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INNOVATION IN EASTERN EUROPE & CENTRAL ASIA: A MULTI-CRITERIA DECISION-MAKING APPROACH

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ABSTRACT

In today's intense competition environment, innovation levels of countries determine their competitive advantages. This study compares the innovation levels of Eastern European and Central Asian (EECA) countries using multi-criteria decision-making methods. The firm-level data set of the World Bank on innovation (BEEPS data) is used to evaluate innovation levels and capabilities of the countries in the region. In our proposed TOPSIS based methodology, countries are compared in terms of four different innovation types (New Product, New Organization, New Marketing, and New Process Innovations). Also, we provide an extensive sensitivity analysis to show the changes in the innovation rankings of the countries with different criteria weights.

Keywords: *Innovation, Multi-Criteria Decision Making, TOPSIS*

JEL Codes: *O30, C44, O57*

DOĞU AVRUPA VE MERKEZ ASYA'DA YENİLİK: BİR ÇOK KRİTERLİ KARAR VERME YAKLAŞIMI

ÖZ

Günümüzün yüksek rekabet ortamında, ülkelerin inovasyon düzeyleri rekabetçi avantajlarını da belirlemektedir. Bu çalışma Doğu Avrupa ve Orta Asya ülkelerinin inovayon düzeylerini çok kriterli karar verme yöntemleri ile karşılaştırmaktadır. Dünya Bankası'nın firma düzeyindeki inovasyon veri seti (BEEPS) kullanılarak ülkelerin inovasyon düzeyleri ve yetenekleri değerlendirilmiştir. Bu çalışmada geliştirilen TOPSIS tabanlı yöntemle dört inovasyon türü (Ürün, Organizasyonel , Pazarlama ve Süreç Yeniliği) kullanılarak ülkeler karşılaştırılmıştır. Ayrıca, ülkelerin inovasyon sıralamasının farklı kriter ağırlıklarında nasıl değiştiğini gösterecek şekilde bir duyarlılık analizi yapılmıştır.

Anahtar Kelimeler: *İnovasyon, Çok Kriterli Karar Verme, TOPSIS*

JEL Kodları: *O30, C44, O57*

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1. INTRODUCTION

Innovation significantly fosters economic development of a country (Grossman & Helpman, 1991; Lema, Rabellotti & Sampath, 2018). The most innovative firms of the world constantly find new ways to surpass customer demand by new and improved products/services. These firms are mostly originated from the most developed countries in the world. This also affects the innovation levels of the countries as shown in Figure 1, which shows that the top five most innovative countries remain mostly unchanged from 2012 to 2015. Figure 2 shows the most innovative countries in 2019. According to these results, South Korea became the most innovative country in the world. Note that, South Korea was not in the top ten most innovative countries in 2015 (Figure 1). This shows the fast-changing conditions of global competition.

Since developing countries face significant global competition (Nuruzzaman, Singh, & Pattnaik, 2018), they need to spend more on research and development (R&D) to be more innovative. According to Wadho & Chaudhry (2018, p.1285), globalization and internet usage has made the competition increase to unprecedented levels. This situation affects developing countries worse due to their fragile economic situation, and poor financial and legal environment. Thus, national innovation policies have become more important in these countries (Veugelers and Schweiger, 2016).

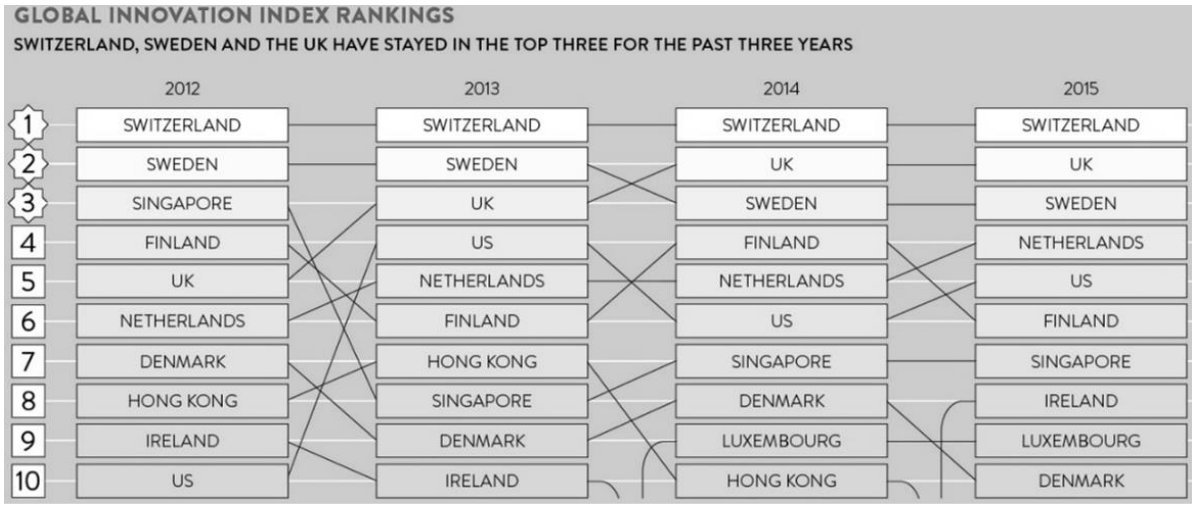

Figure 1. Innovation Comparison of Countries

Source: https://www.raconteur.net/business-innovation/the-worlds-most-innovative-countries-in-5-charts (accessed on 26 March 2019)

