	4.2	3.5
Netherlands		5.6	6.3	5.7	6.6	6	5.3	4.9	4.4	6.1	5.1	5.6	5.4
Portugal		4.4	5.5	3.6	6.3	5.2	4.6	4.3	3.4	5.5	4.3	4.3	4
Slovak Rep.		3.4	4.3	5.2	6	4.6	4.4	3.9	4.4	4.6	4	4.1	3.3
Slovenia		3.9	4.8	4.4	6.4	5.4	4.5	4	2.8	5.1	3.4	4.2	3.8
Spain		3.9	5.9	4	6.2	5.1	4.3	4	3.8	5.6	5.4	4.5	3.7
Sweden		5.6	5.6	6.1	6.4	5.7	5.1	4.8	5	6.2	4.6	5.4	5.5
UK		5.5	6	4.2	6.4	5.6	5.2	5.3	4.8	6.3	5.7	5.5	5
Austria	**2014/2015**	5.1	5.8	5.5	6.4	5.6	5	4.5	4.5	5.7	4.6	5.4	4.8
Belgium		5.1	5.6	4.7	6.7	5.9	5.1	4.3	4.5	5.8	4.8	5.3	4.9
Cyprus		4.4	4.7	3.3	6.5	5.1	4.9	4.6	3.8	4.6	2.8	4.4	3.7
Czech Rep.		3.8	4.7	5.4	6.2	5	4.5	4.3	4.5	5	4.5	4.5	3.7
Denmark		5.3	5.6	6.1	6.4	5.7	5	5	4.7	6.1	4.2	5.3	5.1
Estonia		5	4.8	6	6.3	5.5	4.9	5	4.7	5.3	3.1	4.3	4
Finland		6.1	5.6	5.3	6.9	6.2	5	4.7	5.5	6	4.2	5.4	5.8
France		4.7	6	4.6	6.4	5.3	4.6	4.3	4.8	5.8	5.7	5	4.7
Germany		5.2	6.1	5.8	6.5	5.6	5	4.6	4.8	5.8	6	5.6	5.5
Greece		3.6	4.9	3.3	6.1	4.8	4.2	3.7	3	4.8	4.3	3.9	3.2
Ireland		5.4	5.3	3.5	6.5	5.5	5.3	4.8	4.2	5.9	4.1	5	4.7
Italy		3.4	5.4	4.1	6.4	4.8	4.3	3.3	3.3	4.8	5.6	4.8	3.7
Luxembourg		5.7	5.7	6.4	6.2	4.9	5.5	4.9	5.1	6.4	3.1	5	4.8
Malta		4.5	4.9	4.7	6.4	4.9	4.7	4.3	4.6	5.6	2.5	4.5	3.6
Netherlands		5.5	6.3	5.4	6.6	6	5.3	4.7	4.5	6	5.1	5.6	5.3
Portugal		4.4	5.7	3.5	6.4	5.4	4.6	4.1	3.6	5.4	4.3	4.3	4.1
Slovak Rep.		3.3	4.2	5.2	5.5	4.6	4.4	3.9	4.5	4.4	4	4	3.2
Slovenia		3.8	4.9	4.3	6.5	5.3	4.4	3.9	2.9	5	3.5	4.1	3.6
Spain		3.8	6	3.8	6.3	5.2	4.3	3.9	3.8	5.4	5.4	4.4	3.7
Sweden		5.4	5.5	6.1	6.4	5.6	5	4.8	5.2	6.2	4.6	5.4	5.4
UK		5.4	6	4.1	6.4	5.5	5.2	5.3	5.1	6.3	5.8	5.5	5

The subset of 7 EU countries which are in efficiency-driven stage or in transition from efficiency-to-innovation-driven stage comprises: Bulgaria, Croatia, Hungary, Latvia, Lithuania, Poland and Romania (Table 2). In the discussed three uear period, one of the countries, Romania, has improved its stage of development from efficiency-driven to transition stage from efficiency-driven to innovation-driven.

Table 2: GCI for the 7 efficiency-driven and transition (efficiency-to-innovation-driven) economies in EU, years 2014–2017

