TÜBİTAK

Original Article

Turk J Med Sci
2011; 41 (5): 909-917
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E-mail: medsci@tubitak.gov.tr
doi:10.3906/sag-1006-885

A quantitative appraisal of the genuine contribution of Turkey and Turkish universities to science

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Aim: To assess quantitatively the cumulative and genuine contribution of Turkish universities to science in the main fields over the past 30 years.

Materials and methods: In the Citation Reports section of the Web of Science, over 70 main scientific institutions were searched; and publications that received 60 or more citations by May 2010 were selected. Papers having more than a minor share by international authors were excluded.

Results: Only 47 universities and 6 institutions generated articles that were cited ≥60 times. These publications, numbering 541, received a total of 51.215 citations. Eight universities (İstanbul University, İstanbul Technical University, Hacettepe University, Bilkent University, Middle-East Technical University, Boğaziçi University, Ankara University, and Ege University) acquired 62% of these citations. Primary authors were 335 individuals among whom 121 generated 70% of these citations. It is estimated that Turkish scientists produce about 1 per mil of the global scientific output, which indicates that about 40 such papers are produced annually in Turkey. A substantial variance was recorded across major universities in terms of the ratio of citations to highly-cited papers to the total citations. Engineering and geology had higher relative contributions, followed by agricultural sciences, ecology, pharmacy, chemistry and medicine, while physics, mathematics, and biology had less contributions.

Conclusion: Along with research in general, research potentially to contribute to science needs specifically to be supported with a coherence, milieu creation and consistent long-term policy.

Key words: Contribution to science, fields of science, Turkish universities

Türkiye ve üniversitelerinin bilime "halis" katkılarına nicesel bir bakış

Amaç: Türk bilim kurumlarının bilime çeşitli alanlarda yaptıkları gerçek bireysel ve toplam katkıyı nicesel açıdan araştırmak.

Yöntem ve gereç: Web of Science'in Citation Reports bölümünde 70'i aşkın başlıca bilim kurumumuzun adresi aranarak, Türkiye'de üretilmiş makalelere geçmişte 60 veya daha fazla atıf alan yayınları 2010 Mayısı itibariyle saptandı. Yurtdışı adresli yazarlarla önemli ölçüde ortaklık yapılmış olan yayınlar dışlandı.

Bulgular: Sadece 47 üniversite ve altı kurum ≥60 atıflı bir yayın üretmişti. Bu yayınlar sadece 541'den ibaret olup bunlara toplam 51,215 atıf sağlanmıştır. Bunların % 62'si önde giden 8 üniversite (İstanbul, İTÜ, Hacettepe, Bilkent, ODTÜ, Boğaziçi, Ankara ve Ege) tarafından kazanılmıştır. Bu yayınların başyazarları 335 bilim insanıydı. Yüksek atıfların % 70'ini elde eden yayınlara 121 bilim insanı imza atmıştı. Türkiye'nin bu düzeydeki yayınların katkısının dünyada yaklaşık binde 1 olduğu öne sürülebilir. Anılan saptama, yılda yüksek atıf alabilecek toplam 40 yayın üretebildiğimiz anlamına gelmektedir. Büyük üniversitelerimiz arasında yüksek atıflı yayınlarca sağlanan atıfların toplam atfa oranında geniş saçılım kaydedildi. Mühendislik ve yerbilimleri daha yüksek nispi katkı ile önde yer alırken, ziraat, çevre bilimleri, eczacılık, kimya ve tıp bu alanları izledi; fizik, matematik ve biyoloji alanlarında genel ortalama düzeyin altında katkı yaptığımız gözlemlendi.

Received: 11.06.2010 – Accepted: 07.09.2010

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Sonuç: Üniversitelerde araştırmaların genel teşviki yanında, bilime hatırı sayılır katkı yapabilecek yayınların özellikle desteklenmesi için anlayış, ortam ve politika gerçekleştirilmelidir.