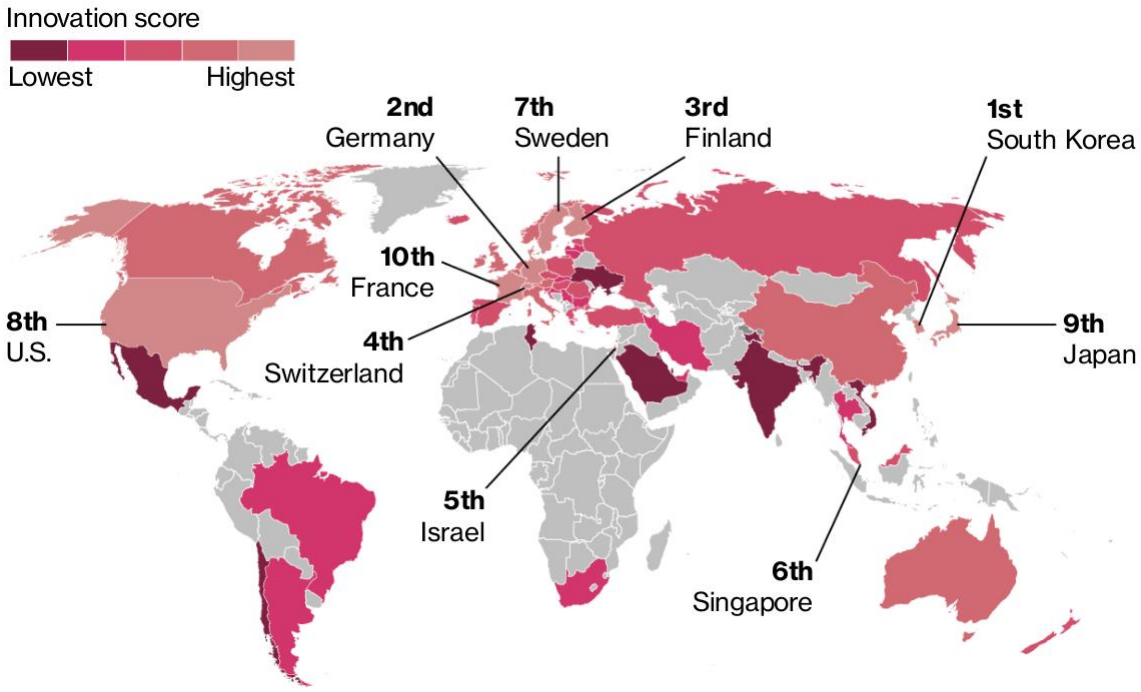

Figure 2. The Most Innovative Countries in 2019

Source: https://www.bloomberg.com/news/articles/2019-01-22/germany-nearly-catches-korea-as-innovation-champ-u-s-rebounds (accessed on 31 May 2019)

This paper compares the innovation capabilities of countries in Eastern Europe and Central Asia (EECA). Although innovation policies in the region started with the European Union (EU) harmonization process, progress has slowed down during the 2008 global crisis and the following EU sovereign debt crisis. Researchers stress the need for developing sustainable competitive advantages through firm-level innovation activities in order to integrate into European and global production networks (Levenko, Oja & Staehr, 2019; Papava, 2018). Thus, our study contributes to our understanding of the implementation of innovation policies in EECA and makes it possible to identify which countries adopt innovative ideas and technologies.

So far, multi-criteria decision-making methods (MCDM) have been applied by very few of studies in the innovation literature. To the best of our knowledge, this study is the first one to apply an MCDM approach to evaluate innovation capabilities of countries in the EECA region. Our study uses the most up-to-date BEEPS survey data (2016) of the World Bank, which includes 32 EECA countries. In this paper, the firm-level innovation data of BEEPS are used to calculate country innovation levels using TOPSIS (Technique for Order Preference by Similarity to Ideal Solution).

This paper is organized as follows. The relevant literature is summarized in Section 2. The survey data are presented in Section 3. Section 4 summarizes the proposed methodology. The results of the TOPSIS method and the sensitivity analysis are shown in Section 5. Section 6 summarizes the final remarks and future studies.

2. LITERATURE REVIEW

The literature review is conducted in two areas: (1) Innovation in EECA, and (2) Use of Multi-criteria Decision Making Approaches to Measure Innovation.

2.1. Innovation in EECA

Innovation policies in EECA mainly started during the European Union (EU) harmonization process through the introduction of the new regulation. These policies aim at boosting science and invention and thus they concentrate on high-tech sectors. However, although the process started in the 2000s, not much progress has been made in shifting these countries to global competitive economies.