Countries (ICA objects)	Year	Pillars of competitiveness (ICA Criteria)											
		1	2	3	4	5	6	7	8	9	10	11	12
Bulgaria	**2016/17**	3.5	4	5.2	5.9	4.6	4.4	4.4	4.1	5.1	3.9	3.8	3.4
Croatia		3.6	4.6	4.4	5.8	4.7	4.1	3.9	3.6	4.7	3.5	3.8	3.1
Hungary		3.3	4.2	5.1	5.6	4.4	4.4	4.1	4	4.5	4.3	3.5	3.2
Latvia		4	4.4	5.6	6.2	5	4.5	4.6	4.2	5.2	3.2	4.1	3.4
Lithuania		4.2	4.7	5.4	6.3	5.3	4.6	4.4	4.1	5.6	3.5	4.3	3.7
Poland		4	4.3	5.1	6.2	5	4.6	4.1	4.2	4.8	5.1	4.1	3.4
Romania		3.6	3.6	5.5	5.5	4.4	4.2	4	3.7	4.7	4.5	3.6	3.1
Bulgaria	**2015/2016**	3.4	4	4.9	6	4.5	4.4	4.2	4	4.9	3.9	3.6	3.1
Croatia		3.6	4.6	4.2	5.8	4.6	4	3.8	3.6	4.6	3.6	3.7	3.1
Hungary		3.5	4.5	4.9	5.7	4.6	4.3	4.2	3.9	4.6	4.3	3.7	3.4
Latvia		4.2	4.5	5.6	6.2	5.1	4.6	4.7	4.4	5.3	3.2	4.1	3.3
Lithuania		4.1	4.7	5.6	6.2	5.3	4.6	4.3	4	5.6	3.6	4.3	3.7
Poland		4.1	4.3	5.1	6.1	5.1	4.5	4.1	4.3	4.8	5.2	4.1	3.3
Romania		3.7	3.6	5.4	5.5	4.5	4.3	4.1	4	4.6	4.6	3.7	3.2
Bulgaria	**2014/2015**	3.3	4.1	5.4	6	4.5	4.4	4.2	4.2	4.7	3.9	3.6	2.9
Croatia		3.6	4.7	4.4	5.9	4.7	4.1	3.9	3.9	4.6	3.6	3.8	3.1
Hungary		3.7	4.6	4.8	5.8	4.7	4.4	4.2	3.9	4.4	4.3	3.8	3.5
Latvia		4.1	4.6	5.5	6.3	5.1	4.7	4.8	4.6	5.1	3.2	4.1	3.3
Lithuania		4	4.7	5.3	6.2	5.3	4.6	4.3	4.1	5.4	3.6	4.3	3.6
Poland		4	4.2	4.8	6.2	5	4.5	4.1	4.6	4.5	5.1	4.1	3.3
Romania		3.6	3.7	5.2	5.5	4.6	4.2	4	4.1	4.5	4.4	3.8	3.3

4 Results and discussion

From each input dataset of evaluations (measurements) of objects (in this case, EU member states over three subsequent years) against criteria (in this case, pillars of competitiveness), ICA computes a new table that contains intuitionistic fuzzy pairs (IFPs, [2]) giving the measure of consonance (positive/negative) or dissonance between each pair of criteria from the original dataset. Positive consonance in ICA is interpreted as the definite presence of relation between two criteria, best exhibited in the pair $\langle 1; 0\rangle$, negative consonance is interpreted as the definite absence of relation, best exhibited in the pair $\langle 0; 1\rangle$, and dissonance is interpreted as uncertainty, where no particular conclusion can be derived, best exhibited in the pair $\langle 0; 0\rangle$. In the resultant table, along the main diagonal are the pairs of each criterion with itself, which naturally yields the pairs $\langle 1; 0\rangle$, and the IFP corresponding to criteria C_i, C_j is identical to the one corresponding to criteria C_j, C_i. For the sake of simplicity, the developed software for ICA [8, 9] returns the computed result in the form of two tables, one giving the membership parts of the IFPs, and the other giving the non-membership parts.

In the present research, ICA returns the following tables with intercriteria correlations between the twelve criteria (pillars of competitiveness): Table 3 (a) and 3 (b) for the case of the 21 innovation-driven economies in the EU, and Table 4 (a) and 4 (b) for the case of the 7 efficiency-driven and transition economies in the union. The precision of the ICA software is 9 digits after the decimal point, but here we flatten the resultant values to 3 digits.

Figure 2 gives how these 66 intercriteria correlations are plotted as points onto the intuitionistic fuzzy triangle for the case of innovation-driven economies, and respectively, Figure 3 – for the rest of the countries. In addition, here we outline the points corresponding to each of the 12 pillars, separately shown and discussed, respectively in Figure 4.1 to 4.12 for the innovation-driven countries, and Figure 5.1 to 5.12, for the others.

Table 3: Intercriteria correlations between the pillars of competitiveness of the innovation-driven economies in EU, years 2014–2017 (Table 1)

μ	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000	0.652	0.681	0.629	0.767	0.819	0.786	0.771	0.838	0.514	0.733	0.800
2	0.652	1.000	0.524	0.538	0.657	0.610	0.610	0.581	0.719	0.752	0.748	0.729
3	0.681	0.524	1.000	0.467	0.595	0.662	0.676	0.752	0.667	0.443	0.633	0.643
4	0.629	0.538	0.467	1.000	0.724	0.590	0.567	0.519	0.567	0.505	0.595	0.667
5	0.767	0.657	0.595	0.724	1.000	0.681	0.667	0.638	0.686	0.605	0.714	0.795
6	0.819	0.610	0.662	0.590	0.681	1.000	0.829	0.700	0.781	0.481	0.681	0.676
7	0.786	0.610	0.676	0.567	0.667	0.829	1.000	0.705	0.776	0.486	0.690	0.671
8	0.771	0.581	0.752	0.519	0.638	0.700	0.705	1.000	0.724	0.519	0.690	0.719
9	0.838	0.719	0.667	0.567	0.686	0.781	0.776	0.724	1.000	0.600	0.781	0.748
10	0.514	0.752	0.443	0.505	0.605	0.481	0.486	0.519	0.600	1.000	0.686	0.629
11	0.733	0.748	0.633	0.595	0.714	0.681	0.690	0.690	0.781	0.686	1.000	0.833
12	0.800	0.729	0.643	0.667	0.795	0.676	0.671	0.719	0.748	0.629	0.833	1.000

