A Taxonomic Study of Innovation in the MENA Region Economies: Reflections on Entrepreneurism in Egypt and Qatar

Amir Forouharfar, Mahshid Sazegar, Victoria Hill, and Nezameddin Faghih

Abstract The research goal of this paper is to study the impact of innovation in an economy. This has an effect not only on the economy in general, but particularly on entrepreneurism. To narrow the focus of the study, the Middle East and North Africa (MENA) region was chosen and two countries were selected: Egypt, which is mainly in North Africa but partially in West Asia; and Qatar, which is in the most eastern portion of the Arabian Peninsula. Egypt is the most populated country in MENA, while Qatar has one of the smallest populations. Numerical taxonomy was applied to secondary data from *Global Innovation Index* (GII) for 2008–2017 for Egypt, Qatar and Switzerland, which was chosen as the benchmark country. Egypt has an efficiency-driven economy while Qatar and Switzerland have innovation-driven economies. Data from these three countries formed the compound distance matrices (i.e. primary data) of the research; the GII's annual country reports were used to specify the innovation distances within all three countries (i.e. secondary data). The results of the paper demonstrated that while emulating Switzerland's innovation success remains a long-term goal for many countries, Qatar is far more innovative than Egypt.

Keywords Innovation · Entrepreneur · Entrepreneurial · Innovation-driven vs. efficiency-driven · MENA · Egypt · Qatar · Numerical taxonomy

A. Forouharfar
University of Sistan and Baluchestan, Zahedan, Iran

M. Sazegar (✉)
Fars Engineering Association, Shiraz, Iran

V. Hill
Faculty of Arts and Sciences, Department of Languages and Continuous Training, Moulay Ismail University, Meknes, Morocco

N. Faghih
UNESCO Chair in Entrepreneurship, Paris, France
e-mail: faghihnezam@ut.ac.ir; nfaghih@rose.shirazu.ac.ir

N. Faghih, M. R. Zali (eds.), *Entrepreneurship Education and Research in the Middle East and North Africa (MENA)*, Contributions to Management Science,
https://doi.org/10.1007/978-3-319-90394-1_14

1 Introduction

"Innovation performance is a crucial determinant of competitiveness and national progress" (OECD 2009). Today, economic growth and increased competitiveness is determined by a nation's ability to translate innovation into successful entrepreneurism.

The Middle East and North Africa region (MENA) faces a plethora of economic challenges: The entire region suffers from the world's highest rates of youth (15–24 years old) unemployment, at roughly 29.6% (ILO 2017a). Egypt suffers from extremely high rates of youth unemployment at 34.6% (WB 2017); and even "...when working, 43% of young workers are wage labourers without written contracts" (ILO 2017b). At the other end of the spectrum, Qatar has been much more successful in solving its own youth unemployment issues; rates were already low in 1991 at 3.4%; but most recent measurements show just 0.9% in 2016 and 1.1% in 2017. While 3.4% is a very admirable rate, the improvements that lead to 1.1% are worth investigation. It would be tempting to consider Qatar's massive oil wealth spread over a relative small population as being the driver of such impressive youth unemployment rates. But, by way of comparison, consider Qatar's very close and similar neighbour, Bahrain, which enjoyed a rate of 5.3% youth unemployment in 1991 but climbed to 5.9% in 2017 (WB 2017). One of the solutions to tackle these economic challenges is to identify those aspects of the economy which could increase innovation in each MENA state.

However, truly innovative outcomes in an economy are bound to the capabilities of the populace (Arnold and Wade 2015: 670). The capabilities of that 'populace' are directly connected to capabilities in research and development (R&D). If a nation does not have sufficient number, educational level, scientific skills and funding for researchers, there is no innovation-promoting populace. Without a large enough share of 'native' researchers, a country's choices are to hire foreign researchers (as China has recently announced in its intention to offer 5–10 year visas to some 50,000 persons representing "high-end foreign talent"[1]; or purchase the scientific output (i.e. innovation) from other countries and markets (Nambisan and Sawhney 2007). However, this latter option removes any possibility of becoming the 'first adopter', thereby reducing economic benefits. Within the *Global Innovation Index* (GII) reports, one can read examples of both improved economic benefits driven by innovation (e.g. Switzerland and Qatar) as well as countries suffering from economic stagnation, many of these in MENA (Global Innovation Index 2017: 43).

Although R&D could be thought of as the 'engine' (or input) for innovation, the output of innovation is much more diffuse (Fig. 1):

[1]In *Evaluation Criteria for Foreigners Employed in China*, *China's* State Administration of Foreign Experts Affairs definers 'high-end talent' as Nobel Prize winners, top scientists in nearly every field of science, heads of major financial institutions, successful entrepreneurs, technology leaders, successful Olympic athletes, directors and professors of "high-level universities" (BBC 2018).

