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An indicator proposal to evaluate research activities based on Scimago Institutions Ranking (SIR) data: an application for Italian high education institutions

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In this paper a synthetic indicator to evaluate Italian universities' scientific research using the Scimago Institutions Ranking (SIR) 2014 data is proposed. After having analysed the shape distribution, fitted parameters of some statistical models, calculated an appropriate standardization, some SIR indicators were aggregated to obtain a Synthetic Indicator (from now, SI) of research evaluation. The synthetic indicator obtained has been used to rank Italian Higher Education Institutions (from now, HEIs). This ranking has been compared firstly with the ranking of National Agency for the Evaluation of Universities and Research Institutes (ANVUR), based on the Evaluation of Research Quality (VRQ 2004-2010) results, in terms of standardized mark. Following, with the ranking based on the assignments of the competitive allocation model (research share of FFO) yearly attributed to the Italian HEIs by the Ministry of University and Research (MIUR).

The analysis results show a moderate positive correlation between SI and the VQR 2004-2010 indicators ($r = 0.543$), and SI and FFO per capita ($r =$

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0.487). The paper's original contribution deals with a Synthetic Indicator with a Gaussian distribution summarizing the SIR variables along with the highlighting of a convergence between Italian ANVUR evaluation, based on peer-to-peer and bibliometric analysis. However, using only few publications and the analysis proposed in this paper, based on Scopus bibliometric data, and related to all the publications in the same period.

keywords: research evaluation, performance indicators, ranking, bibliometrics, Scimago.

1 Introduction

Scimago Institutions Ranking (SIR) is defined as: ≪a science evaluation resource to assess worldwide universities and research-focused institutions≫ and it is developed by a Spanish company, named Scimago Lab, using Scopus databank. It supplies research performance evaluation of leading research institutions worldwide (Bornmann et al., 2011); being published since 2009, in the 2014 edition, it includes 4,851 research Institutions (2,713 are Universities and Higher Education Institutions) producing at least 100 publications during 2012. Bibliometric data are referred to the period 2008-2012.

Differently from other rankings, the goal of SIR is not to supply league tables, but ≪*to characterize research outcomes of organizations to provide useful scientometric rankings to institutions, policymakers and research managers for the analysis, evaluation and improvement of their research results*≫. It includes both size-dependent and size-independent indicators, providing overall statistics of the scientific publications and other outputs of institutions; at the same time SIR enables comparisons between institutions of different sizes. In 2014, to facilitate benchmarking, the ranks of institutions for each of the indicators have been normalized on a scale of 0 (minimum) to 100 (maximum), while in previous years indicators were presented as raw data. SIR indicators are shown in Table 1. The analysis shown in this paper deals with performance indicators only, excluding the size dependent indicators (OUT, STP) and the measure of the degree of specialization (SPEC) since the first two might have an influence on synthetic indictor favouring big HEIs and penalizing the small ones, the third indicator has only a descriptive function in SIR and it can be considered as irrelevant for performance computation.

Table 1: Indicators used in SIR 2014

Indicator	Description	Type
OUT	Total number of documents published in scholarly journals indexed in Scopus	Size dependent
STP	Total number of different authors from an institution in the total publication output of that institution during a particular period of time	Size dependent

EXC	Indicates the amount (in %) of an institution's scientific output that is included in the top 10% of the most cited papers in their respective scientific fields	Size independent
LEAD	Indicates the percentage of an institution's output as main contributor, that is, the amount of papers in which the corresponding author belongs to the institution	Size independent
EWL	Indicates the amount of documents in the Excellence rate in which the institution is the main contributor	Size independent
IC	Institution's output ratio produced in collaboration with foreign institutions	Size independent
NI	It is computed using the methodology established by the Karolinska Institutet in Sweden. The normalization of the citation values is done on an individual article level. The values show the relationship between an institution's average scientific impact and the world average set to a score of 1.	Size independent
SPEC	Indicates the extent of thematic concentration or dispersion of an institution's scientific output. Values range between 0 and 1, indicating generalist versus specialized institutions respectively. This indicator is computed according to the Gini Index	Size independent
Q1	Ratio of publications that an institution publishes in the most influential scholarly journals of the world, those ranked in the first quartile (25%) in their categories as ordered by SCImago Journal Rank (SJRII) indicator	Size independent

Source: http://scimagoir.com/methodology.php

2 A proposal of a synthetic indicator

The Scimago Lab points out that SIR is not a league table like some other rankings (Times, QS, ARWU, NTUR, URAP), but it only supplies indicators which can be used to carry out other analysis. In this paragraph, a proposal to compute a synthetic indicator is shown, starting from SIR indicators, standardizing and aggregating them. A composite quality indicator based on NI, Q1 and EXC indicators was discussed by G. Prathap (Prathap G., 2014) and computed with the following formula:

$$q^2 = \frac{\left[NI^2 + \left(\frac{Q1}{25}\right)^2 + \left(\frac{EXC}{10}\right)^2\right]}{3}$$

using SIR data published in 2013; in that year the indicators were not normalized on a 0-100 scale and there were raw data. q^2 has a value of 1 describing the world norm constituted by three indicators, namely NI, Q1/25 and EXC/10; each of them defines a world norm with a value of 1. According to our experience, Prathap q index represents one of the first attempts of using SIR data to achieve an aggregation of some performance indicators. Prathap's approach could not be applied to SIR 2014 data because in this edition data is normalized, instead of being raw as in previous reports; then, another method to build a synthetic indicator is suggested here, taking advantage of normal/log-normal distribution of some SIR indicators.

We shall use only the indicators of performance, excluding size dependent indicators (OUT, STP) and the measure of the degree of specialization (SPEC) because the first two can have an influence on the synthetic indictor favouring big HEIs and penalizing the small ones, the third indicator has only a descriptive function in SIR and it is irrelevant for performance computation.