(a) Membership parts of the IFPs

ν	1	2	3	4	5	6	7	8	9	10	11	12
1	0.000	0.295	0.286	0.181	0.176	0.076	0.138	0.167	0.100	0.443	0.176	0.138
2	0.295	0.000	0.448	0.286	0.290	0.300	0.319	0.362	0.224	0.210	0.167	0.205
3	0.286	0.448	0.000	0.367	0.371	0.257	0.262	0.210	0.295	0.538	0.300	0.310
4	0.181	0.286	0.367	0.000	0.105	0.200	0.224	0.295	0.248	0.319	0.200	0.148
5	0.176	0.290	0.371	0.105	0.000	0.224	0.248	0.300	0.262	0.362	0.205	0.133
6	0.076	0.300	0.257	0.200	0.224	0.000	0.067	0.200	0.119	0.429	0.190	0.205
7	0.138	0.319	0.262	0.224	0.248	0.067	0.000	0.214	0.143	0.443	0.190	0.238
8	0.167	0.362	0.210	0.295	0.300	0.200	0.214	0.000	0.210	0.433	0.224	0.205
9	0.100	0.224	0.295	0.248	0.262	0.119	0.143	0.210	0.000	0.352	0.133	0.176
10	0.443	0.210	0.538	0.319	0.362	0.429	0.443	0.433	0.352	0.000	0.238	0.314
11	0.176	0.167	0.300	0.200	0.205	0.190	0.190	0.224	0.133	0.238	0.000	0.090
12	0.138	0.205	0.310	0.148	0.133	0.205	0.238	0.205	0.176	0.314	0.090	0.000

(b) Non-membership parts of the IFPs

Table 4: Intercriteria correlations between the pillars of competitiveness of the efficiency-driven and efficiency-to-innovation-driven economies in EU, years 2014–2017 (Table 2)

μ	1	2	3	4	5	6	7	8	9	10	11	12
1	1.000	0.667	0.571	0.810	0.857	0.619	0.524	0.619	0.810	0.333	0.857	0.714
2	0.667	1.000	0.381	0.762	0.762	0.619	0.524	0.524	0.667	0.286	0.714	0.571
3	0.571	0.381	1.000	0.524	0.476	0.524	0.762	0.571	0.667	0.333	0.524	0.524
4	0.810	0.762	0.524	1.000	0.905	0.762	0.667	0.762	0.810	0.286	0.905	0.810
5	0.857	0.762	0.476	0.905	1.000	0.667	0.571	0.667	0.762	0.238	0.905	0.714
6	0.619	0.619	0.524	0.762	0.667	1.000	0.667	0.762	0.667	0.429	0.667	0.714
7	0.524	0.524	0.762	0.667	0.571	0.667	1.000	0.810	0.714	0.238	0.571	0.667
8	0.619	0.524	0.571	0.762	0.667	0.762	0.810	1.000	0.619	0.381	0.667	0.714
9	0.810	0.667	0.667	0.810	0.762	0.667	0.714	0.619	1.000	0.286	0.810	0.762
10	0.333	0.286	0.333	0.286	0.238	0.429	0.238	0.381	0.286	1.000	0.286	0.286
11	0.857	0.714	0.524	0.905	0.905	0.667	0.571	0.667	0.810	0.286	1.000	0.714
12	0.714	0.571	0.524	0.810	0.714	0.714	0.667	0.714	0.762	0.286	0.714	1.000

(a) Membership parts of the IFPs

ν	1	2	3	4	5	6	7	8	9	10	11	12
1	0.000	0.238	0.286	0.143	0.048	0.190	0.286	0.286	0.143	0.524	0.048	0.190
2	0.238	0.000	0.571	0.190	0.143	0.286	0.381	0.381	0.286	0.667	0.190	0.238
3	0.286	0.571	0.000	0.381	0.381	0.333	0.190	0.286	0.238	0.571	0.333	0.238
4	0.143	0.190	0.381	0.000	0.048	0.095	0.190	0.190	0.095	0.619	0.048	0.048
5	0.048	0.143	0.381	0.048	0.000	0.143	0.238	0.238	0.095	0.619	0.000	0.095
6	0.190	0.286	0.333	0.095	0.143	0.000	0.143	0.048	0.190	0.429	0.143	0.000
7	0.286	0.381	0.190	0.190	0.238	0.143	0.000	0.095	0.143	0.619	0.238	0.048
8	0.286	0.381	0.286	0.190	0.238	0.048	0.095	0.000	0.238	0.476	0.238	0.095
9	0.143	0.286	0.238	0.095	0.095	0.190	0.143	0.238	0.000	0.619	0.048	0.095
10	0.524	0.667	0.571	0.619	0.619	0.429	0.619	0.476	0.619	0.000	0.571	0.476
11	0.048	0.190	0.333	0.048	0.000	0.143	0.238	0.238	0.048	0.571	0.000	0.095
12	0.190	0.238	0.238	0.048	0.095	0.000	0.048	0.095	0.095	0.476	0.095	0.000

(b) Non-membership parts of the IFPs

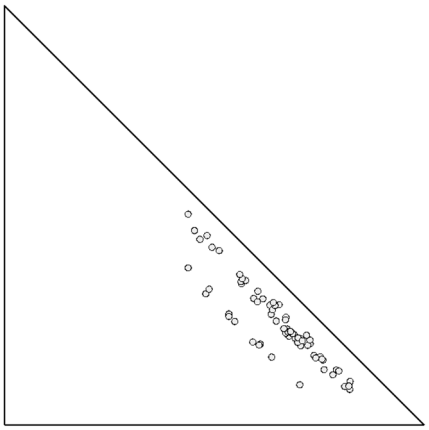

Figure 2. IFS triangle with intercriteria relations for the innovation-driven states