Tiits, Kattel, Kalvet & Tamm (2008) show that they are behind old EU member states and East Asian tigers in terms of the quality of the industrial structure. The literature on EECA mainly focuses on the institutional factors that affect the welfare and growth of these economies. Kattel, Reinert & Suurna (2011) argue that since the restructuring policies in the 1990s replaced the high-value sectors with low value-added ones, and since there is a weak administrative environment, these countries remain path-dependent. Specifically, Central European countries have specialized in the low-value added end of high-tech sectors, while Eastern European countries are specialized around low-tech sectors (Radosevic, 2005). McKinsey & Company 2013 Report argues that competing on labor costs alone is not sufficient and these economies must prioritize investing in knowledge-intensive manufacturing (Labaye et al., 2013). Kravtsova and Radosevic (2012) discuss that Eastern European countries are inefficient in the sense that they cannot convert their innovation and production capabilities to productivity. The authors stress the need for change in the focus of R&D systems from knowledge generation to knowledge diffusion.

Popescu (2014) points out that the FDI inflows to the EECA region were adversely affected by the 2008 Global Crisis and the 2011 Eurozone sovereign debt crisis. This slowed down economic growth rates and the catching up the process through foreign technology transfers. Thus, innovation activities of firms in the region have become one of the main factors that could help the region's growth and convergence (Grela et al., 2017). Countries in Eastern

Europe and Central Asia need to increase their competitiveness by participating more in Global Value Chain (Hagemejer and Muck, 2019). However, inclusion into global flows depends on each country's internal capabilities such as access to multimodal transport (which affects exports performance), R&D intensity, and human capital stock (Smetkowski, 2018).

2.2. Use of Multi-criteria Decision Making Approach to Measure Innovation

Since 2000, the number of studies applying multi-criteria decision-making methods in economics has significantly increased (Zavadskas and Turskis, 2011). However, this study is the first to investigate innovation scores of EECA countries using MCDM approaches.

In the literature, very few studies investigated innovation levels. Among them, Silva et al. (2017) compared innovation levels of Latin American and Caribbean countries using seven criteria (Human capital & research, Institutions, Infrastructure, Market and Business sophistication, Knowledge & technology outputs, and Creative outputs) of the WIPO (World Intellectual Property Organization). Using TOPSIS, they calculated the innovation scores of the countries. Despite the fact that they used the TOPSIS method and calculated innovation levels of countries similar to our study, we applied our methodology to EECA countries and used BEEPS data. Another study by Kaynak et al. (2017) used country-level data from several sources including the Global Competitiveness Index and Global Innovation Index to compare the Innovation levels of European Union candidate countries with entropy-TOPSIS method.

MCDM methods are also applied to country-level economic comparisons. Urfalıoğlu and Tolga (2013) ranked EU candidate countries (including Turkey) according to their macroeconomic indicators using various MCDM methods. Similar to Urfalıoğlu and Tolga (2013), Mangir and Erdogan (2011) employed macro-level economic indicators to rank Turkey, Italy, Greece, Portugal, Spain, and Ireland which were severely affected by the 2008 global economic crisis using fuzzy TOPSIS method. Note that none of these studies analyzed innovation.

Another MCDM research avenue in the literature is to compare firms in terms of innovation. The performances of energy firms are analyzed by Li and Gao (2015) using entropy-TOPSIS method. Using the same method, the top five high-tech industries of China were evaluated by Chen (2017). Again in China, 30 regions were classified according to their innovation levels by Nan and Tian (2011). The barriers to green innovation for companies are analyzed by Gupta and Barua (2018) using fuzzy TOPSIS. Using the same method, Suder and Kahraman (2016) analyzed the innovation investments for companies.

3. DATA

In this study, we use data for more than 20,000 firms in the EECA region from the 5th wave of the Business Environment and Enterprise Performance Survey (BEEPS 2012-2016). The Enterprise Surveys use stratified random sampling which ensures that the data represents the population characteristics. The surveys cover firms in manufacturing and service sectors (ISIC Rev.3.1). In addition to the sector, the strata include firm location (geographic region) and size. The survey topics include several topics such as access to finance, sales, corruption, infrastructure, competition, taxation, informality, business-government relations, innovation, and performance measures. For our focus, we use questions regarding the innovation activities of the firms.

The survey questions focus on four different innovation types: New product, New Process, New Organization, and New Marketing Innovations. The firms are asked if they made an innovation in these areas in the last three years. If so, they answer "yes". To demonstrate the data, Table 1 shows a sample of the survey results of Turkish firms. Notice that the names of the firms are not revealed by the survey. If a firm answers "yes" to a specific innovation question, the relevant entry in the table is marked as one (otherwise, zero).

Using this raw data of the survey, the percentages of the firms reporting each innovation type for each country are calculated as in Table 2. For instance, process innovation question was answered positively by 11.83% of Turkish firms.

Table 1. A Sample Data of Turkey from the Survey

Firm id	Sector	New Product Innovation	New Organization Innovation	New Marketing Innovation	New Process Innovation
5300403750	Chemical	1	1	1	1
5300443742	Non-metallic mineral	0	0	0	0
5300599680	Textiles	0	1	0	1
5300674313	Machinery	1	1	1	1
5300676259	Tanning	1	0	0	0
5300689361	Wholesale	1	0	0	0
5300706221	Food	1	1	1	1
5300725617	Food	0	0	0	0
5300889577	Garments	1	1	0	1
530057710100	Garments	0	1	0	1
5300022205179	Food	1	1	1	1
5300025205174	Food	1	1	0	1
5300027217920	Textiles	1	1	1	1
5300158211396	Fabricated metal	1	1	1	1
5300170215897	Retail	0	1	1	1
5300206200695	Construction	0	0	0	0
5300207200991	Supporting transport activities	1	1	1	1
5300209200859	Supporting transport activities	0	0	0	0
5300210200754	Wholesale	1	1	1	1
5300211200797	IT	0	0	0	0
5300383204152	Basic metals	0	0	0	0
5300386204134	Motor vehicles	1	1	1	0