Some SIR indicators have a normal distribution, assessed by Shapiro Wilk normality test, as shown in Section 2.1. The others have a log-normal distribution with the density function of three parameters log-normal distribution:

$$f\left(x;\mu,\sigma,\theta\right)=\frac{1}{(x-\theta)\sigma\sqrt{2\pi}}exp\left\{\frac{\left[log\left(x-\theta\right)-\mu\right]^2}{2\sigma^2}\right\}$$

σ_{yi} is estimated using the Maximum-likelihood method using R software (MASS library).

The log-transformation $Y_i = log(X_i - \theta_i)$ has been applied to these indexes, where θ is the threshold parameter of the three parameters log-normal distribution; then, the normality of the transformed variables has been tested using the Shapiro Wilk test.

After normalizing indicators by log-transformation (Y_i) when needed, the variables were scaled with mean and standard deviation, so getting the standardized variables Z_i (dimensionless):

$$Z_i=\frac{\left(Y_i-\overline{Y}\right)}{\sigma_{yi}}$$

in the case of indicators with a log-transformation

$$Z_i=\frac{\left(X_i-\overline{X}\right)}{\sigma_{xi}}$$

in the case of indicators having a Gaussian distribution in natural scale.

The synthetic indicator (SI) is obtained as a mean of the 6 standardized indicators as shown:

$$\mathrm{SI}=\frac{1}{6}\sum_{i=1}^{6}Z_i$$

Having all Z_i variables a Gaussian distribution, SI is an average of Gaussian standardized variables and therefore, it still has a normal distribution; it can be considered a unidimensional measure of performance in scientific research. The SI is computed in a simple and clear way, while, in some international rankings, the methods for indexes aggregation and for the final scores computation are often not so clear. SI is not only a quality measure of research as q^2, since it takes also into account international collaborations and leadership. It was stated that the same importance of each indicator, then any particular system of subjective weights has been used. Differently from other research rankings (URAP, NTUR), the dimension (output) of HEIs is not taken into account in the SI structure, consisting of performance indicators exclusively, therefore SI is size independent.

2.1 The synthetic indicator computed for the Italian HEIs

In the 2014 SIR report, there are 64 Italian HEIs, 42 located in Central and Northern Italy while the remaining 22 in Southern Italy (Mezzogiorno). By means of R software, using the packages `nortest` and MASS, the normality or log-normality of indicators related to Italian Universities was tested and skewness and kurtosis measures were computed, fitting the parameters with maximum likelihood method (Giesbrecht and Kempthorne, 1976; Chieppa and Ricci, 1979; Cohen and Jones Whitten, 1980; Chieppa and Amato, 1981).

The class sizes of Figure 1 and 2 have been computed by R software assuming the number of breaks as input parameter; 10 breaks have been chosen. It emerges that EXC, EWL, IC and NI need a log-transformation, while LEAD and Q1 already have a Gaussian distribution (Table 2).

Table 2: Testing normality with Shapiro Wilk's test of indicators

Indicator	2009			2014	
	Shapiro Wilk's test			Shapiro Wilk's test	
	Distribution shape	Value	p-value	Value	p-value
EXC	Lognormal	0.975	0.243	0.965	0.063
LEAD	Normal	0.983	0.545	0.978	0.291
EWL	Lognormal	0.975	0.243	0.984	0.576
IC	Lognormal	0.959	0.092	0.969	0.105
NI	Lognormal	0.989	0.854	0.993	0.983
Q1	Normal	0.944	0.051	0.970	0.125

Shapiro Wilk's test shows that normal or log-normal model fit our data quite well, being the normality test non significant at 5%. In Figure 1 there are the histograms of indicators with the Gaussian superimposed referred to 2014 data. Table 3 and 4 show parameters estimation of SIR indicators.

Table 3: Estimates of normal/*log*-normal parameters of SIR indicators (2009)

Indicator	Distribution shape	Parameters estimation* (2009)			
		mean/mean *log*	σ_{yi} / σ_{xi}	θ	*log*lik
EXC	Lognormal	2.513 (0.2248)	0.41 (0.097)	16.609 (2.4806)	-188.570
LEAD	Normal	56.923 (0.9136)	7.1931 (0.646)	-	-210.308
EWL	Lognormal	2.581 (0.1939)	0.4286 (0.0885)	7.56 (2.2429)	-195.456
IC	Lognormal	4.0198 (0.5475)	0.144 (0.0801)	-23.001 (30.156)	-217.227
NI	Lognormal	1.25 (0.2197)	0.654 (0.1453)	11.46 (0.5728)	-139.127
Q1	Normal	46.388 (1.016)	8.000 (0.7184)	-	-216.900

(*) s.d. in brackets

Table 4: Estimates of normal/*log*-normal parameters of SIR indicators (2014)

Indicator	Distribution shape	Parameters estimation* (2014)			
		mean/mean *log*	σ_{yi} / σ_{xi}	θ	*log*lik
EXC	Lognormal	3.516 (0.5088)	0.167 (0.0857)	-3.040 (16.880)	-200.919
LEAD	Normal	57.709 (0.946)	7.569 (0.6689)	-	-220.342
EWL	Lognormal	2.842 (0.3043)	0.358 (0.1121)	6.267 (4.841)	-206.874
IC	Lognormal	3.805 (0.4679)	0.172 (0.0819)	-7.102 (20.690)	-221.613
NI	Lognormal	0.968 (0.2507)	0.405 (0.1056)	4.472 (0.5956)	-94.903
Q1	Normal	53.387 (1.0744)	8.596 (0.7597)	-	-228.492