Anahtar sözcükler: Bilim alanları, bilime katkı, Türkiye üniversiteleri

Introduction

Correct answers to the following 2 questions are intimately linked to the cultural and economic development of Turkey: What is the extent of Turkey's contribution to science as of 2010? What is the picture of the genuine contributions of Turkish universities to science? The number of scientific publications or citations received by them is a coarse surrogate of the scientific output, since the sum of citations may represent an inflated indicator due to following 2 reasons: 1) hundreds or even thousands of papers cited only a few times may be of virtually negligible relevance, 2) large citation figures may be attained even in the instance of very low or negligible share of the native author to papers materialized abroad or in collaboration with foreign institutions, which would hardly reflect the genuine contribution.

Inclusion of social sciences as well as arts and humanities would highly increase the heterogeneity and raise the difficulty in the evaluation process. Hence, the current analysis aims to evaluate the performance of various universities or other scientific institutions based on their genuine output in science and technology, by using a relatively but not an excessively high threshold of citations (such as 60 or more times in the past). A rationale for this selection is the opinion that the number of "top 1%-cited" papers is a better surrogate of scientific output than the total number of citations (1). The selected threshold in this article represents roughly the top 8%-10% of global publications.

Materials and methods

Citation data of the Science Citation Index were searched using addresses of institutions in the section Citation Reports of the Thomson Reuters Web of Science. Data comprised citations to articles and reviews published generally in the past 30 years, in the vast majority between 1990 and 2006. In searching addresses of institutions, alternatives (such as Ankara Univ or Univ Ankara) were not neglected. In the case of the total number of articles searched exceeding 10,000 (such as Hacettepe or İstanbul Univ), in which case details were not made available by the Citation Report, articles of the past 2 years were excluded from these universities since a high number of citations were highly unlikely to be received. "Reviews" with an address from Turkey was searched separately. Publications of the institution having acquired ≥60 citations were recorded providing that they also met the afore-mentioned criteria of not sharing more than in a minor fashion authors of foreign institutions. The selected articles will be referred to herein as "highly cited", although highly-cited papers designated in the Web of Science are much more selective and are referred to top 1% of cited publications.

In collaboration with foreign institutions, it was stipulated that the contribution of the author(s) of foreign institution be as low as not to merit to be listed among the first 3 authors; in other words, papers were selected when the first 3 authors had addresses and were active in Turkey. In co-authored papers with multiple institutions, each institution received fractional credit on basis of author sequence, similar to a method used elsewhere (2). In cases of scientists who transferred to another university in the course of their careers, citations received were credited to the university from which the article originated. When suspicion arose, citation report specific to the author was consulted.

Citations (numbering 2907) received by the highly-cited articles published in the past decade for TÜBİTAK were removed from this institution to the respective universities listed to share the paper. The following additional data were collected in regard to the institutions: *h* index, total number of articles cited in the past, total citations and citations in 2009 of the institution, citations to the 10^{th} and 40^{th} article, the number of essentially domestic articles cited ≥60, the total number of citations to the latter articles, scientific field relative to these articles, the name of the primary author, and the routinely collaborating

group in the institution. Provision of some of these additional data aimed to enable the reader to make additional analyses.

Data reported herein pertain to those available in the Web of Science as of May, 2010. Numbers of citations contained in the Citation Reports are lower than those registered in the Cited Reference Search of the Web of Science, as references erroneously or incompletely cited or those relative to journals not covered in the SCI database are excluded. These citations may be estimated to be 5% to 15% of the total SCI citations.

In evaluating the domestic performance in different scientific fields, the following global percentage shares were taken into account (2): mathematics 2.3, physics 14.9 (incl. electronics & astrophysics), chemistry 13.5, geosciences (incl. marine & ecology) 6.1, agricultural sciences (incl. food technology) 2.5, engineering (incl. chem. & metallurgy) 9.8, computer science 1, biological sciences (incl. plant & animal science, immunology, microbiology, molecular biology) 23, pharmacy, toxicology, and dentistry 2.5, and medicine 24.4.