Source: http://www.enterprisesurveys.org/methodology (accessed on 21 February 2019)

Table 2. The Percentage Of Reported Innovation Types For All Countries

Alternative	New Product Innovation	New Organization Innovation	New Marketing Innovation	New Process Innovation
Albania	10.56%	5.00%	6.94%	4.72%
Armenia	15.83%	6.94%	11.94%	5.83%
Azerbaijan	2.05%	3.08%	2.31%	2.82%
Belarus	30.83%	41.94%	47.50%	36.94%
Bosnia-Herzegovina	36.67%	26.94%	25.83%	25.00%
Bulgaria	24.91%	30.38%	24.57%	17.41%
Croatia	40.00%	33.33%	34.17%	30.56%
Cyprus	20.56%	10.83%	13.89%	14.17%
Czech Republic	50.79%	24.80%	24.80%	34.65%
Estonia	22.71%	17.95%	17.58%	20.15%
FYR Macedonia	31.11%	39.17%	36.39%	21.67%
Georgia	10.00%	6.67%	8.61%	9.72%
Greece	49.23%	32.20%	34.98%	35.91%
Hungary	21.29%	13.23%	19.35%	20.00%
Kazakhstan	19.33%	15.50%	14.83%	13.50%
Kosovo	53.47%	52.48%	54.95%	41.09%
Kyrgyzstan	38.15%	37.04%	40.37%	26.67%
Latvia	19.94%	11.61%	11.61%	11.90%
Lithuania	24.44%	20.00%	16.30%	20.00%
Moldova	29.72%	27.50%	28.06%	30.28%
Mongolia	26.11%	36.39%	37.78%	33.89%
Montenegro	12.67%	9.33%	12.67%	9.33%
Poland	33.39%	23.43%	29.52%	22.32%
Romania	40.56%	39.26%	46.30%	36.67%
Russia	24.86%	24.08%	25.02%	23.55%
Serbia	35.83%	21.94%	29.72%	21.39%
Slovak Republic	19.78%	13.43%	14.18%	13.81%
Slovenia	35.19%	21.11%	25.56%	11.11%
Tajikistan	16.43%	19.22%	27.02%	12.53%
Turkey	12.57%	14.21%	15.40%	11.83%
Ukraine	19.96%	9.48%	12.87%	12.48%
Uzbekistan	4.87%	1.79%	1.79%	1.79%

Source: BEEPS (2016), Authors' Calculations

4. METHODOLOGY

The innovation levels of countries are compared by the TOPSIS method herein. TOPSIS method was developed by Hwang & Yoon (1981) and it is one of the most widely applied MCDM methods. It ranks the alternatives from the best (the most innovative) to the worst by distinguishing the scores of the alternatives from the positive ideal to the negative ideal. The resulting scores of the alternatives are normalized between 0 and 1.

This study assumes the equal significance of four different innovation types (New Product, New Organizational, New Marketing, and New Process Innovations). The proposed TOPSIS method uses the aggregate data of Table 2 as inputs and rank countries in terms of their innovation levels as explained in detail in Section 5.

5. RESULTS

Using the input data presented in Table 2, the standardized decision matrix is obtained (Table 3) by normalizing all values with the square root of the sum of square values of each column. As an example, New Process Innovation value of Turkey is standardized according to:

$$0.0928 = 0.1183/\sqrt{(0.0472^2 + 0.0583^2 + \cdots + 0.0179^2)}.$$

The weighted standardized decision matrix is then found by multiplying the standardized decision matrix values with the corresponding criterion weight as given in Table 4. Note that the weights of all innovation types are assumed to be 25 percent.

Table 3. Standardized Decision Matrix

Country	New Product Innovation	New Organization Innovation	New Marketing Innovation	New Process Innovation
Albania	0.06437	0.03539	0.04563	0.03704
Armenia	0.09655	0.04916	0.07848	0.04576
Azerbaijan	0.01251	0.02178	0.01516	0.02212
Belarus	0.18802	0.29691	0.31209	0.2898
Bosnia-Herzegovina	0.22359	0.19073	0.16974	0.1961
Bulgaria	0.15192	0.21502	0.16146	0.13654
Croatia	0.24391	0.23596	0.22449	0.23968
Cyprus	0.12534	0.07669	0.09126	0.11112
Czech Republic	0.30969	0.17558	0.16297	0.27176
Estonia	0.13848	0.12705	0.11552	0.15803
FYR Macedonia	0.18971	0.27725	0.23909	0.16996
Georgia	0.06098	0.04719	0.05658	0.07626
Greece	0.30017	0.22792	0.22986	0.28171
Hungary	0.12982	0.09362	0.12717	0.15688
Kazakhstan	0.11789	0.10972	0.09746	0.1059
Kosovo	0.32602	0.37146	0.36105	0.32231
Kyrgyzstan	0.23262	0.26218	0.26525	0.20918
Latvia	0.12159	0.08216	0.07626	0.09338
Lithuania	0.14906	0.14157	0.10707	0.15688
Moldova	0.18124	0.19467	0.18434	0.2375
Mongolia	0.15922	0.25759	0.24821	0.26583
Montenegro	0.07724	0.06607	0.08322	0.07321
Poland	0.20363	0.16587	0.19396	0.17512
Romania	0.2473	0.27791	0.30418	0.28762
Russia	0.15158	0.17043	0.16442	0.18476
Serbia	0.2185	0.15534	0.19529	0.16778
Slovak Republic	0.12059	0.09509	0.09316	0.1083
Slovenia	0.21455	0.14944	0.16791	0.08716
Tajikistan	0.10021	0.13605	0.17753	0.09832
Turkey	0.07668	0.1006	0.1012	0.0928
Ukraine	0.12171	0.06711	0.08459	0.09786
Uzbekistan	0.02971	0.01271	0.01179	0.01408