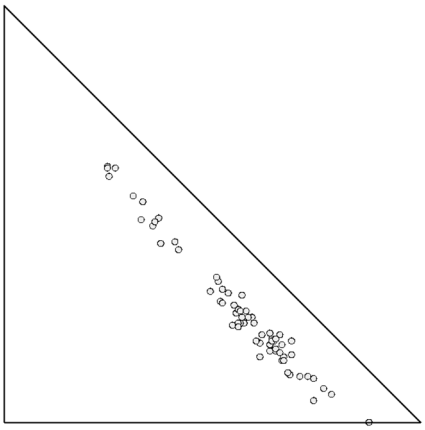

Figure 3. IFS triangle with intercriteria relations for the efficiency-driven states

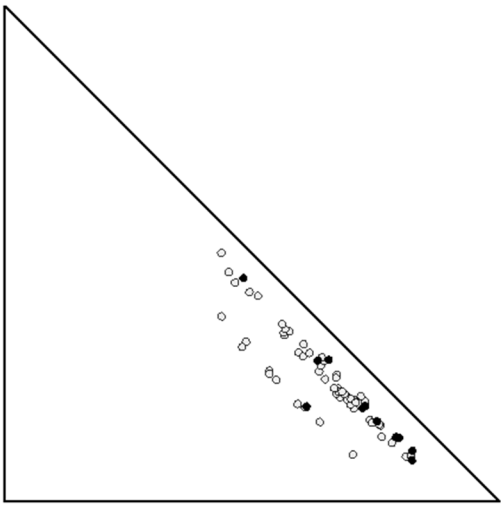

Figure 4.1. Pillar 1. “Institutions” in innovation-driven economies

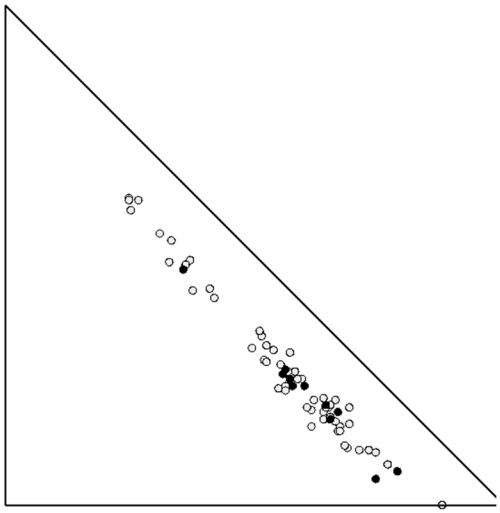

Figure 5.1. Pillar 1. “Institutions” in efficiency-driven and transition economies

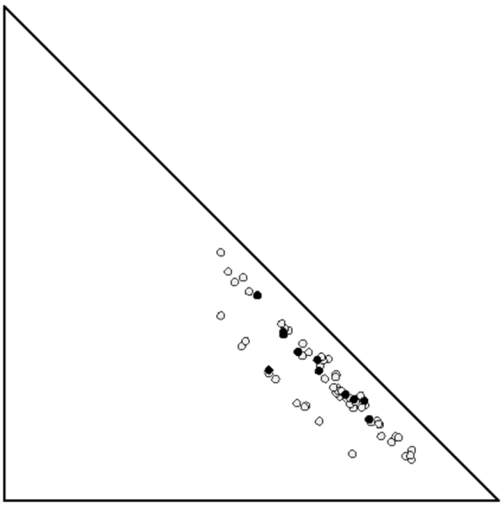

Figure 4.2. Pillar 2. “Infrastructure” in innovation-driven economies

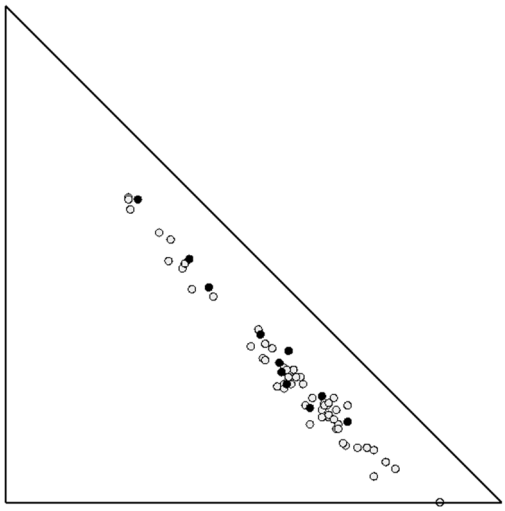

Figure 5.2. Pillar 2. “Infrastructure” in efficiency-driven and transition economies