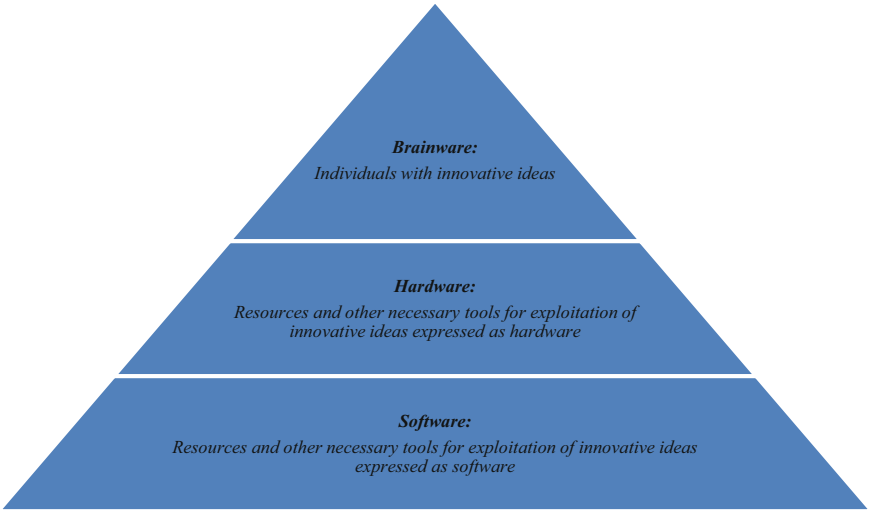

Fig. 1 Application of innovation from R&D labs to development of products and/or services. Source: Authors' own work

1. *Brainware* represents the individuals—initially the researchers, but especially later as diffusion occurs, the members of the population, especially the youth—accepted into entrepreneurial development programmes as well as those who independently develop innovative ideas.
2. *Hardware* represents both the resources and other tools made available because of innovation, as well as for the promotion and facilitation of developing entrepreneurial ideas.
3. *Software* is one of the 'outputs', i.e. the broad collection of original ideas developed by individual researchers/teams. The best of these are refined further into entrepreneurial and innovation-oriented businesses.

The OECD and Eurostat offer an even more specific description:

> It goes far beyond the confines of research labs to users, suppliers and consumers everywhere—in government, business and non-profit organisations, across borders, across sectors, and across institutions. The *Oslo Manual for Measuring Innovation* defines four types of innovation: **product** innovation, **process** innovation, **marketing** innovation and **organisational** innovation:
>
> - **Product innovation**: A good or service that is new or significantly improved. This includes significant improvements in technical specifications, components and materials, software in the product, user friendliness or other functional characteristics.
> - **Process innovation**: A new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
> - **Marketing innovation**: A new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
> - **Organisational innovation**: A new organisational method in business practices, workplace organisation or external relations (OECD and Eurostat 2005).

While the benefits of innovation to an economy are clear, not every government shares that perspective. It should be noted that excessive intervention by governments in the nation's economy stymies the development of innovation's benefits. Unfortunately, governmental interventions in MENA economies are prevalent (Salehi Esfahani 2006). And, "while the developing world has moved toward more market-oriented policies and production systems that are dominated by the private sector and rely on market signals, MENA has maintained much of the old style industrial policies and high state intervention in the economy that characterized much of the developing world in the past" (Nabli et al. 2006). Thus, the economies of MENA countries are particularly prone to excessive governmental intervention. It should be remembered that organizational DNA also determines the destiny of an organization, public or private. Faghih et al. (2016) believe: "...the defining elements of the genetic code or DNA of an organization ... and their unique combination in an organization determine how ably and agilely the organization functions. Hence, they imperil or ensure enduring results" (p. 7).

2 Methodology

"Innovation inputs include factors like human capital and research, infrastructure, market sophistication and business sophistication. Innovation outputs refer to knowledge and technology outputs, as well as creative outputs" (Switzerland Global Enterprise 2016). Egypt, Qatar and Switzerland are compared based on their GII scores between 2008 and 2016 using Numerical Taxonomy. Switzerland, an innovation-driven economy, was chosen as a benchmark as it was the GII's highest-scoring economy in 2017—as it's been every year since 2011. Switzerland has also been considered the world's top-performing economy for the past nine successive years by the World Economic Forum (2018). The taxonomic results were used to consider the distances of Efficiency-driven Egypt and Innovation-driven Qatar's economies relative to the world's top-scoring innovation economy in the GII's 2016 report.

A description of the methodological steps for developing comparative data appears as a flowchart (Fig. 2).

3 Calculations of Comparative Indices

3.1 Step 1: Development of the Data Matrix

$$\mathrm{Xoj} = \left(\sum\nolimits_{i=1}^{n} Xij\right)/\mathrm{n} \tag{1}$$

Fig. 2 Flowchart of methodological steps. Source: Authors' own work

The purpose of step 1 was to develop a matrix with 'n' members (1, 2, 3, . . ., n) to represent the variables as groups. The groups were shown with 'm' (as an indicator of each study). The matrix, as it was shown in Eq. (1), consisted of 'i' rows and 'j' columns. The data matrices of the three countries were formed by using the GII's indices data from 2008 to 2016. It should be noted that each indicator (for the scores of the indices and sub-indices) was normalized. In the tables that follow, the sub-indices of the innovation input and output for each year are placed in rows 1–7. Additionally, the first five sub-indices of institution, human capacity, infrastructure, market sophistication, and business sophistication (1–5) beside the two sub-indices of knowledge (scientific outputs) and creative outputs (6–7) comprise the Innovation Input Index and Innovation Output Index, respectively.