Table 4. Weighted Standardized Decision Matrix

Country	New Product Innovation	New Organization Innovation	New Marketing Innovation	New Process Innovation
Albania	0.01609	0.00885	0.01141	0.00926
Armenia	0.02414	0.01229	0.01962	0.01144
Azerbaijan	0.00313	0.00545	0.00379	0.00553
Belarus	0.047	0.07423	0.07802	0.07245
Bosnia-Herzegovina	0.0559	0.04768	0.04243	0.04903
Bulgaria	0.03798	0.05375	0.04036	0.03413
Croatia	0.06098	0.05899	0.05612	0.05992
Cyprus	0.03134	0.01917	0.02281	0.02778
Czech Republic	0.07742	0.04389	0.04074	0.06794
Estonia	0.03462	0.03176	0.02888	0.03951
FYR Macedonia	0.04743	0.06931	0.05977	0.04249
Georgia	0.01524	0.0118	0.01414	0.01907
Greece	0.07504	0.05698	0.05747	0.07043
Hungary	0.03246	0.02341	0.03179	0.03922
Kazakhstan	0.02947	0.02743	0.02437	0.02647
Kosovo	0.08151	0.09286	0.09026	0.08058
Kyrgyzstan	0.05815	0.06554	0.06631	0.05229
Latvia	0.0304	0.02054	0.01907	0.02335
Lithuania	0.03726	0.03539	0.02677	0.03922
Moldova	0.04531	0.04867	0.04608	0.05938
Mongolia	0.03981	0.0644	0.06205	0.06646
Montenegro	0.01931	0.01652	0.02081	0.0183
Poland	0.05091	0.04147	0.04849	0.04378
Romania	0.06182	0.06948	0.07605	0.0719
Russia	0.03789	0.04261	0.0411	0.04619
Serbia	0.05463	0.03883	0.04882	0.04194
Slovak Republic	0.03015	0.02377	0.02329	0.02707
Slovenia	0.05364	0.03736	0.04198	0.02179
Tajikistan	0.02505	0.03401	0.04438	0.02458
Turkey	0.01917	0.02515	0.0253	0.0232
Ukraine	0.03043	0.01678	0.02115	0.02446
Uzbekistan	0.00743	0.00318	0.00295	0.00352

The positive and negative ideal solutions are calculated as in Table 5. As the innovation types are “benefit” type criteria in our study, the negative (positive) ideal solution of a given criterion is the minimum (maximum) weighted standardized decision value of that criterion. Table 5 reports the positive and negative ideal solutions.

Table 5. Positive and Negative Ideals

Criterion	Positive Ideals	Negative Ideals
New Product Innovation	0.08151	0.00313
New Organization Innovation	0.09286	0.00318
New Marketing Innovation	0.09026	0.00295
New Process Innovation	0.08058	0.00352

As the next step, the distance of each country from the positive ideal solution is calculated by taking the square root of the differences of the values found in Table 4 and their corresponding positive ideal values. For instance, Poland's positive ideal distance value is calculated as:

$$\sqrt{(0.05091 - 0.08151)^2 + \cdots + (0.04378 - 0.08058)^2} = 0.08171.$$

The negative ideal distance of a country is calculated by taking the square root of the sum of square of all differences between the weighted standardized values and their corresponding negative ideal values. To demonstrate, Hungary's negative ideal distance value is calculated below:

$$\sqrt{(0.03246 - 0.00313)^2 + \cdots + (0.03922 - 0.00352)^2} = 0.0581.$$

In the TOPSIS method, an alternative is considered to be better if it is close to the positive ideal and away from the negative ideals. Table 6 reports the distances from negative and positive ideal values.

To calculate the TOPSIS scores of the countries, the relative closeness values of countries to the positive ideal solution are calculated by dividing the distance from the negative ideal solution to the sum of distances of the positive and negative ideal solutions. For instance, the relative closeness of Czech Republic is found by:

$$0.11294/(0.0709 + 0.11294) = 0.61435.$$

Table 7 shows the relative closeness values of all countries. Note that the values in Table 7 are also regarded as the innovation scores of the countries (1 being the best and 0 being the worst).

The ordered innovation scores are presented in Table 8. According to these country rankings, the most innovative countries are Kosova, Romania, and Belarus. Among them, the score of Kosova is 1.00, which makes Kosova the best country in terms of four innovation

criteria of this study. The second most innovative country, Romania, has a score of 0.79337, which is not close to the score of Kosova.