Results

Distribution of citations to institutions

Table 1 comprises certain data related to universities and other scientific institutions. The number of publications that received 60 or more citations totaled only 541, which received just over 51,200 citations. Of these, 62% was received by 8 major universities. İnstitutions are listed in Table 1 by their total citations to the papers studied. Only 26 institutions could produce a minimum of 4 publications, and 47 universities alone generated a paper with ≥60 citations. The first 5 columns in Table 1 pertain to global citation data of the institutions, while the selected data on highly-cited papers are contained in the last 2 columns.

The relationship between total citations and the total number of citations to highly-cited papers of the institutions are shown graphically in Figure 1. Correlation coefficient was 0.84 ($P < 0.001$), yet a large variance existed across universities, as may be discerned from the SD of the mean 5.9% ± 6.6%.

Median year (interquartile range) of publications was calculated in a random sample and found to be 2001 (1995; early 2004).

Leading investigators according to scientific fields

Scientists formed by primary authors of highly cited papers numbered 335. Those that generated 2 such papers or earned 120 citations in 1 publication consisted only of 121 scientists, listed in Table 2. This list comprises over 70% of the total citations to highly-cited papers.

Geology: İstanbul Technical U (and IU) [AM C. Şengör, A. İ. Okay, Y Yılmaz] and Middle-East Technical U (E Bozkurt, A Koçyiğit) were the leading researchers.

Chemical engineering: Z. Aksu of Hacettepe U, A. Demirbaş of Karadeniz Technical U /Selçuk U, İ. Bahar, B. Erman and İ. Arslan of Boğaziçi U, H. Y. Erbil of Kocaeli U and Y. Yağcı of İstanbul Technical U ranked top.

Chemistry: V. Ahsen and A. R. Koray of TÜBİTAK, Ö. Bekaroğlu and O. Okay of İTÜ, E. U. Akkaya and A. Coşkun of ME Technical U, İ. Gülçin of Atatürk U, M Ş. Özsöz, K Kerman and B. Çetinkaya of Ege U were leaders. M. Balcı and M. Alkan of Atatürk/Balıkesir U, M. Soylak of Erciyes U, L. Elçi of Pamukkale U, M. M. Demir of Sabancı U, R. Say and A.S. Özcan of Anadolu U and E. Karadağ of Adnan Menderes U each contributed with more than 1 publication.

Physics: Bilkent U ranked top by a large margin (E. Özbay, E. Çubukçu and M. Bayındır forming the nanotechnology group, S. Çıracı and Ö. Morgül). Boğaziçi U, mainly with R Güven, Ege U with F. Büyükkılıç, Atatürk U with A Türüt followed.

Electricity-electronics: The young S. Arık of İstanbul U was prominent along with M İ. Aksun and M.A. Kutay of Bilkent U and M. Sezgin of Boğaziçi U.

Mathematics: Chief contributors were T. Öziş of Ege U, M. Şimşek of Gazi U, N. Bildik of C. Bayar U.

Materials science: Contributions of A.C. Taş and his 2 colleagues of Middle-East Technical U lead the field.

T. Oğuz and E. Özsoy of METU significantly contributed in *oceanography* and C Kahraman of İTÜ in *industrial engineering*. While E Ayrancı of Akdeniz

Table 1. Certain data pertaining to output of science in Turkey's scientific institutions.