Concerning Tables 1 and 2, which represent the released data by GII in the years 2008 and 2009, GII reports have reported the data of the countries based on their rankings. Therefore, the values in these 2 years do not represent mathematical values, but the rankings. Obviously, Switzerland's numbers in both the tables are lower than that of the Egypt and Qatar, which are due to Switzerland's better rankings (Tables 3, 4, 5, 6, 7, 8 and 9).

Table 1 GII's indices for Egypt, Qatar and Switzerland in 2008

		2008			
	Index (Xij)	Egypt	Qatar	Switzerland	Xoj
1	Institution	75	29	4	36.00
2	Human capacity	66	32	4	34.00
3	Infrastructure	71	34	4	36.33
4	Market sophistication	86	36	23	48.33
5	Business sophistication	74	27	3	34.67
6	Knowledge	73	32	2	35.67
7	Competitiveness[a]	78	41	14	44.33

Source: Authors' own work based on GII data
[a]The year 2008 was the last year that Competitiveness was the label used in Item 7. In subsequent years, the Competitiveness label was replaced by Creativity

Table 2 GII's indices for Egypt, Qatar and Switzerland in 2009

		2009			
	Index (Xij)	Egypt	Qatar	Switzerland	Xoj
1	Institution	74	25	7	35.33
2	Human capacity	77	21	8	35.33
3	Infrastructure	82	37	5	41.33
4	Market sophistication	74	92	16	60.67
5	Business sophistication	103	28	4	45.00
6	Knowledge	84	51	4	46.33
7	Creative outputs	58	42	4	34.67

Source: Authors' own work based on GII data

Table 3 GII's indices for Egypt, Qatar and Switzerland in 2010

		2010			
	Index (Xij)	Egypt	Qatar	Switzerland	Xoj
1	Institution	61.7	83.5	92.6	79.27
2	Human capacity	26.4	52.5	55.1	44.67
3	Infrastructure	21.7	33.9	44.5	33.37
4	Market sophistication	35	39.2	70.1	48.10
5	Business sophistication	30.7	49.5	68	49.40
6	Knowledge	17.2	50.6	62	43.27
7	Creative outputs	29.5	36.9	54.4	40.27

Source: Authors' own work based on GII data

3.2 Step 2: Forming the Standard Matrix

Since the indicators were measured by different units, Z_{ij} *Matrix* was formed by the following formula, to eliminate the discrepancy between the units and to convert them to unit scales:

Table 4 GII's indices for Egypt, Qatar and Switzerland in 2011

		2011			
	Index (Xij)	Egypt	Qatar	Switzerland	Xoj
1	Institution	40.4	70.2	88.0	66.20
2	Human capacity	25.9	55.7	57.9	46.50
3	Infrastructure	33.6	49.0	60.8	47.80
4	Market sophistication	30.5	35.3	69.8	45.20
5	Business sophistication	31.9	60.3	63.5	51.90
6	Knowledge	22.6	25.2	72.0	39.93
7	Creative outputs	24.0	48.6	65.0	45.87

Source: Authors' own work based on GII data

Table 5 GII's indices for Egypt, Qatar and Switzerland in 2012

		2012			
	Index (Xij)	Egypt	Qatar	Switzerland	Xoj
1	Institution	43.9	73.80	87.30	68.33
2	Human capacity	28.3	31.90	55.40	38.53
3	Infrastructure	33.7	46.00	57.00	45.57
4	Market sophistication	35.8	47.40	77.50	53.57
5	Business sophistication	27.4	40.10	55.30	40.93
6	Knowledge	18	19.90	61.50	33.13
7	Creative outputs	28.2	48.50	71.80	49.50

Source: Authors' own work based on GII data

Table 6 GII's indices for Egypt, Qatar and Switzerland in 2013

		2013			
	Index(Xij)	Egypt	Qatar	Switzerland	Xoj
1	Institution	42.1	75.5	87.60	68.40
2	Human capacity	27.8	33.6	56.70	39.37
3	Infrastructure	36.1	53.1	59.00	49.40
4	Market sophistication	35.4	46.3	74.70	52.13
5	Business sophistication	28.9	43.4	54.20	42.17
6	Knowledge	25.4	20.4	60.90	35.57
7	Creative outputs	26.6	40.1	65.30	44.00

Source: Authors' own work based on GII data

$$Sj = \sqrt{\sum_{i=1}^{n} \left(Xij - \overline{Xj}\right)^2 / n} \tag{2}$$

$$\mathrm{Z_{ij}} = \left(\mathrm{X_{ij}} - \mathrm{X_{oj}}\right) / \mathrm{S_j} \tag{3}$$