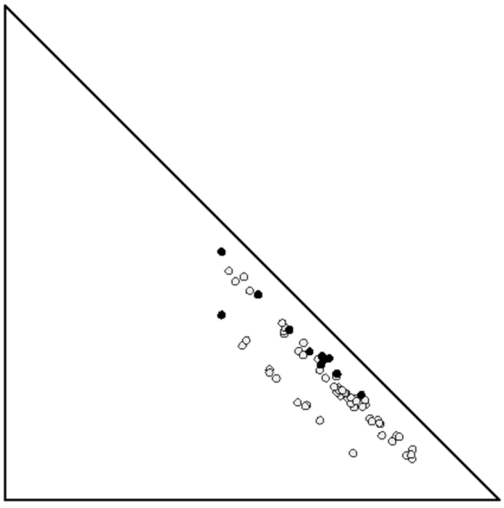

Figure 4.3. Pillar 3. “Macroeconomic environment” in innovation-driven economies

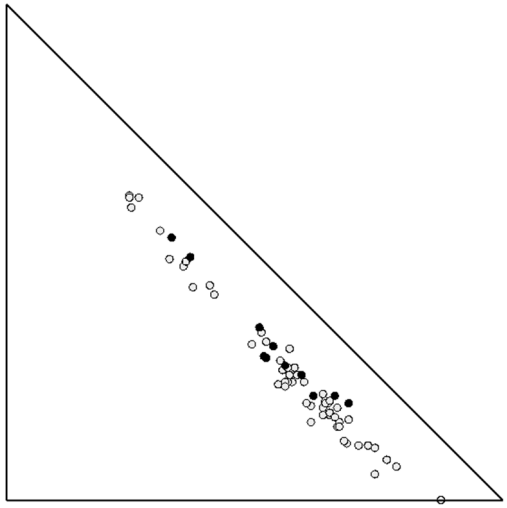

Figure 5.3. Pillar 3. “Macroeconomic environment” in efficiency-driven and transition economies

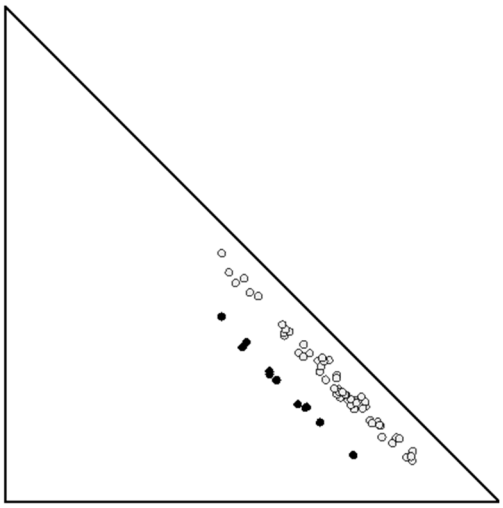

Figure 4.4. Pillar 4. “Health and primary education” in innovation-driven economies

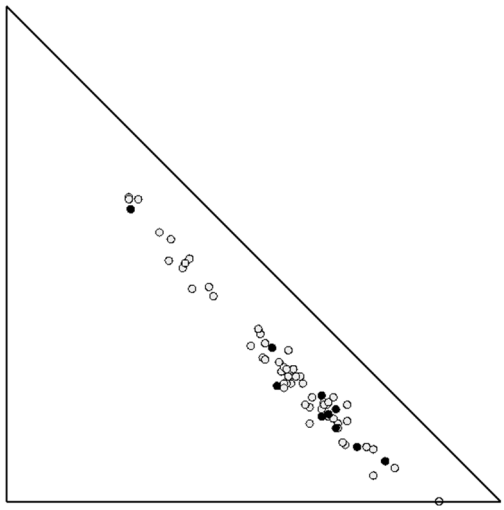

Figure 5.4. Pillar 4. “Health and primary education” in efficiency-driven and transition economies

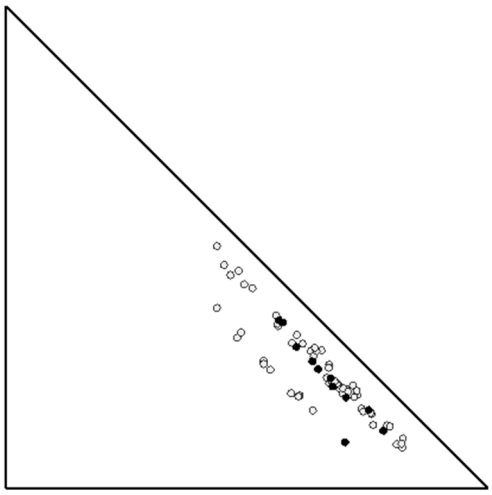

Figure 4.5. Pillar 5. “Higher education and training” in innovation-driven economies

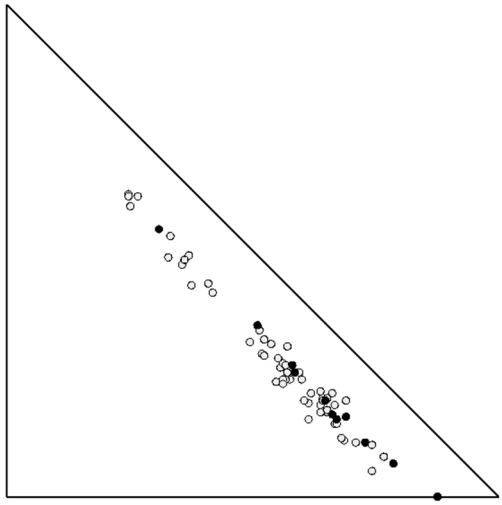

Figure 5.5. Pillar 5. “Higher education and training” in efficiency-driven and transition economies