	h index	Cited publications	Number of citations			Papers ≥60-cited	
			Year 2009	10. paper	40th	Papers	Citations
İstanbul U	64	9500	8162	158	78	61	6723
İstanbul Technical U	66	6660	8177	194	91	59	5488
Hacettepe U	74	15,818	12,267	172	94	54	4905
Bilkent U	69	3048	4530	210	95	34	4209
Middle-East Technical U	67	9712	8177	116	77	37	3037
Boğaziçi U	69	3506	4609	240	106	20	2865
Ankara U	68	9200	9407	120	68	25.8	2291
Ege U	54	8562	9271	102	61	27.5	2233
Karadeniz Technical U	39	3646	3811	65	39	16.3	1784
Atatürk U	48	5854	6361	87	49	15.5	1318
GATA	44	5210	2172	94	50	12	1130
Erciyes U	43	4840	5374	75	45	11.5	975
Dokuz Eylül U	51	5890	6024	129	58	11	936
Akdeniz U	43	3604	3816	101	44	8	880
Kocaeli U	32	2133	2027	63	37	7.3	869
TÜBİTAK	63	2489	3481	179	85	8*	848*
Marmara U	47	4593	4809	93	50	9.5	774
Gazi U	49	9187	8442	91	56	8	720
Cumhuriyet U	35	2011	1934	64	31	9.5	682
İnönü U	43	2820	3196	81	44	8.5	629
Sabancı U	34	806	1545	91	31	5	618
Fırat U	39	3676	4116	66	39	7.5	580
Selçuk U	36	3767	4103	68	36	7	548
Çukurova U	46	4774	4638	100	48	6.4	511
Pamukkale U	32	2032	2128	48	30	5.5	505
Balıkesir U	24	695	794	41	17	5.5	459
Harran U	27	1439	1546	45	21	4	450
Gaziantep U	30	1371	1265	55	26	6	407
Anadolu U	37	1964	2581	68	35	5	384
Kırıkkale U	35	1662	1963	59	34	5	342
Mersin U	31	1788	1967	46	28	4.5	314
Yıldız Technical U	32	1871	2228	51	30	4	275
Ondokuz Mayıs U	34	4388	3085	54	31	3	271
Dicle U	33	2512	2247	49	31	2.5	262
Süleyman Demirel U	32	2699	2752	49	27	3.5	256
Trakya U	25	2220	1614	36	21	3	178
Sakarya U	29	1110	1340	43	26	2	174
Celal Bayar U	27	1678	1583	43	23	1.3	151
Sütçü İmam U	24	843	738	32	16	2	133
Niğde U	28	795	1017	45	22	2	128
Uludağ U	34	3349	2928	66	32	1.5	107
T.Yüksek İhtisas Hast.	17	538	338	23	12	1	102
Yüzüncü Yıl U	24	1823	1301	38	20	1	93
Ankara Numune H.	20	460	292	30	16	1	92
Osmangazi U	32	2157	2338	59	28	1	72
Çankaya U	24	405	640	40	17	1	89
Koşuyolu H.	14	250	170	20	7	1	68
Dumlupınar U	18	571	497	22	8	1	68
Türk. Petroleum						1	62
Zonguldak Karaelmas U	22	1389	1316	28	19	1	61
Gaziosmanpaşa Ü	29	1209	1480	51	19	1	61
Kocatepe U	22	1538	1143	35	15	1	60
Başkent U	30	4334	3038	47	26	0.5	38
21 Institute avg¶	*14.4*	*519*	*421*	*18.8*	*8.5*	*0*	0
	34.2	**8792**	**3573**	**68.2**	**34.6**	**541**	**51.215**

* Roughly 3/4 of the data of the papers cited ≥60 times and citations of TÜBİTAK have been transferred to the respective universities.

¶ List includes *Koç U,* Adnan Menderes U, İzmir Inst Technology, *Yeditepe U, Fatih U*, Mustafa Kemal U, Izzet Baysal U, Kafkas U, *Atılım U*, Siyami Ersek Thorac & Cardiovasc Surg, *Işık U, Kadir Has U*, Bozok U, *Maltepe U*, Aksaray U, *Ufuk U*, *Bahçeşehir U*, Rize U, *İstanbul Bilim U*, Muğla U and Çanakkale 18 Mart U.