'Xij' is a *Data Matrix*, 'Xoj' is an *Average Matrix* (Eq. 1) and 'Sj' is a *Standard Deviation* for 'j' indicators, which are derived from the GII' reports from 2008 to 2016. Therefore, in this paper 'i' represents the countries (Egypt, Qatar and Switzerland) in the time span 2008–2016. The *Standard Matrices* of them were

Table 7 GII's indices for Egypt, Qatar and Switzerland in 2014

		2014			
	Index (Xij)	Egypt	Qatar	Switzerland	Xoj
1	Institution	39.5	77.70	89.60	68.93
2	Human capacity	27.9	35.30	59.20	40.80
3	Infrastructure	37.2	55.50	58.60	50.43
4	Market sophistication	35.9	45.90	72.30	51.37
5	Business sophistication	31.6	27.70	60.00	39.77
6	Knowledge	21.7	24.50	72.40	39.53
7	Creative outputs	25.1	34.70	64.80	41.53

Source: Authors' own work based on GII data

Table 8 GII's indices for Egypt, Qatar and Switzerland in 2015

		2015			
	Index (Xij)	Egypt	Qatar	Switzerland	Xoj
1	Institution	39	75.00	90.30	68.10
2	Human capacity	27.3	32.60	63.30	41.07
3	Infrastructure	38.3	60.50	61.00	53.27
4	Market sophistication	34.2	42.80	69.80	48.93
5	Business sophistication	20	29.30	57.60	35.63
6	Knowledge	18.5	20.00	67.00	35.17
7	Creative outputs	21.8	33.80	61.40	39.00

Source: Authors' own work based on GII data

Table 9 GII's indices for Egypt, Qatar and Switzerland in 2016

		2016			
	Index (Xij)	Egypt	Qatar	Switzerland	Xoj
1	Institution	40.4	72.80	89.50	67.57
2	Human capacity	26.9	33.30	63.60	41.27
3	Infrastructure	38.4	58.10	65.10	53.87
4	Market sophistication	36.7	42.60	67.50	48.93
5	Business sophistication	21	28.00	62.60	37.20
6	Knowledge	17	23.10	69.10	36.40
7	Creative outputs	21.6	34.50	62.50	39.53

Source: Authors' own work based on GII data

calculated and shown in the tables that follow (Tables 10, 11, 12, 13, 14, 15, 16, 17 and 18). Moreover, by converting the scales of the indices to the scales of the unit in the average $= 0$ and *Standard Deviation* $= 1$ in the *Z Matrix*, we could control *'Z' Matrix* acceptability.

Table 10 Standard matrix of 2008

	Index	2008 "Z Matrix"			Z_{oj}	s_{zoj}
		Egypt	Qatar	Switzerland		
1	Institution	1.326	−0.238	−1.088	0.00	1.00
2	Human capacity	1.262	−0.079	−1.183	0.00	1.00
3	Infrastructure	1.265	−0.085	−1.180	0.00	1.00
4	Market sophistication	1.646	−0.539	−1.107	0.00	1.00
5	Business sophistication	1.334	−0.260	−1.074	0.00	1.00
6	Knowledge	1.283	−0.126	−1.157	0.00	1.00
7	Competitiveness	1.283	−0.127	−1.156	0.00	1.00

Source: Authors' own work based on GII data

Table 11 Standard matrix of 2009

	Index	2009 "Z Matrix"			Z_{oj}	s_{zoj}
		Egypt	Qatar	Switzerland		
1	Institution	1.366	−0.365	−1.001	0.00	1.00
2	Human capacity	1.392	−0.479	−0.913	0.00	1.00
3	Infrastructure	1.710	−0.182	−1.527	0.00	1.00
4	Market sophistication	0.614	1.442	−2.056	0.00	1.00
5	Business sophistication	1.658	−0.486	−1.172	0.00	1.00
6	Knowledge	1.709	0.212	−1.921	0.00	1.00
7	Creative outputs	1.631	0.513	−2.143	0.00	1.00

Source: Authors' own work based on GII data

Table 12 Standard matrix of 2010

	Index	2010 "Z matrix"			Z_{oj}	s_{zoj}
		Egypt	Qatar	Switzerland		
1	Institution	−1.355	0.327	1.028	0.00	1.00
2	Human capacity	−1.409	0.604	0.805	0.00	1.00
3	Infrastructure	−1.252	0.057	1.195	0.00	1.00
4	Market sophistication	−0.837	−0.569	1.406	0.00	1.00
5	Business sophistication	−1.228	0.007	1.221	0.00	1.00
6	Knowledge	−1.371	0.386	0.985	0.00	1.00
7	Creative outputs	−1.031	−0.322	1.354	0.00	1.00

Source: Authors' own work based on GII data

3.3 Step 3: Calculation of Compound Distance Among the Countries

In this step, Eq. (4) helped us to measure the *Compound Distance* between the three countries:

Table 13 Standard matrix of 2011

	Index	2011 "Z matrix"			Z_{oj}	s_{zoj}
		Egypt	Qatar	Switzerland		
1	Institution	−1.314	0.204	1.110	0.00	1.00
2	Human capacity	−1.412	0.630	0.781	0.00	1.00
3	Infrastructure	−1.275	0.108	1.167	0.00	1.00
4	Market sophistication	−0.840	−0.566	1.405	0.00	1.00
5	Business sophistication	−1.408	0.591	0.817	0.00	1.00
6	Knowledge	−0.764	−0.649	1.413	0.00	1.00
7	Creative outputs	−0.552	0.069	0.483	0.00	1.00

Source: Authors' own work based on GII data

Table 14 Standard matrix of 2012

	Index	2012 "Z matrix"			Z_{oj}	s_{zoj}
		Egypt	Qatar	Switzerland		
1	Institution	−1.347	0.301	1.046	0.00	1.00
2	Human capacity	−0.852	−0.552	1.404	0.00	1.00
3	Infrastructure	−1.247	0.046	1.201	0.00	1.00
4	Market sophistication	−1.011	−0.351	1.362	0.00	1.00
5	Business sophistication	−1.187	−0.073	1.260	0.00	1.00
6	Knowledge	−0.754	−0.659	1.413	0.00	1.00
7	Creative outputs	−1.196	−0.056	1.252	0.00	1.00

Source: Authors' own work based on GII data

Table 15 Standard matrix of 2013

	Index	2013 "Z matrix"			Z_{oj}	s_{zoj}
		Egypt	Qatar	Switzerland		
1	Institution	−1.367	0.369	0.998	0.00	1.00
2	Human capacity	−0.927	−0.462	1.389	0.00	1.00
3	Infrastructure	−1.370	0.381	0.989	0.00	1.00
4	Market sophistication	−1.010	−0.352	1.362	0.00	1.00
5	Business sophistication	−1.280	0.119	1.161	0.00	1.00
6	Knowledge	−0.564	−0.841	1.405	0.00	1.00
7	Creative outputs	−0.445	−0.100	0.545	0.00	1.00

Source: Authors' own work based on GII data

$$Dab = \sqrt{\sum_{i=1}^{n} (Zaj - Zbj)^2} \tag{4}$$

D_{ab} is a distance between two 'a' and 'b' countries.

Therefore:

$D_{aa} = 0$

$D_{bb} = 0$

$D_{ab} = D_{ba}$

Table 16 Standard matrix of 2014

	Index	2014 "Z matrix"			Z_{oj}	s_{zoj}
		Egypt	Qatar	Switzerland		
1	Institution	−1.377	0.410	0.967	0.00	1.00
2	Human capacity	−0.966	−0.412	1.378	0.00	1.00
3	Infrastructure	−1.401	0.537	0.865	0.00	1.00
4	Market sophistication	−1.007	−0.356	1.363	0.00	1.00
5	Business sophistication	−0.567	−0.838	1.406	0.00	1.00
6	Knowledge	−0.766	−0.646	1.413	0.00	1.00
7	Creative outputs	−0.972	−0.404	1.376	0.00	1.00

Source: Authors' own work based on GII data

Table 17 Standard matrix of 2015

	Index	2015 "Z Matrix"			Z_{oj}	s_{zoj}
		Egypt	Qatar	Switzerland		
1	Institution	−1.353	0.321	1.032	0.00	1.00
2	Human capacity	−0.867	−0.534	1.401	0.00	1.00
3	Infrastructure	−1.414	0.683	0.731	0.00	1.00
4	Market sophistication	−0.971	−0.404	1.376	0.00	1.00
5	Business sophistication	−0.978	−0.396	1.374	0.00	1.00
6	Knowledge	−0.740	−0.674	1.414	0.00	1.00
7	Creative outputs	−1.037	−0.314	1.351	0.00	1.00

Source: Authors' own work based on GII data

Table 18 Standard matrix of 2016

	Index	2016 "Z Matrix"			Z_{oj}	s_{zoj}
		Egypt	Qatar	Switzerland		
1	Institution	−1.333	0.257	1.076	0.00	1.00
2	Human capacity	−0.898	−0.498	1.395	0.00	1.00
3	Infrastructure	−1.368	0.375	0.994	0.00	1.00
4	Market sophistication	−0.917	−0.474	1.391	0.00	1.00
5	Business sophistication	−0.891	−0.506	1.397	0.00	1.00
6	Knowledge	−0.834	−0.572	1.406	0.00	1.00
7	Creative outputs	−1.050	−0.295	1.345	0.00	1.00

Source: Authors' own work based on GII data

Therefore, as shown in the tables that follow, the *Compound Distance Matrices* 'D' for the three countries (Egypt, Qatar and Switzerland) were symmetric and their diameters were equal to zero. As seen in the right-most column D, the names D12, D13 and D23 or D32, show the distances between 'Egypt and Qatar,' 'Egypt and Switzerland,' and 'Qatar and Switzerland,' respectively (Tables 19, 20, 21, 22, 23, 24, 25, 26 and 27).