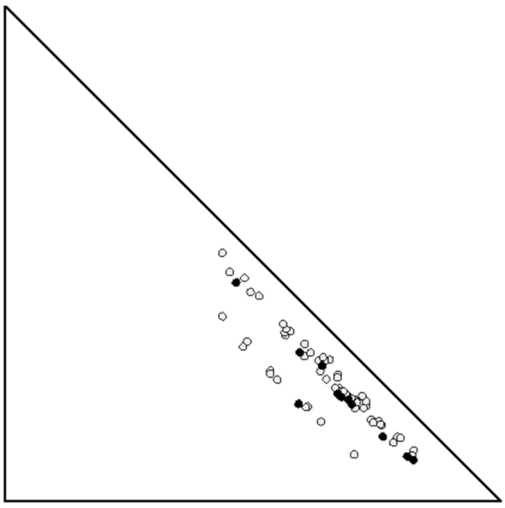

Figure 4.6. Pillar 6. “Goods market efficiency” in innovation-driven economies

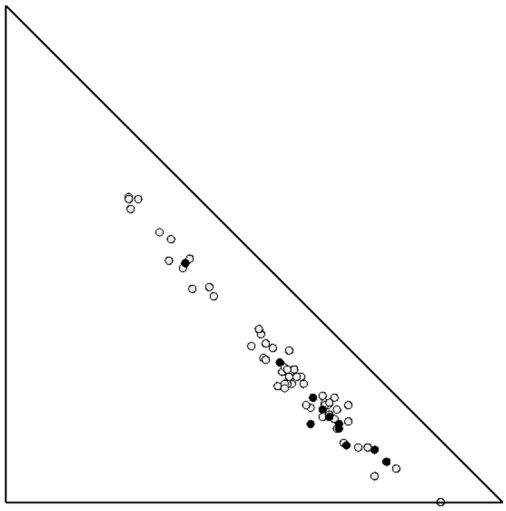

Figure 5.6. Pillar 6. “Goods market efficiency” in efficiency-driven and transition economies

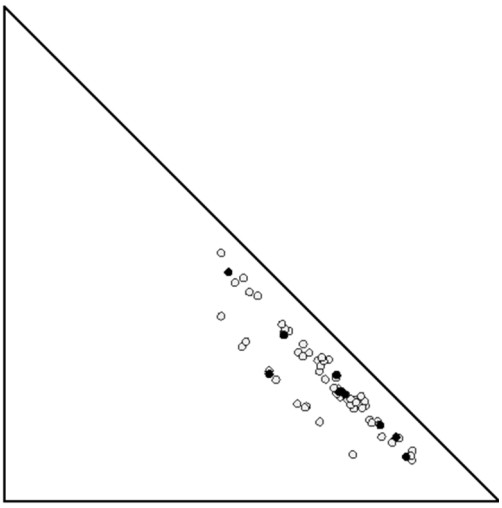

Figure 4.7. Pillar 7. “Labor market efficiency” in innovation-driven economies

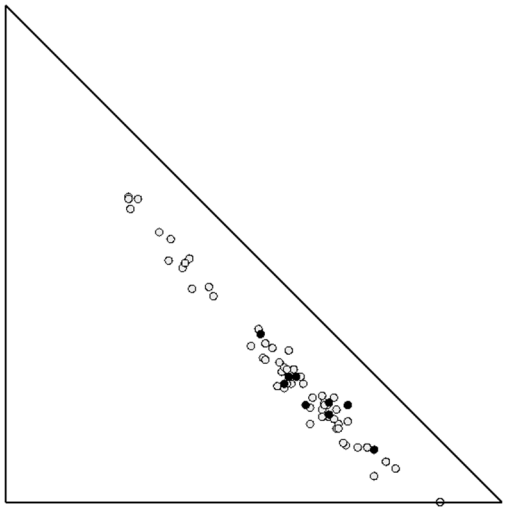

Figure 5.7. Pillar 7. “Labor market efficiency” in efficiency-driven and transition economies

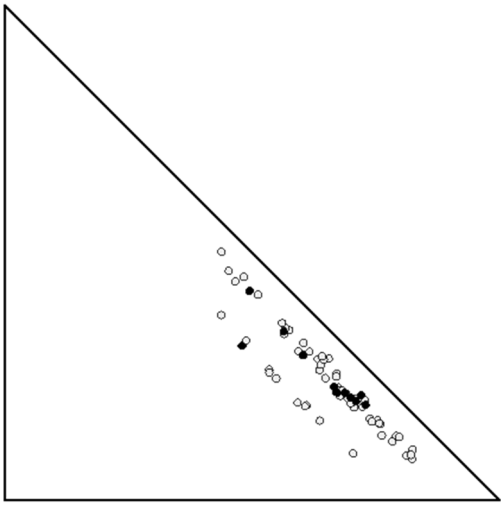

Figure 4.8. Pillar 8. “Financial market development” in innovation-driven economies

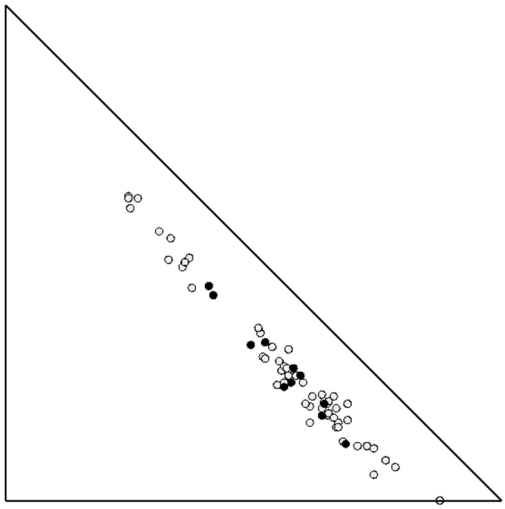

Figure 5.8. Pillar 8. “Financial market development” in efficiency-driven and transition economies