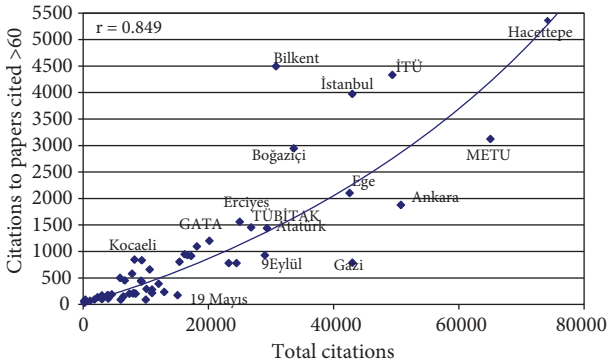

Figure 1. The relationship between the total number of citations and those to highly (≥60) cited papers generated by Turkish universities (n = 47) and further 6 institutions. A great variance in citations to highly cited papers is noted across major universities at similar total number of citations.

U, İ.T. Toğrul of Fırat U and R Apak of IU were front runners in *food technology*; İ. Çakmak of Çukurova/ Sabancı U and the group of O. Yaldız and C. Ertekin of Akdeniz U led in *agricultural sciences* by a margin.

Ecology: N.H. İnce of Boğaziçi U, D. Orhon of I Technical U, M Canlı, B Gözmen and B. Bayat of Çukurova U, İ. Kapdan and M. Odabaşı of Dokuz Eylül U, H.S. Altundoğan of Fırat U, O. Yavuz of Dicle U, Y. Orhan of 19 Mayıs U contributed the most.

Contributions in *biology* came from M.Y. Arıca of Kırıkkale U and B. Tepe of Cumhuriyet U. *Pharmacy and toxicology*: A. Erdem of Ege U, M. Yıldız of Ankara U, H.S. Kaş of Hacettepe U and F. Gültekin of S. Demirel U deserve to be stated ahead. In *biochemistry,* leaders were İ. Durak of Ankara U, Ö. Erel of Harran U and U. Koltuksuz of İnönü U. B. Akkayan of İstanbul U and B. H. Şen of Ege U were notable contributors in *dentistry*.

In *medicine,* 177 papers were generated by 137 researchers working in 36 institutions, which acquired 15,147 citations. İstanbul U with 3943 citations to 44 publications, Hacettepe 2238, Ankara U 1211, and GATA with 1130 citations were leaders and together received 56% of these citations. H. Yazıcı and his group on Behçet's disease (including S. Yurdakul and V. Hamuryudan) authored 14 highly-cited papers during 1983 to 2000. The current author followed with 4 papers since 1992. The late M. Aksoy contributed to medicine with 2 important findings in his era. Hacettepe U generated 26 articles by 22 scientists. K. Ateş and hematologists A. O. Çavdar and Nejat Akar led among the 16 papers from Ankara U, C. Ertekin and M. Özkahya among the 7 papers from Ege U. S. Akpınar, A. Uygun and B. Ayhan of Gülhane Military Med. Academy authored 12 papers. Marmara U contributed to medicine with 8 articles. In addition, Dokuz Eylül U (neurosciences in top), Erciyes U (A. Abacı and F. Keleştimur) and İnönü U each with 7 papers, Gaziantep U (H. Herken) and Fırat U (M. Atmaca) generated 2 highly-cited papers each. Harran U contributed importantly especially in biochemistry with Ö. Erel. Akdeniz, Karadeniz Teknik, Kocaeli, Atatürk (Ü. Tan), Trakya, Gazi, Mersin, Selçuk, Yüzüncü Yıl, Cumhuriyet, Dicle, Çankaya, Çukurova, Sütçü İmam, Osmangazi, Uludağ, Başkent, S. Demirel, Kocatepe, and Celal Bayar universities and the T. Yüksek İhtisas (O. Taşdemir), Ankara Numune, as well as Koşuyolu Kalp hospitals contributed each with a scientific publication.

Assessment of relative performance in the scientific fields

This issue was evaluated in 10 major scientific fields by relating the number of total citations received to the highly-cited papers in each field to the proportion of global unique citations, as provided in the methods section. The mean level (index = 1) was formed by computer sciences (Figure 2). Engineering, geosciences including ecology, and pharmacy and toxicology (index around 2) formed the fields contributing to a greater extent. While agricultural sciences, chemistry, and medicine represented slightly higher levels than the mean (index 1.2 to 1.8), physics, mathematics, and the large field of biological sciences were found below the mean level.