Table 19 Compound distances for Egypt, Qatar and Switzerland in 2008

Country	Egypt '1'	Qatar '2'	Switzerland '3'	D Matrix (2008)
Egypt '1'	0	3.997	6.393	D12 = 3.997
Qatar '2'	3.997	0	2.481	D23 = 2.481
Switzerland '3'	6.393	2.481	0	D32 = 2.481

Source: Authors' own work based on GII data

Table 20 Compound distances for Egypt, Qatar and Switzerland in 2009

Country	Egypt '1'	Qatar '2'	Switzerland '3'	D Matrix (2009)
Egypt '1'	0	4.342	7.997	D12 = 4.342
Qatar '2'	4.342	0	5.169	D21 = 4.342
Switzerland '3'	7.997	5.169	0	D32 = 5.159

Source: Authors' own work based on GII data

Table 21 Compound distances for Egypt, Qatar and Switzerland in 2010

Country	Egypt '1'	Qatar '2'	Switzerland '3'	D Matrix (2010)
Egypt '1'	0	3.713	5.688	D12 = 3.713
Qatar '2'	3.713	0	3.22	D23 = 3.22
Switzerland '3'	5.688	3.22	0	D32 = 3.22

Source: Authors' own work based on GII data

Table 22 Compound distances for Egypt, Qatar and Switzerland in 2011

Country	Egypt '1'	Qatar '2'	Switzerland '3'	D Matrix (2011)
Egypt '1'	0	3.586	5.688	D12 = 3.586
Qatar '2'	3.586	0	3.213	D23 = 3.213
Switzerland '3'	5.688	3.213	0	D32 = 3.213

Source: Authors' own work based on GII data

Table 23 Compound distances for Egypt, Qatar and Switzerland in 2012

Country	Egypt '1'	Qatar '2'	Switzerland '3'	D Matrix (2012)
Egypt '1'	0	2.732	5.688	D12 = 2.732
Qatar '2'	2.732	0	4.053	D21 = 2.732
Switzerland '3'	5.688	4.053	0	D32 = 4.053

Source: Authors' own work based on GII data

Table 24 Compound distances for Egypt, Qatar and Switzerland in 2013

Country	Egypt '1'	Qatar '2'	Switzerland '3'	D Matrix (2013)
Egypt '1'	0	2.98	5.688	D12 = 2.98
Qatar '2'	2.98	0	3.698	D21 = 2.98
Switzerland '3'	5.688	3.698	0	D32 = 3.698

Source: Authors' own work based on GII data

Table 25 Compound distances for Egypt, Qatar and Switzerland in 2014

Country	Egypt '1'	Qatar '2'	Switzerland '3'	D Matrix (2014)
Egypt '1'	0	2.845	5.688	D12 = 2.845
Qatar '2'	2.845	0	4.361	D21 = 2.845
Switzerland '3'	5.688	4.361	0	D32 = 4.361

Source: Authors' own work based on GII data

Table 26 Compound distances for Egypt, Qatar and Switzerland in 2015

Country	Egypt '1'	Qatar '2'	Switzerland '3'	D Matrix (2015)
Egypt '1'	0	2.916	5.688	D12 = 2.916
Qatar '2'	2.916	0	4.205	D21 = 2.916
Switzerland '3'	5.688	4.205	0	D32 = 4.205

Source: Authors' own work based on GII data

Table 27 Compound distances for Egypt, Qatar and Switzerland in 2016

Country	Egypt '1'	Qatar '2'	Switzerland '3'	D Matrix (2016)
Egypt '1'	0	2.59	5.688	D12 = 2.59
Qatar '2'	2.59	0	4.282	D21 = 2.59
Switzerland '3'	5.688	4.282	0	D32 = 4.282

Source: Authors' own work based on GII data

3.4 Step 4: Assignment of the Shortest Distances

In this step of the methodology every cell demonstrates the distances between the countries. Each matrix 'D' line defines the gaps between the countries, for example there is the most approximation among two countries if 'a' and 'b' have the shortest distance, i.e. country 'b' is a model for country 'a' and country 'a' is named a shade.

3.5 Step 5: Optimum Chart Drawing

The countries which had the most commonalities were connected together by a vector towards the country which is assumed as a model and the vector length equal to the shortest distance between the countries. For determining homogeneous countries, at first upper-line distance $d_{(+)}$ and lower-limit distance $d_{(-)}$ were calculated with the following Eqs. (5) and (6), (d is the average of the shortest distances and S_d is the standard deviation):

$$d_{(+)} = d + 2S_d \tag{5}$$

$$d_{(-)} = d - 2S_d \tag{6}$$

Furthermore, after measuring $d_{(+)}$ and $d_{(-)}$ for the three countries (Egypt, Qatar and Switzerland) in 2016 from the Eqs. (4) and (5), it became evident that the distances among the countries are not out of upper $d_{(+)}$ and lower $d_{(-)}$ limits range for the year 2016, therefore the three countries could be compared with one another.