(*) s.d. in brackets

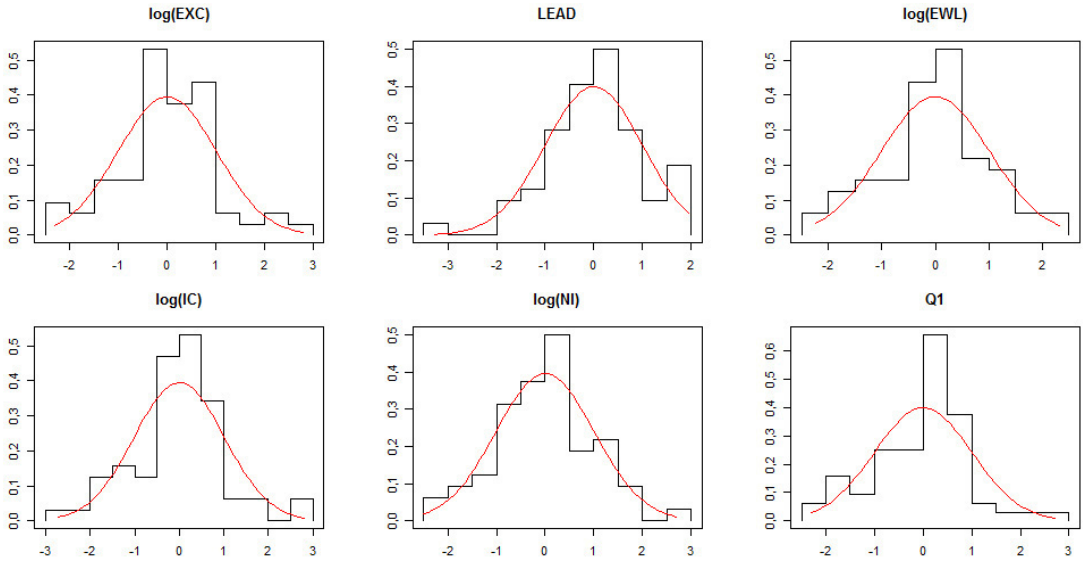

Figure 1: Histograms of SIR indicators, year 2014

Figure 2 shows the synthetic indicator histogram for Italian HEIs, computed as described above. It is important to underline that Shapiro Wilk's test p-value for synthetic indicator is 0.373 in 2014 and 0.5149 in 2009 meaning its normality.

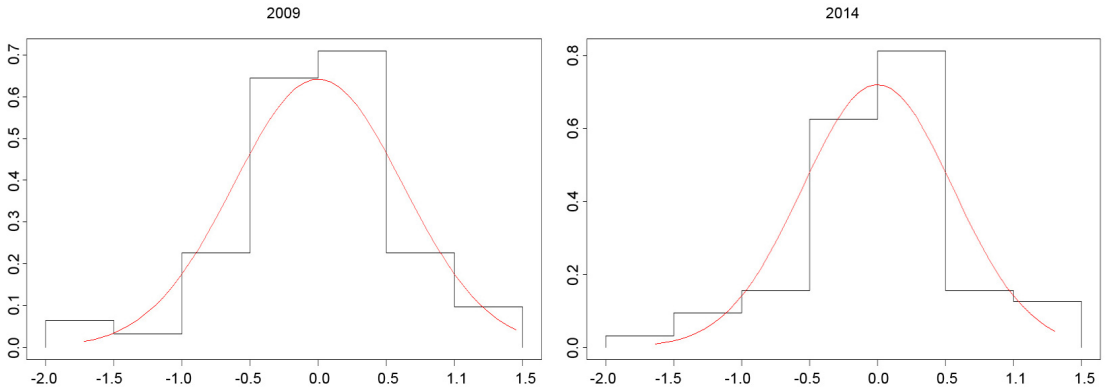

Figure 2: Distribution of the synthetic indicator with 2009 and 2014 data

The proposed synthetic indicator SI is used to rank Italian HEIs participating in SIR 2014 and then, in order to make comparisons with SIR 2009, when Italian HEIs were 62 instead of 64, the percentile ranks are computed. The league table is shown in Table 5.

Table 5: Testing normality with Shapiro Wilk's test of indicators

HEIs	Abbr.	2009		2014		Percentile rank	
		SI	Rank	SI	Rank	2009	2014
Milano Bocconi	MBO	1.451	1	1.303	1	100.0	100.0
Milano San Raffaele	MSR	0.904	4	1.103	2	95.0	98.4
Trieste SISSA	SISSA	1.170	2	1.070	3	98.3	96.8
Pisa Normale	NOR	0.690	8	1.041	4	88.5	95.2
Bari Politecnico	BAP	0.552	10	0.818	5	85.2	93.6
Pisa S. Anna	SAN	1.053	3	0.778	6	96.7	92.0
Padova	PD	0.646	9	0.594	7	86.8	90.4
Torino Politecnico	TOP	0.844	5	0.587	8	93.4	88.8
Milano Politecnico	MIP	0.703	7	0.558	9	90.1	87.3
Trento	TN	0.731	6	0.491	10	91.8	85.7
Torino	TO	0.355	18	0.409	11	72.1	84.1
Perugia	PG	0.403	16	0.379	12	75.4	82.5
European Univ. Institute	EUI	n.a.	n.a.	0.373	13	n.a.	80.9
Firenze	FI	0.459	11	0.372	14	83.6	79.3
Calabria	CAL	0.277	20	0.353	15	68.8	77.7
Bologna	BO	0.458	12	0.336	16	81.9	76.1
Milano Bicocca	MI2	0.168	29	0.315	17	54.0	74.6
Verona	VR	0.266	22	0.294	18	65.5	73.0
Ferrara	FE	0.446	13	0.207	19	80.3	71.4
Bolzano	BZ	n.a.	n.a.	0.206	20	n.a.	69.8
Napoli Federico II	NA1	0.029	32	0.197	21	49.1	68.2
Reggio Calabria	RC	-0.474	52	0.180	22	16.3	66.6
Udine	UD	0.435	15	0.151	23	77.0	65.0
Salerno	SA	0.209	24	0.145	24	62.2	63.4
Brescia	BS	0.233	23	0.133	25	63.9	61.9
Milano	MI1	0.183	27	0.105	26	57.3	60.3
Modena e Reggio Emilia	MR	0.176	28	0.104	27	55.7	58.7
Pisa	PI	0.132	30	0.103	28	52.4	57.1
Parma	PR	0.326	19	0.100	29	70.4	55.5
Pavia	PV	0.209	25	0.094	30	60.6	53.9
Salento	LE	-0.144	39	0.083	31	37.7	52.3