Discussion

The present study aimed to assess the domestic contribution of Turkey and its universities to world science and engineering in the past 3 decades. Articles produced in international institutions or with more than minor contribution by international co-authorship were not taken into account. In recognition of scientific contribution being mainly

Table 2. Primary authors, fields, institutions and total citations of Turkey's genuine publications having received ≥60 citations.

Publ.	*Citat.*		*Field*	*University*	*Publ.*	*Citat.*		*Field*	*University*
3	314	O.Yaldız-C.Ertekin	Agr, Eng	Akdeniz	2	223	Y. Yılmaz[i]	Geosci	İTÜ
4	338	İ. Çakmak	Agr.	Çukurova/Sabancı	2	316	E. Bozkurt	Geosci	ODTÜ
2	142	B. Tepe	Biol	Cumhuriyet	2	137	A. Koçyiğit[j]	Geosci	ODTÜ
5	342	M Y Arıca	Biol	Kırıkkale	3	219	E. Özsoy	Marine	ODTÜ
2	201	A S Özcan	Chem	Anadolu	2	179	T. Oğuz	Marine	ODTÜ
2	170	R. Say[a]	Chem	Anadolu	3	258	A. C. Taş	Material	ODTÜ
4	563	E. Erdik	Chem	Ankara	1	129	N. Bildik	Mathemat	Celal Bayar
1	149	M. Balcı	Chem	Atatürk	2	139	T. Öziş	Mathemat	Ege
4,5	378	M. Doğan-M. Alkan	Chem	Balıkesir	4	330	İ. Durak	Biochem	Ankara
2,5	180	E. Karadağ	Chem	Cumhuriyet	3	389	Ö. Erel	Biochem	Harran
2	167	K. Kerman[b]	Chem	Ege	2	143	U Koltuksuz	Biochem	İnönü
2	162	B. Çetinkaya	Chem	Ege	1	137	A. C. Öğüş	Med	Akdeniz
1	102	M.Ş. Özsöz¶ [c]	Chem	Ege	1	160	K. Ateş	Med	Ankara
3,5	257	M. Soylak	Chem	Erciyes	2	130	A. O. Çavdar	Med	Ankara
1	204	S Taşçıoğlu	Chem	Gazi	2	125	N. Akar	Med	Ankara
2	151	H. Bağ	Chem	Gazi/Pamukkale	1	205	M. Çelik	Med	Dokuz Eylül
5	404	A. Denizli¶	Chem	Hacettepe	2	133	M. Tunca	Med	Dokuz Eylül
9	825	Ö. Bekaroğlu[d]	Chem	İTÜ	2	122	Ş. Genç	Med	DokuzEylü
4	481	O. Okay	Chem	İTÜ	2	186	M. Özkahya	Med	Ege
3	361	A. Gül[e]	Chem	İTÜ	2	180	C. Ertekin	Med	Ege
2	131	O. Altıntaş	Chem	İTÜ	1	212	A. Abacı	Med	Erciyes
3	324	E U. Akkaya¶	Chem	ODTÜ	2	155	M. Altınbaş	Med	Erciyes
3	175	A. Coşkun[f]	Chem	ODTÜ	2	128	F. Keleştimur	Med	Erciyes
3,5	268	L. Elçi	Chem	Pamukkale	2	145	M. Atmaca	Med	Fırat
1	163	E. Erdem	Chem	Pamukkale	2	207	S. Akpınar	Med	GATA
2	325	M. M. Demir	Chem	Sabancı	2	203	A. Uygun	Med	GATA
2	174	M. Özacar	Chem	Sakarya	1	163	H. Bayhan	Med	GATA