3.6 Step 6: Ranking of the Countries in Terms of Improvement and Development

According to step 5, if the countries or places are not located in homogeneous groups then *Data Matrix* could be formed for homogenous group of countries and again *Standard Matrix*-calculated. In the *Standard Matrix*, we can find the biggest value in each column which is named the *'Ideal Amount'*. In this paper all of the three reviewed countries are in an equally seamlessly space, so they can be compared with one another.

3.7 Step 7: Calculation of the Countries' Improvement

For finding improvement degrees for the countries, Co (the upper limit of the development pattern) should be measured and then put up in the relation: $f_i = (C_{io}/C_o)$ that C_{io} is development pattern over the upper limit of the development pattern, then C_o obtains from the Eq. (7):

$$\mathrm{Co} = \overline{Cio} + 2Sio \tag{7}$$

Development degree is between '0' and '1', i.e. when 'f_i' value gets near to '0', the country is more developed than the case 'f_i' approaches to '1'; in other words, the country gets close to undeveloped characteristics. After measuring C_{io} and f_i the countries were sorted based on the development degrees.

4 Conclusion

By considering the least distances between Qatar and the benchmark country (Switzerland) in the years 2008–2016 (Tables 19–27), the years 2008, 2010 and 2011 with the distances equal to D23 = 2.481, D23 = 3.22 and D23 = 3.213 respectively, had been the most innovative years of Qatar. In 2011 the absolute value for Business Sophistication (60.3 for Qatar, 63.5 for Switzerland) presented in Table 4, while in 2010 and 2011 the absolute values for Human Capacity of Qatar (52.5 and 55.7, respectively) presented in Tables 3 and 4, had been the most effective

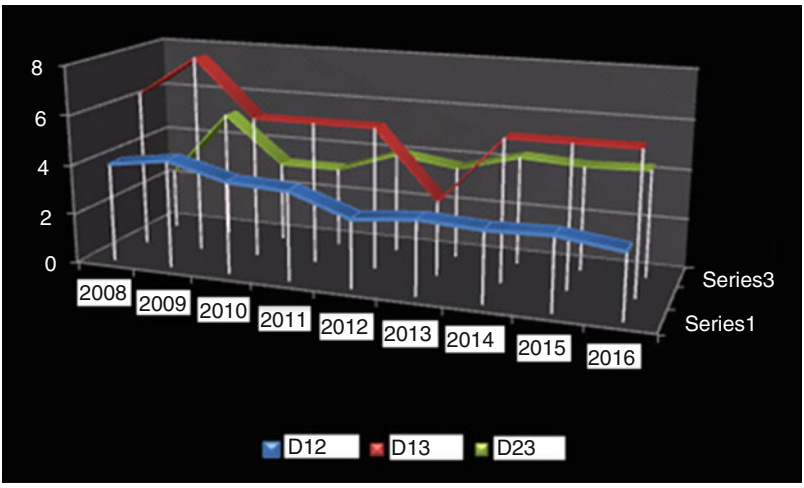

Fig. 3 The line graph of taxonomic distances between study countries. Source: Authors' own work based on the taxonomic study results

scores in shortening the distance between Qatar and the Human Capacity scores of Switzerland, which were 55.1 and 57.9, for 2010 and 2011, respectively.

Therefore, it could be concluded that Business Sophistication and Human Capacity indices are the potential competitive advantages of Qatar for having better innovative scores; in other words, Qatar can generate more innovation by concentrating on its market dynamics and especially on its human capital. Likewise, the taxonomic results for the time span between 2008 through 2016, presented in Tables 19–27, reinforce the fact that Innovation-driven economies perform better than those that are Efficiency-driven; Qatar should be expected to perform better than Egypt. What is noteworthy is Qatar has shown that performing as an Innovation-driven economy is not the preserve of older, more well-established, often Western, nations. Qatar's key capability is the development and encouragement of more Innovation. As our taxonomic results in Compound Distance Matrices (Tables 19–27) show the least distance between Egypt and Qatar was reached in 2016 (D12 = 2.59) presented in Table 27. Hopefully Egypt will be able to maintain this momentum.

The taxonomic results of this paper compare the Innovation distances between all three countries from 2008 to 2016 (Fig. 3).

Figure 3 shows the Innovation distances between Egypt and Qatar (blue), Egypt and Switzerland (red), and Qatar and Switzerland (green). Furthermore, the nearer the graph is to the lower horizontal axis (i.e. the base in the figure), the shorter the distance to the benchmark country's score; thus, the more innovative the country is. As the figure shows, in 2008, Qatar reached its closest point to meeting the innovation level of the paper's benchmark (Switzerland (D23 = 2.481)). The innovation distance between the two countries in 2009 (D23 = 5.159) was the most experienced distance in the span 2008–2016. After 2013, Qatar had an

approximately continuous distance with the benchmark (2014: 4.361; 2015: 4.205; and 2016: 4.282).