Cassino	CAS	-0.774	56	0.055	32	9.8	50.7
Tuscia	VT	0.382	17	0.039	33	73.7	49.2
Trieste	TS	0.193	26	0.026	34	59.0	47.6
Politecnica Marche	AN	-0.259	44	0.016	35	29.5	46.0
Roma Tor Vergata	RM2	-0.163	40	-0.008	36	36.0	44.4
Roma Campus Biomed.	RCB	-0.733	55	-0.047	37	11.4	42.8
Roma Tre	RM3	0.277	21	-0.058	38	67.2	41.2
Piemonte Orientale	PO	-0.337	46	-0.073	39	26.2	39.6
Sannio	BN	0.442	14	-0.080	40	78.6	38.0
Milano Cattolica	MIC	-0.033	33	-0.109	41	47.5	36.5
Roma La Sapienza	RM1	-0.044	34	-0.192	42	45.9	34.9
L'Aquila	AQ	-0.184	42	-0.216	43	32.7	33.3
Bari	BA	-0.134	38	-0.237	44	39.3	31.7
Cagliari	CA	-0.167	41	-0.239	45	34.4	30.1
Genova	GE	0.036	31	-0.258	46	50.8	28.5
Napoli Parthenope	NA3	-1.719	62	-0.288	47	0.0	26.9
Insubria	INS	-0.119	37	-0.316	48	40.9	25.3
Catanzaro	CZ	-0.813	57	-0.321	49	8.1	23.8
Napoli II	NA2	-0.450	51	-0.325	50	18.0	22.2
Catania	CT	-0.731	54	-0.341	51	13.1	20.6
Palermo	PA	-0.441	50	-0.348	52	19.6	19.0
Teramo	TE	-0.510	53	-0.351	53	14.7	17.4
Siena	SI	-0.045	35	-0.386	54	44.2	15.8
Urbino	UR	-0.432	49	-0.427	55	21.3	14.2
Chieti-Pescara	PE	-0.370	48	-0.570	56	22.9	12.6
Sassari	SS	-0.350	47	-0.599	57	24.5	11.1
Camerino	CAM	-0.328	45	-0.686	58	27.8	9.5
Basilicata	PZ	-0.072	36	-0.737	59	42.6	7.9
Venezia	VE	-0.208	43	-0.855	60	31.1	6.3
Foggia	FG	-1.580	61	-1.112	61	1.6	4.7
Messina	ME	-0.970	58	-1.146	62	6.5	3.1
Molise	CB	-1.268	60	-1.157	63	3.2	1.5
Bergamo	BG	-0.986	59	-1.636	64	4.9	0.0

Figure 3 shows the plot of the synthetic indicator computed with 2009 and 2014 data.

There is a strong correlation, with a Pearson's coefficient of 0.82, meaning there are small differences from 2009 to 2014. According to the synthetic indicator, HEIs, which lie over the straight line, had an improvement in research performance between the two years, while those lying under it had a worsening in their performance between 2009 and 2014. The University that registered the biggest positive difference is Napoli Parthenope, which, being the last in 2009 climbs several positions up to the first quartile in 2014.

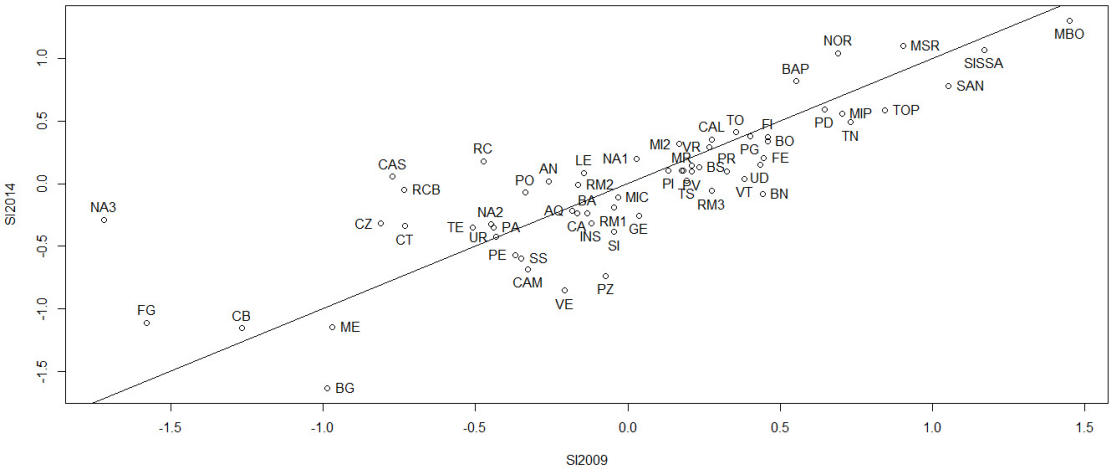

Figure 3: SI values 2009 vs 2014

2.2 About the multidimensionality of the synthetic indicator

In order to investigate the multidimensionality of SIR components, a factor analysis on 2014 data involving the variables used to build SIR indicator is carried out; the first two factors explain 73% of the common variance. In Figure 4, the scatterplot of factorial loadings shows that Factor1 is a latent variable influenced by research quality, while Factor2 is influenced by leadership.