According to Global Innovation Index (GII) 2018 (World Intellectual Property Organization, 2018), the most innovative country is Estonia and the least innovative country is Tajikistan (Table 8, Column 3). In addition, Czech Republic, Cyprus, Slovenia, and Hungary are among the most innovative countries in EECA. Kosovo and Uzbekistan are not included in the rankings. However, in contrast to our expectations, TOPSIS analysis shows that Kosovo ranks higher than both Estonia (18^{th}) and Czech Republic (9^{th}) when we compare innovation levels by firm-level data. Another surprising finding is with respect to Turkey, which ranks 26^{th} in our list with a score of 0.24188, one rank below Tajikistan (Turkey ranks 50^{th} in the GII and Tajikistan ranks 101th).

We believe that these unexpected results are due to the initial values of the survey. As can be seen in Table 2, Kosova largest percentage of innovator firms (firms reporting "yes" to innovation activities). Specifically, the percentages of firms that responded "yes" to questions regarding Product Innovation, Organizational Innovation, Marketing Innovation, and Process Innovation are 53.47%, 52.48%, 54.95%, and 41.09%, respectively.

Our results reveal that although the BEEP Survey and more generally the Enterprise Surveys are widely used in the innovation literature, they suffer from response-bias. The problem could be the acquiescence bias that is; firms are more likely to say "yes" if they are required to agree/disagree with the statement. Another bias could result from the respondents' expectations of the survey. If they think that they are expected to say "yes" to innovation activities, they can alter their response to match expectations. Therefore, we believe that researchers should approach with caution when using these surveys. One of the major contributions of our paper is that we showed that some answers of this survey may be misleading although it is widely used in the literature.

Table 6. Distances from the Positive and Negative Ideals

Country	Distance From Positive Ideals	Distance from Negative Ideals
Albania	0.15047	0.01746
Armenia	0.13983	0.02941
Azerbaijan	0.16399	0.00315
Belarus	0.04187	0.13176
Bosnia-Herzegovina	0.07733	0.09163
Bulgaria	0.08984	0.07817
Croatia	0.05622	0.11167
Cyprus	0.12363	0.04511
Czech Republic	0.0709	0.11294
Estonia	0.1067	0.06146
FYR Macedonia	0.064	0.10528
Georgia	0.14332	0.02425
Greece	0.05008	0.12456
Hungary	0.11117	0.0581
Kazakhstan	0.11941	0.04762
Kosovo	0	0.16658
Kyrgyzstan	0.05163	0.11538
Latvia	0.12723	0.04121
Lithuania	0.10489	0.0636
Moldova	0.07526	0.09396
Mongolia	0.05953	0.11202
Montenegro	0.13564	0.03126
Poland	0.08171	0.08628
Romania	0.03481	0.13364
Russia	0.08959	0.07772
Serbia	0.08277	0.08663
Slovak Republic	0.12149	0.04607
Slovenia	0.09821	0.07468
Tajikistan	0.10904	0.05993
Turkey	0.12643	0.04034
Ukraine	0.12776	0.04123
Uzbekistan	0.1646	0.0043

Table 7. Relative Closeness Values of All Countries to the Positive Ideal Solution

Country	Relative Closeness to the Positive Ideal Solution
Albania	0.10396
Armenia	0.17379
Azerbaijan	0.01883
Belarus	0.75884
Bosnia-Herzegovina	0.5423
Bulgaria	0.46527
Croatia	0.66512
Cyprus	0.26733
Czech Republic	0.61435
Estonia	0.36546
FYR Macedonia	0.62192
Georgia	0.14473
Greece	0.71324
Hungary	0.34324
Kazakhstan	0.28511
Kosovo	1
Kyrgyzstan	0.69087
Latvia	0.24465
Lithuania	0.37748
Moldova	0.55525
Mongolia	0.65296
Montenegro	0.1873
Poland	0.51359
Romania	0.79337
Russia	0.46452
Serbia	0.51138
Slovak Republic	0.27497
Slovenia	0.43195
Tajikistan	0.35468
Turkey	0.24188
Ukraine	0.24399
Uzbekistan	0.02546

Table 8. Rankings of All Countries in terms of Innovation Scores

Country	Innovation Ranking	Innovation Score	GII 2018 Ranking
Kosovo	1	1	-
Romania	2	0.79337	49
Belarus	3	0.75884	86
Greece	4	0.71324	42
Kyrgyzstan	5	0.69087	94
Croatia	6	0.66512	41
Mongolia	7	0.65296	53
FYR Macedonia	8	0.62192	84
Czech Republic	9	0.61435	27
Moldova	10	0.55525	48
Bosnia-Herzegovina	11	0.5423	77
Poland	12	0.51359	39
Serbia	13	0.51138	55
Bulgaria	14	0.46527	37
Russia	15	0.46452	46
Slovenia	16	0.43195	30
Lithuania	17	0.37748	40
Estonia	18	0.36546	24
Tajikistan	19	0.35468	101
Hungary	20	0.34324	33
Kazakhstan	21	0.28511	74
Slovak Republic	22	0.27497	36
Cyprus	23	0.26733	29
Latvia	24	0.24465	34
Ukraine	25	0.24399	43
Turkey	26	0.24188	50
Montenegro	27	0.1873	52
Armenia	28	0.17379	68
Georgia	29	0.14473	59
Albania	30	0.10396	83
Uzbekistan	31	0.02546	-
Azerbaijan	32	0.01883	82

5.1. Sensitivity Analysis

The most important innovation capabilities of a country are new product and new process innovations. These two are commonly known as *technological innovations* and can help countries to improve their competitive advantages. Therefore, in this section, we reevaluate the country rankings using higher weights for new product and new process innovation capabilities.