Based on Fig. 3, Egypt in the interval between 2008 through 2016 always lagged behind the Innovation distance with Qatar (blue) i.e. a distance consistently greater than 2.50. The results of the Compound Distance Matrices of the paper summarized in Tables 19–27, also reveal that the least distance between Qatar and Egypt is related to 2016 (D12 = 2.59) and the most distance occurred in 2009 (D12 = 4.342). The decreasing effect on the distance between the two countries in 2016 is due to both Egypt's Institution index (40.4) as well as the country's Infrastructure index (38.4). The two highest scores of Egypt among all the scores of the country in the 2016 report are presented in Table 9. The good news for the innovation of Egypt is its decreasing distance in most years from Qatar. For example, the 'D12' scores of Egypt in the years 2008–2016 were 3.997 in 2008, 4.342 in 2009, 3.713 in 2010, 3.586 in 2011, 2.732 in 2012, 2.98 in 2013, 2.845 in 2014, 2.916 in 2015 and recently 2.59 in 2016. The year 2013 is also the sonly year that Egypt's innovation distance from Qatar is the same as its distance with Switzerland.

In *Towards a Measurement Agenda for Innovation*, the OECD sets out five key action areas to make measurement and tracking of Innovation statistics easier and more accurate: (1) "develop innovation metrics that can be linked to aggregate measures of economic performance; (2) invest in a high-quality and comprehensive statistical infrastructure to analyse innovation at the firm-level; (3) promote metrics of innovation in the public sector and for public policy evaluation; (4) find new and interdisciplinary approaches to capture knowledge creation and flows; (5) promote the measurement of innovation for social goals and of social impacts of innovation" (OECD 2009). The authors hope that this paper helps to contribute to these worthwhile attempts to measure Innovation.

Acknowledgement The authorization granted to use the data and material originally provided by WIPO (the World Intellectual Property Organization) is gratefully acknowledged. The secretariat of WIPO assumes no responsibility or liability with regard to the transformation of this data.

References

Arnold RD, Wade JP (2015) A definition of systems thinking: a systems approach. Procedia Comput Sci 44:669–678. https://doi.org/10.1016/j.procs.2015.03.050

BBC (2018) China offers 10-year visas to 'high end talent'. 5 Jan 2018, London. Available via the World Wide Web. http://www.bbc.com/news/business-42575436. Accessed 30 Jan 2018

Faghih N, Bavandpour M, Forouharfar A (2016) Biological metaphor and analogy upon organizational management research within the development of clinical organizational pathology. QSci Connect 2016(2):4. https://doi.org/10.5339/connect.2016.4. Accessed 2 Dec 2017

Global Innovation Index (2017) Innovation feeding the world, Cornell University, INSEAD, and WIPO: Ithaca, Fontainebleau, and Geneva. https://www.globalinnovationindex.org/about-gii#reports. Accessed 16 Dec 2017

Global Innovation Indices (2008–2017) http://www.wipo.int/publications/en/details.jsp?id=4064. Accessed 1 Dec 2017

ILO (2017a) http://www.ilo.org/wesodata/?chart
ILO (2017b) https://issuu.com/stuhyouth/docs/wcms_598669
Nabli MK, Keller J, Nassif C, Silva-Jáuregui C (2006) The political economy of industrial policy in the Middle East and North Africa. World Bank, Washington, DC. https://openknowledge.worldbank.org/handle/10986/28426
Nambisan S, Sawhney M (2007) The innovation Bazaar. Harv Bus Rev. https://hbr.org/2007/06/a-buyers-guide-to-the-innovation-bazaar. Accessed 20 Jan 2018
OECD (2009) Innovation and growth: rational for an innovation strategy. OECD, Paris. https://www.oecd.org/sti/inno/39374789.pdf. Accessed 23 Feb 2018
OECD and Eurostat (2005) Oslo manual: guidelines for collecting and interpreting innovation data, 3rd edn. http://www.oecd-ilibrary.org/science-and-technology/oslo-manual_9789264013100-en. Accessed 20 Jan 2018
Salehi Esfahani H (2006) Are examination of the political economy of growth in the MENA countries. In: Nugent JB, Hashem Pesaran M (eds) Explaining growth in the Middle East, Contributions to economic analysis, vol 278. Emerald Group, Bingley, pp 61–102
Switzerland Global Enterprise (2016) https://www.s-ge.com/en/article/news/global-innovation-index-switzerland-remains-undisputed-number-one
World Bank (2017) Unemployment, youth total (% of total labor force ages 15–24). World Bank Group, Washington, DC. https://data.worldbank.org/indicator/SL.UEM.1524.ZS. Accessed 18 Dec 2017
World Economic Forum (2018) Global competitiveness report 2017–2018. World Economic Forum, Geneva. http://www3.weforum.org/docs/GCR2017–2018/05FullReport/TheGlobalCompetitivenessReport2017–2018.pdf