Summing up Factor1 and Factor2, a unidimensional indicator, denoted with F, is obtained:

$$\mathrm{F} = \mathrm{F1} + \mathrm{F2}$$

F has a normal distribution as tested by Shapiro test (p-value= 0.0042) and it is strictly correlated with our synthetic indicator (r=0.718) as shown in Figure 5.

The comparison between the proposed SIR indicator and the one based on factor analysis shows that both have a normal distribution; moreover, SIR indicator has a higher p-value if testing normality with Shapiro test, then it is possible to affirm that the Gaussian distribution fits SIR indicator better than others.The first two factors explain

about 70% of common variance and this has an influence on F, while SIR indicator, including all the original variables, takes into account 100% of common variance.

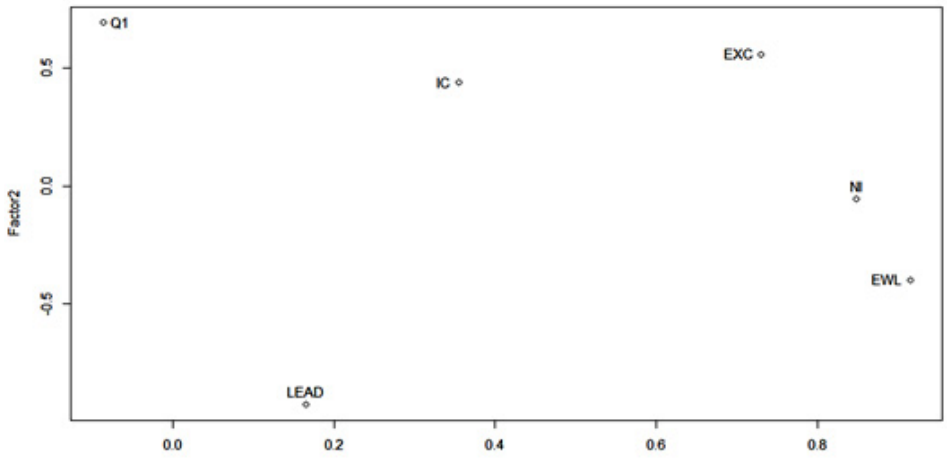

Figure 4: Scatterplot (loadings plot) of indicators on the two main components

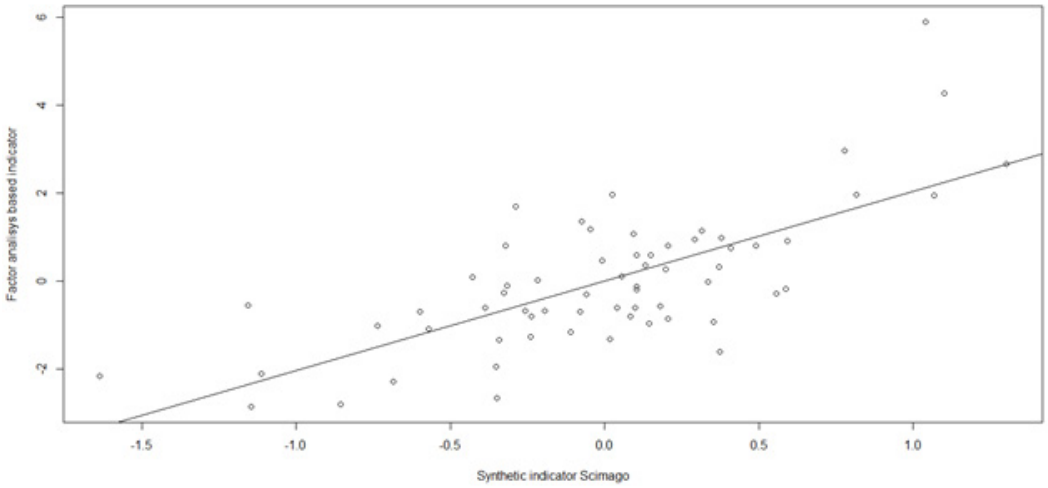

Figure 5: Scatterplot SIR vs Factor Analysis based indicator

3 A comparison between SIR and VQR 2004-2010

In this paragraph, the proposed synthetic indicator is used to compare its rank with VQR 2004-2010[1] evaluation results. As an aggregate measure of VQR results, the standardized mark is considered, scaling his own mark with the mean value and the standard deviation of his scientific sector for each evaluated subject; then there is the aggregation for Universities. The distribution of standardized mark among Italian Universities is Gaussian (Shapiro Wilks' test p-value=0.2932) as shown in Figure 6.

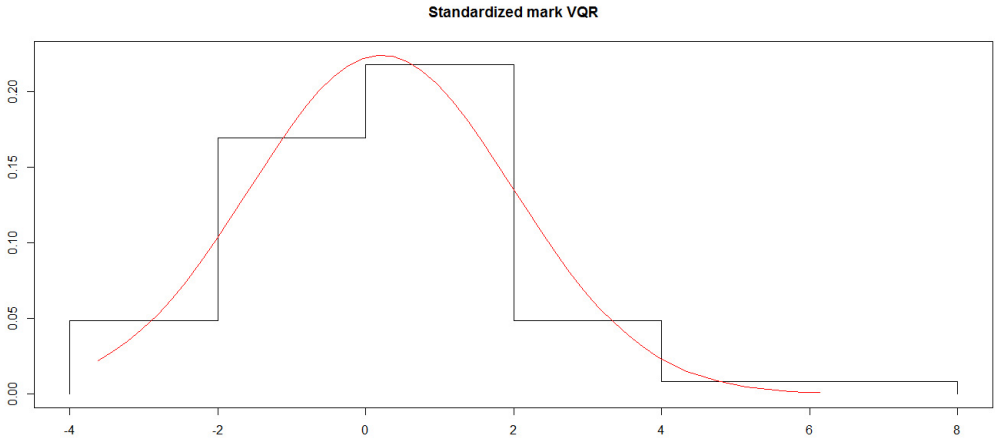

Figure 6: Distribution of the VQR standardized mark in Italian HEIs

In Table 6 the rankings of Italian HEIs according to the two evaluation methods are shown.