2	139	H. Deligöz	Chem	Selçuk	2	153	H. Herken	Med	Gaziantep
7	675	V. Ahsen[g]	Chem	TÜBİTAK	1	301	Y. Koç	Med	Hacettepe
1	173	A. R. Koray	Chem	TÜBİTAK	3	207	H. Yaralı	Med	Hacettepe
2	267	O. Kaynak	Computer	Boğaziçi	3	204	S. Karakaş	Med	Hacettepe
1	131	B. Akkayan	Dentistry	İstanbul	2	155	T. Dalkara	Med	Hacettepe
4	321	N. H. İnce	Ecology	Boğaziçi	2	168	A. İlhan	Med	İnönü
1	137	Ilgi Kapdan	Ecology	Dokuz Eylül	2	259	G. Akman-Demir	Med	İst -Çapa
2	168	H.S. Altundoğan	Ecology	Fırat	7	673	Yazıcı Behçet group	Med	Ist-Cerrahpaşa
3	202	D. Orhon	Ecology	İTÜ	4	484	V. Hamuryudan	Med	Ist-Cerrahpaşa
1	148	Y. Orhan	Ecology	Ondokuz Mayıs	4	407	A. Onat	Med	Ist-Cerrahpaşa
2	325	B. Erman[h]	Eng	Boğaziçi	4	317	S. Yurdakul	Med	Ist-Cerrahpaşa
3	243	Y. Sağ	Eng-Bioch	Hacettepe	2	130	A. Siva	Med	Ist-Cerrahpaşa
3	801	İ. Bahar	Eng-Chem	Boğaziçi	4,5	263	A. Gül	Med	Ist-Çapa
1	120	İ. Arslan	Eng-Chem	Boğaziçi	2	255	P. Serdaroğlu	Med	İst -Çapa
13	1502	Z. Aksu	Eng-Chem	Hacettepe	2	164	M. Aksoy	Med	İst -Çapa
3	208	Y..Yağcı	Eng-Chem	İTÜ	2	126	B. F. Erden	Med	Kocaeli
14	1577	A. Demirbaş	Eng-Chem	KTÜ/Selçuk	2	164	H. Direskeneli	Med	Marmara
2	159	A. Midilli	Eng-Chem	KTÜ	2	147	M N. Pamir	Med	Marmara
1	450	H. Y. Erbil	Eng-Chem	Kocaeli	1	139	N. İmeryüz	Med	Marmara
2	149	A. Özer	Eng-Chem	Mersin	2	178	M. Yıldız	Pharmacy	Ankara U
3	379	M. A. Kutay	Eng-Electr	Bilkent	6	477	İ. Gülçin	Chem	Atatürk U
2	277	M. İ. Aksun¶	Eng-Electr	Bilkent	7	511	A. Erdem	Pharmacy	Ege
1	336	M. Sezgin	Eng-Electr	Boğaziçi	2	184	H. S. Kaş	Pharmacy	Hacettpe
8	1167	S. Arık	Eng-Electr	İstanbul	2	150	F. Gültekin	Pharmacy	S Demirel
1	145	O. Yavuz	Eng-Envir	Dicle	2,5	242	A. Türüt	Physics	Atatürk
2,5	250	C. Kahraman	Eng-Ind	İTÜ	10	1855	E. Özbay¶ (M.Bayındır, E. Çubukçu)	Physics	Bilkent
1	146	S. Yaman	Eng-Metalrj	İTÜ				Physics	Bilkent
2	143	R. Apak	Eng-Metalrj	İstanbul	8	826	S. Çıracı	Physics	Bilkent
1	149	E. Ayrancı	FoodTechn	Akdeniz	2	177	S. Dağ[k]	Physics	Bilkent
2	142	B. Tepe	FoodTechn	Cumhuriyet	2	173	Ö. Morgül	Physics	Bilkent
2	163	İ. T. Toğrul	FoodTechn	Fırat	2	120	H. M. Özaktaş	Physics	Bilkent
9	1776	A.M.C. Şengör	Geosci	İstanbul / İTÜ	2	312	R. Güven	Physics	Boğaziçi
5	545	A. İ Okay	Geosci	İTÜ	2	189	F. Büyükkılıç	Physics	Ege
					340.5	**36127**			