In the sensitivity analysis, various scenarios are tested to see the effects of the increased weights of new product and new process innovations. All steps of the TOPSIS method have been conducted and the final rankings of the countries are found for all scenarios. Table 9 summarizes the sensitivity analysis of the results. In the sensitivity analysis, seven different scenarios are tested. The weight of each innovation type (new product or new process) is considered as 50%, 75% and 90%, where all other non-technological innovations are considered as equal importance. Also, in the last sensitivity analysis scenario, the weights of new product and new process innovations are increased to 40% to see the changes in the results. These results are compared to our original results in which all weights are 25%.

The results show that the change of the weights does not significantly alter the ordering of the most innovative countries. The first place is still Kosova, however, 2nd and 3rd places change. For example, Belarus is placed 2nd when new process innovation has higher importance, but it becomes 11th and 12th as the weight of new product innovation increases. This shows that Belarus focuses mainly on new process innovation. Similar trends are observed in other countries, such as Russia. However, some countries perform better on new product innovation than new process innovation. For example, Slovenia and Serbia increased their rankings when the weight of new product innovation increased, however, reduced their rankings when the weight of new process innovation increased.

On the other hand, some countries perform better than their original ranking as the weights of the new product or new process innovations increase. For example, Czech Republic is placed 9th in the original ranking, however, its ranking increased significantly (up to 2nd place) as the weights of new product or new process innovations increase. This result shows that Czech Republic mainly focuses on new product and new process innovation.

Table 9. Sensitivity Analysis of the Results for all Countries

Innovation Type	The weights of the Innovation Types for Each Scenario							
New Product	25%	50%	75%	90%	16.67%	8.33%	3.33%	40%
New Organization	25%	16.67%	8.33%	3.33%	16.67%	8.33%	3.33%	10%
New Marketing	25%	16.67%	8.33%	3.33%	16.67%	8.33%	3.33%	10%
New Process	25%	16.67%	8.33%	3.33%	50%	75%	90%	40%
Countries	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**
Albania	30	30	29	29	30	30	30	30
Armenia	28	26	26	26	29	29	29	28
Azerbaijan	32	32	32	32	31	31	31	32
Belarus	3	7	11	12	3	2	2	6
Bosnia-Herzegovina	11	8	7	7	10	10	10	9
Bulgaria	14	15	15	15	17	18	18	17
Croatia	6	5	5	5	7	7	7	5
Cyprus	23	20	20	20	21	19	19	20
Czech Republic	9	3	3	2	6	5	5	3
Estonia	18	18	18	18	16	15	15	18
FYR Macedonia	8	10	12	11	11	13	13	13
Georgia	29	29	30	30	28	27	27	29
Greece	4	2	2	3	4	4	4	2
Hungary	20	19	19	19	18	17	17	19
Kazakhstan	21	22	24	24	23	21	21	22
Kosovo	1	1	1	1	1	1	1	1
Kyrgyzstan	5	6	6	6	9	9	9	7
Latvia	24	23	22	22	25	24	24	24
Lithuania	17	17	17	17	15	16	16	16
Moldova	10	13	13	13	8	8	8	10
Mongolia	7	14	14	14	5	6	6	8
Montenegro	27	28	28	27	27	28	28	27
Poland	12	11	10	10	13	12	12	12
Romania	2	4	4	4	2	3	3	4
Russia	15	16	16	16	12	11	11	14
Serbia	13	9	8	8	14	14	14	11
Slovak_Republic	22	21	23	23	22	20	20	21
Slovenia	16	12	9	9	19	26	26	15
Tajikistan	19	25	25	25	20	22	22	25
Turkey	26	27	27	28	26	25	25	26
Ukraine	25	24	21	21	24	23	23	23
Uzbekistan	31	31	31	31	32	32	32	31

For Turkey, the ranking does not significantly change as the weights change. This suggests that Turkey has a balanced innovation characteristic on all four innovation categories. However, to have a higher competitive advantage in the global value chain, Turkey must focus more on technological innovations (new product and new process).

The same sensitivity analysis has been conducted for EU member countries and non-member countries as given in Tables 10 and 11. Note that, all steps of the TOPSIS method have been completed for both EU member and non-member countries. The results confirm the ones

found in Table 9 and show the differences between the countries in terms of their success on new product and new process innovations.