Table 6: Rankings of Italian HEIs according to the synthetic indicator and the standardized mark

HEIs	Abbr.	Scores		Rank		
		SI	VQR standardized mark	SI	VQR standardized mark	Difference SI-VQR
Milano Bocconi	MBO	1.303	3.127	1	3	-2
Milano San Raffaele	MSR	1.103	6.138	2	1	1
Trieste SISSA	SISSA	1.070	4.463	3	2	1
Pisa Normale	NOR	1.041	2.474	4	5	-1

[1] http://www.anvur.org/index.php?option=com_content&view=article&id=28&Itemid=119

Bari Politecnico	BAP	0.818	-1.287	5	50	-45
Pisa S. Anna	SAN	0.778	2.265	6	8	-2
Padova	PD	0.594	2.303	7	7	0
Torino Politecnico	TOP	0.587	1.028	8	17	-9
Milano Politecnico	MIP	0.558	1.708	9	12	-3
Trento	TN	0.491	2.468	10	6	4
Torino	TO	0.409	1.071	11	16	-5
Perugia	PG	0.379	-1.126	12	47	-35
Firenze	FI	0.372	0.142	13	34	-21
Calabria	CAL	0.353	-0.850	14	44	-30
Bologna	BO	0.336	1.521	15	13	2
Milano Bicocca	MI2	0.315	1.756	16	11	5
Verona	VR	0.294	1.975	17	9	8
Ferrara	FE	0.207	0.925	18	19	-1
Napoli Federico II	NA1	0.197	-1.873	19	56	-37
Reggio Calabria	RC	0.180	-2.037	20	57	-37
Udine	UD	0.151	0.904	21	21	0
Salerno	SA	0.145	-0.101	22	36	-14
Brescia	BS	0.133	0.923	23	20	3
Milano	MI1	0.105	1.262	24	14	10
Modena e Reggio E.	MR	0.104	0.600	25	25	0
Pisa	PI	0.103	0.265	26	33	-7
Parma	PR	0.100	0.561	27	26	1
Pavia	PV	0.094	0.669	28	24	4
Salento	LE	0.083	-1.221	29	48	-19
Cassino	CAS	0.055	-0.132	30	37	-7
Tuscia	VT	0.039	0.327	31	32	-1
Trieste	TS	0.026	-1.230	32	49	-17
Politecnica Marche	AN	0.016	0.787	33	22	11
Roma Tor Vergata	RM2	-0.008	-0.656	34	41	-7
Roma Campus Biom.	RCB	-0.047	2.618	35	4	31
Roma Tre	RM3	-0.058	0.361	36	31	5
Piemonte Orientale	PO	-0.073	1.973	37	10	27
Sannio	BN	-0.080	0.957	38	18	20

Milano Cattolica	MIC	-0.109	-0.293	39	39	0
Roma La Sapienza	RM1	-0.192	-1.096	40	46	-6
L'Aquila	AQ	-0.216	-2.143	41	58	-17
Bari	BA	-0.237	-2.884	42	60	-18
Cagliari	CA	-0.239	-1.482	43	54	-11
Genova	GE	-0.258	-0.707	44	42	2
Napoli Parthenope	NA3	-0.288	-1.339	45	52	-7
Insubria	INS	-0.316	0.405	46	30	16
Catanzaro	CZ	-0.321	0.526	47	27	20
Napoli II	NA2	-0.325	-1.399	48	53	-5
Catania	CT	-0.341	-2.560	49	59	-10
Palermo	PA	-0.348	-3.006	50	61	-11
Teramo	TE	-0.351	0.001	51	35	16
Siena	SI	-0.386	0.405	52	29	23
Urbino	UR	-0.427	-1.751	53	55	-2
Chieti-Pescara	PE	-0.570	-0.241	54	38	16
Sassari	SS	-0.599	-0.895	55	45	10
Camerino	CAM	-0.686	-1.339	56	51	5
Basilicata	PZ	-0.737	-0.720	57	43	14
Venezia	VE	-0.855	1.237	58	15	43
Foggia	FG	-1.112	0.760	59	23	36
Messina	ME	-1.146	-3.621	60	62	-2
Molise	CB	-1.157	-0.372	61	40	21
Bergamo	BG	-1.636	0.523	62	28	34

There are some differences in the two rankings, in some cases very big, as for Bari-Politecnico, which is 5th according to SIR indicator and 50th using the VQR, or for Venezia University being 58th for SIR indicator and 15th for VQR. On the contrary, for the top 10 Universities ordered by SIR, there are very small differences between the two rankings, the largest belonging to Bari-Politecnico.

In Figure 7, the plot of the relationship between the SI and the VQR standardized mark is shown.

The Paerson's correlation coefficient between the two scores is 0.543 (significant at 0.5%), while Spearman's coefficient is 0.528 (significant at 0.5%). Moreover, the SI explains about 30% of standardized mark's variance.