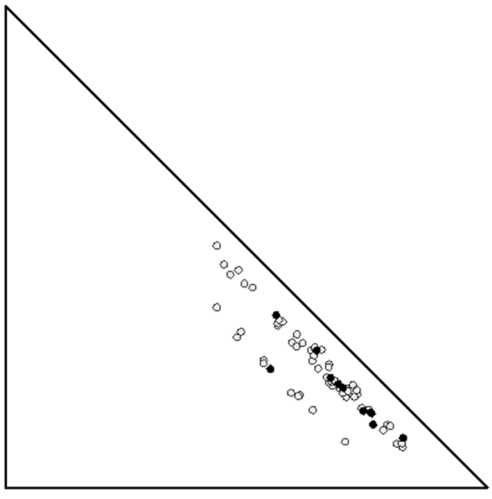

Figure 4.9. Pillar 9. “Technological readiness” in innovation-driven economies

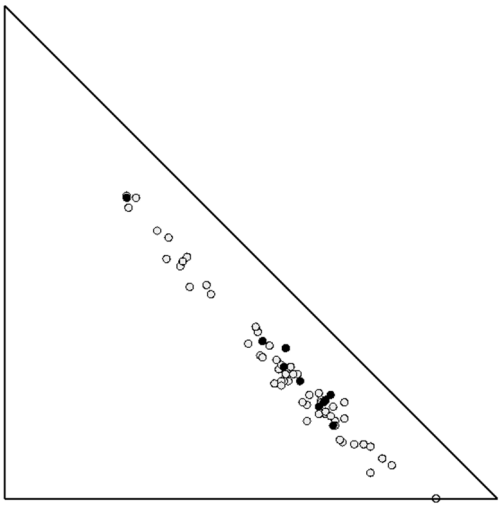

Figure 5.9. Pillar 9. “Technological readiness” in efficiency-driven and transition economies

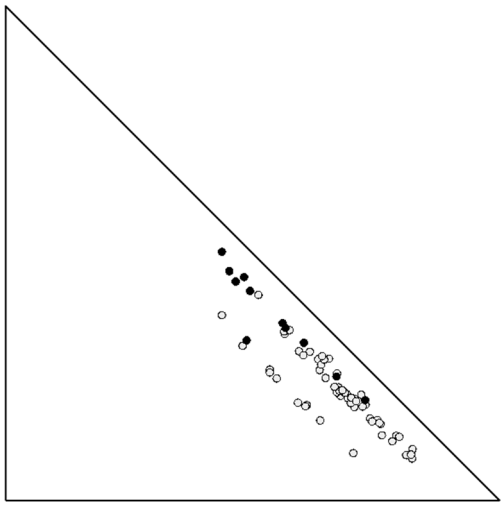

Figure 4.10. Pillar 10. “Market size” in innovation-driven economies

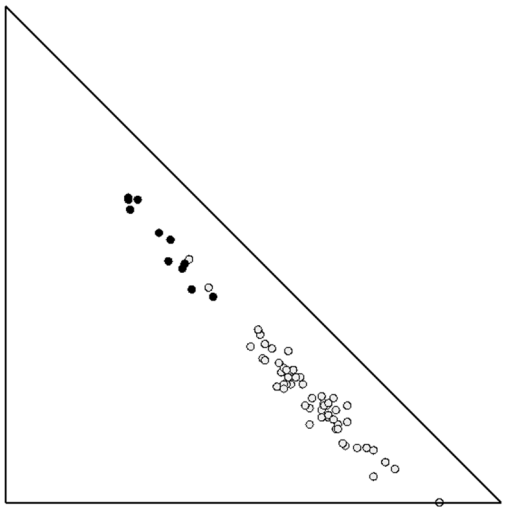

Figure 5.10. Pillar 10. “Market size” in efficiency-driven and transition economies

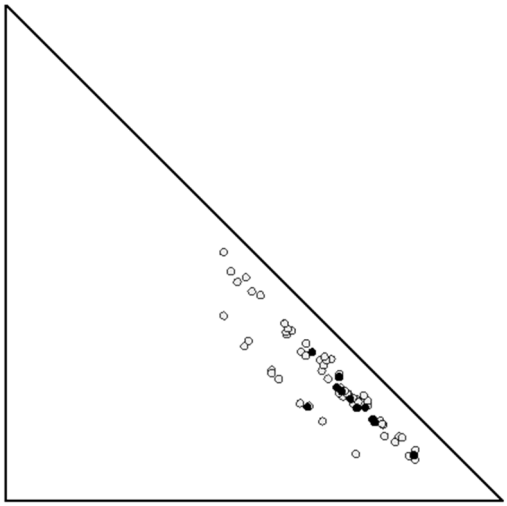

Figure 4.11. Pillar 11. “Buisiness sophistication” in innovation-driven economies

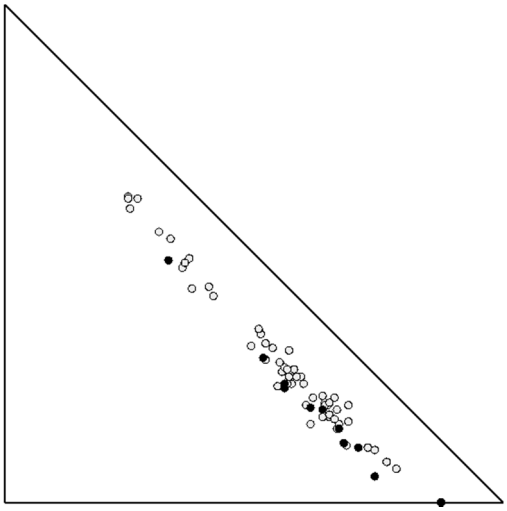

Figure 5.11. Pillar 11. “Buisiness sophistication” in efficiency-driven and transition economies