Table 10. Sensitivity Analysis of the Results for all European Union Countries

Innovation Type	**The weights of the Innovation Types for Each Scenario**							
New Product	25%	50%	75%	90%	16.67%	8.33%	3.33%	40.00%
New Organization	25%	16.67%	8.33%	3.33%	16.67%	8.33%	3.33%	10.00%
New Marketing	25%	16.67%	8.33%	3.33%	16.67%	8.33%	3.33%	10.00%
New Process	25%	16.67%	8.33%	3.33%	50%	75%	90%	40%
Countries	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**
Bulgaria	6	7	7	7	6	9	9	9
Croatia	3	4	4	4	4	4	4	4
Cyprus	12	12	11	11	11	10	10	11
Czech_Republic	4	2	2	1	3	3	3	2
Estonia	9	9	9	9	8	6	6	8
Greece	2	1	1	2	2	2	2	1
Hungary	10	10	10	10	9	8	8	10
Latvia	13	13	13	13	13	13	12	13
Lithuania	8	8	8	8	7	7	7	7
Poland	5	5	6	6	5	5	5	5
Romania	1	3	3	3	1	1	1	3
Slovak_Republic	11	11	12	12	12	11	11	12
Slovenia	7	6	5	5	10	12	13	6

Similar to our finding in Table 9, the ranking of Turkey among the non-member countries (Table 11) does not significantly change which again indicates the balanced innovation structure of Turkey. However, the relatively low ranking of Turkey also suggests that there is still much to be done to improve the innovation capabilities of Turkey.

Table 11. Sensitivity Analysis of the Results for all European Union Countries

Innovation Type	The weights of the Innovation Types for Each Scenario							
New Product	25%	50%	75%	90%	16.67%	8.33%	3.33%	40%
New Organization	25%	16.67%	8.33%	3.33%	16.67%	8.33%	3.33%	10%
New Marketing	25%	16.67%	8.33%	3.33%	16.67%	8.33%	3.33%	10%
New Process	25%	16.67%	8.33%	3.33%	50%	75%	90%	40%
Countries	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**	**Rank**
Albania	17	17	16	16	17	17	17	17
Armenia	15	13	13	13	16	16	16	14
Azerbaijan	19	19	19	19	18	18	18	19
Belarus	2	4	5	6	2	2	2	2
Bosnia-Herzegovina	7	3	3	3	6	6	6	4
FYR Macedonia	5	6	6	5	7	8	8	8
Georgia	16	16	17	17	15	14	14	16
Kazakhstan	11	10	11	11	11	10	10	10
Kosovo	1	1	1	1	1	1	1	1
Kyrgyzstan	3	2	2	2	5	5	5	3
Moldova	6	7	7	7	4	4	4	6
Mongolia	4	8	8	8	3	3	3	5
Montenegro	14	15	15	14	14	15	15	15
Russia	9	9	9	9	8	7	7	9
Serbia	8	5	4	4	9	9	9	7
Tajikistan	10	12	12	12	10	11	11	12
Turkey	13	14	14	15	13	13	13	13
Ukraine	12	11	10	10	12	12	12	11
Uzbekistan	18	18	18	18	19	19	19	18

6. CONCLUSION

Today's increased competitive trade environment and globalization of the world have forced firms to be more innovative by increasing their research and development budgets. By doing so, they try to be more innovative, and thus, survive in the global competition. Many firms in developing countries are competing with each other in global markets. The innovation levels of the firms determine the innovation capabilities of countries.

This study uses MCDM methods to evaluate innovation levels of EECA countries for the first time in the literature. Using the well-known BEEPS data set of the World Bank (the latest version, 2016), TOPSIS method is used to rank countries in terms of innovation levels. This survey includes random sampling of firms from different sectors (e.g., information technology, food, garment, transportation) representing the entire economy of a country. The four innovation types (New Product, New Organizational, New Marketing, and New Process Innovations) reported in the BEEPS data are used as input values in the TOPSIS method.

The TOPSIS results indicate Kosova as the most innovative country in EECA category. The rest of the top five countries are found as Romania, Belarus, Greece, and Kyrgyzstan. Turkey is ranked very low (26th among 32 countries). The sensitivity analysis showed that the results do not change significantly for most of the countries, including Turkey. However, some countries (e.g., Czech Republic) are ranked significantly higher as the weights of new product and new process innovations increase because of their higher technological innovation capabilities. Reversely, the rankings of some countries (e.g., Macedonia and Kyrgyzstan) become lower as the weights of new product and new process innovations increase due to their main focus on new marketing and new organization innovations. Turkey's ranking does not significantly change according to different criteria weights because it has balanced innovation scores for all innovation types.

Despite its unexpected low score, Turkey has a very significant potential innovation because of its unique and critical geographical position between the East and West. According to the results of this study, Turkey's low score is caused by its engagement in marketing and organizational innovation. Also, Turkey's technological innovations (i.e., process and product innovations) are not very high. However, technological innovations are key to increase the competitive advantages for the firms. Therefore, Turkey should focus on technological innovations to increase the innovation capacity of the country and increase economic growth through innovation.

The main limitation of this study is that our methodology only uses BEEPS data. The results showed that some developing countries (e.g., Kosova, Romania, and Belarus) may have exaggerated their innovation results in this well-known data set. To address this issue, this study can be enriched by including other innovation data sets. Also, only EECA countries are compared in this paper. However, Turkey also competes with other developing countries in various regions (e.g., Brazil or India). As another future work, the criteria weights will be

calculated by surveying the innovation experts and a fuzzy MCDM method will be used to better capture the uncertainties in the data.

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