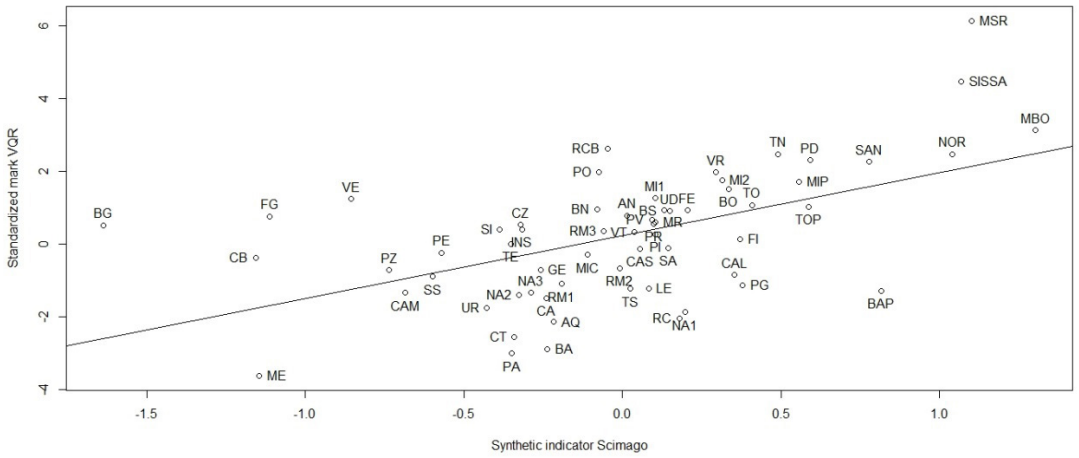

Figure 7: Synthetic indicator vs VQR standardized mark

4 Empirical study: SIR vs FFO 2013 research share per capita

In this section, the proposed synthetic indicator SI is compared with the index used by the Italian Government (FFO, *Fondo di finanziamento ordinario*) to fund public HEIs; it is partially linked both to teaching and research performances of HEIs *(quota premiale)*. The FFO 2013 quota concerning research carried out in the same period of the SIR data is considered and divided by the number of people in the academic staff at 31.12.2013; in this way, the size dependent effect is removed.

Table 7: Testing normality of indicators with Shapiro Wilk test

Indicator	Distribution shape	Shapiro Wilk test	
		Value	p-value
EXC	Lognormal	0.952	0.051
LEAD	Normal	0.969	0.165
EWL	Lognormal	0.977	0.375
IC	Lognormal	0.954	0.052
NI	Lognormal	0.991	0.954
Q1	Normal	0.967	0.129

The synthetic indicator has only been computed for the group of 55 HEIs funded by FFO. In Table 7, there are the p-values of Shapiro Wilk's test and in Table 8 the parameters' estimates are shown. The SI has a Gaussian distribution (Shapiro Wilk's test p-value=0.118). In Table 9, the results are shown.

Table 8: Estimates of normal/log-normal parameters of SIR indicators

Indicator	Distribution shape	Parameters estimation*			
		mean/mean *log*	σ_{yi} / σ_{xi}	θ	*log*lik
EXC	Lognormal	3.513 (0.5464)	0.158 (0.0880)	-2.992 (18.0824)	-194.482
LEAD	Normal	57.457 (1.0122)	7.506 (0.7157)	-	-213.793
EWL	Lognormal	2.864 (0.3470)	0.334 (0.1190)	5.484 (5.7030)	-206.409
IC	Lognormal	3.701 (0.4559)	0.189 (0.0878)	-3.301 (18.1019)	-212.470
NI	Lognormal	0.980 (0.2800)	0.380 (0.1106)	4.383 (0.6824)	-104.599
Q1	Normal	53.358 (1.0806)	8.014 (0.7641)	-	-220.344

(*) s.d. in brackets

Table 9: FFO *quota premiale* for research in 2013, academic staff, value per capita and synthetic indicator

Italian Universities (HEIs)	Abbr.	FFO *quota premiale* research 2013 (€)	Academic staff at 31.12.2013	FFO *quota premiale* research 2013 per capita (€)	Synthetic indicator
Bari	BA	10,942,035	1,499	7,299.56	-0.198
Bari Politecnico	BAP	2,451,808	288	8,513.22	0.884
Basilicata	PZ	2,472,565	311	7,950.37	-0.709
Bergamo	BG	3,547,537	325	10,915.50	-1.643
Bologna	BO	39,435,348	2,724	14,477.00	0.388
Brescia	BS	6,228,223	550	11,324.04	0.186
Cagliari	CA	8,192,020	949	8,632.27	-0.208

Calabria	CAL	7,312,991	816	8,962.00	0.399
Cassino	CAS	2,923,763	305	9,586.11	0.094
Catania	CT	9,576,222	1,330	7,200.17	-0.316
Catanzaro	CZ	2,455,259	239	10,273.05	-0.270
Chieti-Pescara	PE	6,621,902	688	9,624.86	-0.541
Ferrara	FE	7,060,444	590	11,966.85	0.259
Firenze	FI	20,633,118	1,667	12,377.40	0.430
Foggia	FG	4,018,541	355	11,319.83	-1.082
Genova	GE	12,353,104	1,246	9,914.21	-0.221
Insubria	INS	3,914,030	364	10,752.83	-0.275
Messina	ME	7,649,996	1,126	6,793.96	-1.143
Milano	MI1	25,667,548	2,013	12,750.89	0.161
Milano Bicocca	MI2	12,459,359	860	14,487.63	0.373
Milano Politecnico	MIP	17,609,090	1,245	14,143.85	0.606
Modena e Reggio E.	MR	8,795,918	772	11,393.68	0.156
Molise	CB	2,972,951	268	11,093.10	-1.130
Napoli Federico II	NA1	21,565,169	2,364	9,122.32	0.252
Napoli Parthenope	NA3	2,466,255	314	7,854.32	-0.244
Napoli II	NA2	6,428,532	967	6,647.91	-0.287
Padova	PD	30,578,931	2,080	14,701.41	0.659
Palermo	PA	11,659,096	2,080	5,605.33	-0.324
Parma	PR	9,387,760	1,615	5,812.85	0.147
Pavia	PV	10,954,123	881	12,433.74	0.146
Perugia	PG	11,033,480	1,052	10,488.10	0.439
Piemonte Orientale	PO	4,841,358	377	12,841.80	-0.019
Pisa	PI	16,384,691	1,487	11,018.62	0.149
Pisa Normale	NOR	2,032,096	84	24,191.62	1.132
Pisa S. Anna	SAN	2,184,992	74	29,526.92	0.844
Politecnica Marche	AN	5,921,038	507	11,678.58	0.057
Reggio Calabria	RC	2,203,745	269	8,192.36	0.221
Roma La Sapienza	RM1	34,635,799	3,734	9,275.79	-0.154
Roma Tor Vergata	RM2	14,685,597	1,370	10,719.41	0.036
Roma Tre	RM3	9,335,151	852	10,956.75	-0.028
Salento	LE	5,463,018	652	8,378.86	0.120