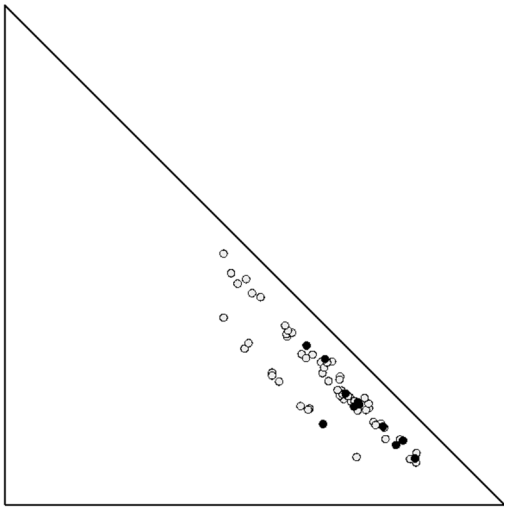

Figure 4.12. Pillar 12. “Innovation” in innovation-driven economies

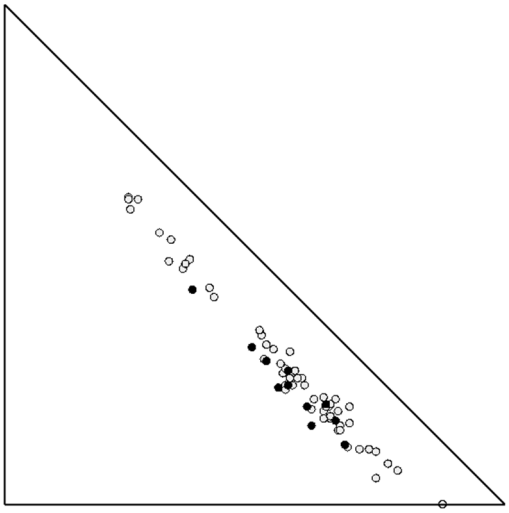

Figure 5.12. Pillar 12. “Innovation” in efficiency-driven and transition economies

We note particular differences in the interrelations between the pillars of competitiveness for each of these two disjoint sets of member states of the same political and economic union, i.e. how differently these two stages of economies are "wired".

For both subsets of countries, Tables 3 and 4 show visibly that pillar 10 "Market size" tends to not correlate with almost any of the rest pillars, which is especially well expressed for the efficiency-driven and transition economies (Figure 5.10), where the corresponding points form a cluster closest to the *Falsity* (the point / pair ⟨0; 1⟩). Similar is the result for pillar 3 "Macroeconomic environment", which also tends to correlate rather weakly in the period 2014–2017.

Pillar 4 "Health and primary education" exhibits the strongest difference between both subsets (Figure 4.4 and 5.4), showing that in innovation-driven economies these intercriteria pairs form a separate cluster of the points that are closest to *Uncertainty* (the point / pair ⟨0; 0⟩), while for efficiency-driven and transition economies the majority of points are relatively close to *Truth* (the point / pair ⟨1; 0⟩). A possible explanation is that pillar 4 is one of the so called "basic requirements" which are the key to factor-driven economies, which are closer to efficiency-driven economies compared to innovation-driven ones.

It is interesting to comment on the pillar 5 "Higher education and training" which from Tables 3 and 4 is seen to be better exhibited in efficiency-driven and transition economies, compared to innovation-driven ones. To the degree that the closest intercriteria pair is the one between pillar 5 and pillar 11 "Buisiness sophistication", which is one of the two indicators for innovation-driven economies, which can be interpreted that in the countries in the efficiency and transition stage, this is a relatively more significant factor for the innovation culture of the country.

5 Conclusion

Several findings were outlined from the results of application of InterCriteria Analysis (ICA) on datasets extracted from the World Economic Forum's Global Competitiveness Reports for the 28 members of the European Union in the period 2014–2017. Some more notable differences were discussed from the comparison of the 21 economies in innovation-driven stage with the 7 economies in efficiency-driven or transition stage. These shed a light on how different economies in EU are "wired", as separated by their stage of economic development

The rest of the presented intercriteria relations can inspire economists to extend this research with additional observations on the rest of the pillars, while also taking into consideration that huge differences between the results from both datasets are not expected and plausible, given that all the countries are members of the same political and economic union and their economies are strongly interconnected. The present research however address the observation in the 2015–2016 GCR that the pillars of competitiveness are not independent, and they tend to reinforce each other. The attempt to identify the correlations between the different pillars of competitiveness further resonates with the WEF's address to state policy makers to identify and strengthen the transformative forces that will drive future economic growth [12]. Any other meaningful separation of the set into subsets can shed additional light on the functioning of the Union and its member states.

In addition, these results can be further extended to detect potential triples of correlating pillars of competitiveness, instead of just pairs, [7, 10]. Comparison with other results obtained using alternative algorithms for ICA computations, [11] are also promising to yield informative results.

As a prospective next step of research, the herewith performed analysis can be extended to compare the performance of the five categories of countries in the world, in each of these three stages of development and the two transition ones. This can show on a global level what is common for otherwise unrelated economies belonging to the same stage of economic development and what are the relations between the pillars of competitiveness. This research may not only confirm existing patterns but also help finding new ones, using the apparatus of the intuitionistic fuzzy sets-based InterCriteria Analysis.

Acknowledgements

The present research has been partly funded by the National Science Fund of Bulgaria, Grant No. DFNI-I-02-5/2014 “InterCriteria Analysis: A New Approach to Decision Making” and by the bilateral FWO-BAS project VS.096.16N “Bipolarity in Information Management – Theory and Applications”.

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