Salerno	SA	10,490,778	967	10,848.79	0.184
Sannio	BN	2,070,802	191	10,841.90	-0.047
Sassari	SS	6,041,359	620	9,744.13	-0.563
Siena	SI	12,738,710	787	16,186.42	-0.351
Teramo	TE	2,536,091	233	10,884.51	-0.312
Torino	TO	22,299,106	1,940	11,494.38	0.470
Torino Politecnico	TOP	10,224,495	788	12,975.25	0.634
Trieste	TS	7,443,980	676	11,011.80	0.080
Trieste SISSA	SISSA	1,332,040	61	21,836.72	1.139
Tuscia	VT	3,459,152	288	12,010.94	0.082
Udine	UD	8,213,338	666	12,332.34	0.202
Urbino	UR	3,011,262	337	8,935.50	-0.382
Venezia	VE	6,946,660	469	14,811.64	-0.835
Verona	VR	10,464,394	711	14,717.85	0.355

In Figure 8 there is the plot of SI vs FFO quota premiale per capita showing a positive correlation between the two variables, with Pearson's correlation coefficient equal to 0.487; fitting regression model, with Synthetic indicator as explicative variable and FFO quota premiale per capita as response variable, gets R^2=0.237. Even if there is a positive relationship between the two variables, the SI, measuring research performance using SIR data, explains less than a quarter of FFO quota premiale per capita variance. Looking at the plot, most of the Universities seem to have received a funding allocation proportional to their SI, with some exceptions. At the top, on the right side, we find the two Pisa Universities of S. Anna and Normale and the Venezia International School of Advanced Studies; these Universities belong to the Italian Scuole d'Eccellenza network, like the French "grandes ecoles", and are characterized by a high specialization. Unexpectedly, Bari Politecnico shows a high score in terms of SI but a very low funding allocation while University of Bergamo has a low SI and a higher funding allocation. Probably, for the last one, the VQR evaluation, responsible for the amount of government funding, is highly influenced by the quality of research of non bibliometric areas, that are not considered by SIR.

5 Concluding remarks

The paper deals with the proposal of a Synthetic Indicator (named SI), with a Gaussian distribution, conveniently aggregating the nine SIR variables of the report, and independent to the number of students enrolled in a university. The SIR Report does not bring out a league table, like some other rankings (Times, QS, ARWU, NTUR, URAP), but it only supplies indicators, making them available to carry out further analysis. Taking

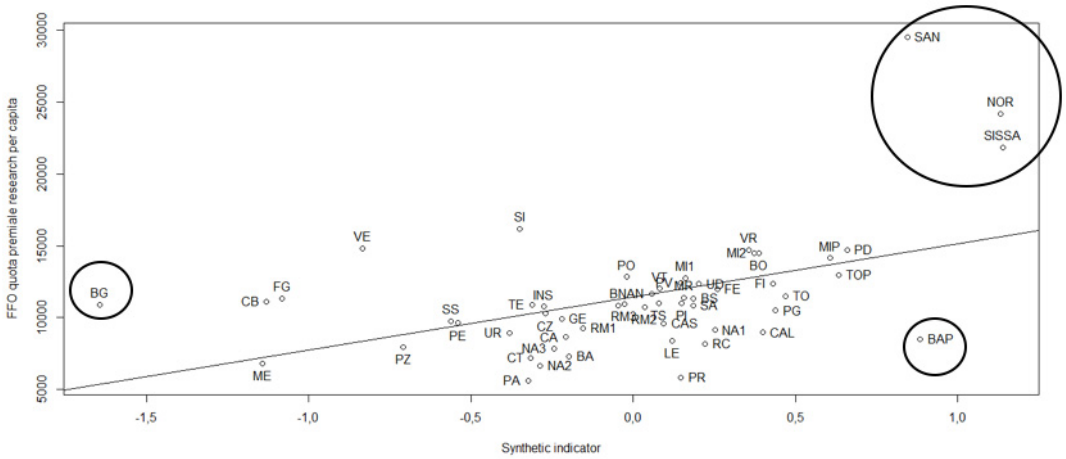

Figure 8: SI vs FFO quota premiale per capita

into account the multidimensionality of the SI components, a factor analysis is also carried out to make a few observations about the use of latent variables in the construction of the index, so overcoming its unidimensional nature. The Synthetic Indicator is used to rank public Italian Universities, making a comparison between 2009 and 2014; small differences are found. As an empirical study, the SI ranking has been compared firstly with the ranking of the National Agency for the Evaluation of Universities and Research Institutes (ANVUR), based on the Evaluation of Research Quality (VRQ 2004-2010) results. Following, with the ranking based on the assignments of the competitive allocation model (research share of FFO) yearly attributed to the Italian HEIs by the Ministry of University and Research (MIUR). In particular, it is considered only the quota of FFO related to universities' research activities held in the same period of SIR data; in fact research activity is founded on the basis of professors' performance, being independent on the number of students, which is a variable influencing the complementary FFO share related to the results of educational activities.

The results of the analysis show a moderate positive correlation between SI and the VQR 2004-2010 indicator, in terms of standardized mark (r=0.543) and between SI and FFO per capita (r=0.487).

Finally, a convergence between the ANVUR evaluation and the analysis proposed in this paper is shown; the first is based on peer-to-peer and bibliometric analysis but using only few publications, the second uses bibliometric data from Scopus and is related to all the publications in the same period.

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