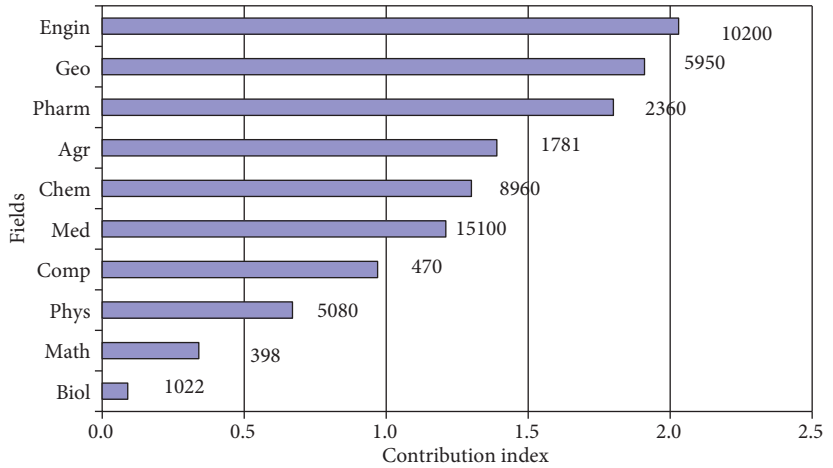

Figure 2. The relative contribution of Turkey's "highly-cited" publications to main scientific fields. The contribution index is shown in the bars, while Index 1 represents Turkey's average level. Absolute numbers of these total citations are additionally provided.

determined not by total but rather by highly-cited publications, papers cited ≥60 times were considered as an inclusion criterion. Only 53 universities and institutions generated a minimum of 1 such publication. These consisted of 541 papers, which received a sum of 51,200 citations. The majority of these were acquired by the top 8 universities. At least half of Turkish universities active in the first decade of this century have not succeeded to produce a single paper of such quality. Highly-cited articles were authored by 335 scientists; 70% of these citations were received by 121 scientists.

Selection of citation threshold

A threshold of 60 citations corresponds to about 90th to 92nd percentile of global publications (2,3). Selection of top 1% of cited papers, strictly speaking the "highly cited" ones, would require about 200 citations, which would drastically reduce the number of articles and its statistical power. A threshold of, say, 40 citations would more than double the number of papers and dilute the global contribution; and most likely would not significantly impact the results of this analysis. Highly cited papers and citations studied herein are estimated to represent roughly 0.4%-0.5% of the papers and roughly 8%-9% of received citations generated in Turkey in the past quarter century published in journals covered by the SCI database (4).

Of papers cited ≥60 times, those considered as domestic were found to be 45% (±16%) of the total publications originated from Turkey; the remainder was internationally co-authored, or the attributed fraction count reduced the number of unique papers and citations for authorship shared by domestic institutions.

Turkey's scientific contribution is not commensurate with its potential

The most notable conclusion of the present study is that the genuine domestic contribution, i.e. the output by Turkish scientists, with their "know-how" and own resources, is less than may be anticipated. This contribution may be expressed as the equivalent to an output of a total of 40 highly-cited articles in each of the recent years. In other words, it may be summarized that TÜBİTAK and each leading 9 universities would generate annually 1-3 highly-cited papers, and the remaining 40 universities less than 1 yearly, whereas the remaining 60 universities active around the turn of the century would be considered not to have attained a productivity to contribute to science.

I estimate that 600,000 SCI articles of this level exist having received 50 million citations; hence, the global share of Turkey's similar articles is approximately 1 per mil. This ratio, when compared with a 5 per mil

world share of Turkey's total citations, may lead to the appreciation to what extent our highly cited articles lag behind.

It is to be recalled that the combined share of world citations of USA and the European Union was 71.5% in 2008 (3). It may be stated that Turkey clearly ranks behind India, Brazil and Taiwan, which share ranks 23rd to 25th with a 5 per mil share in world citations (1). Turkey currently ranks around 31st, in my opinion. This contrasts with its population and gross domestic product each ranking 17th in the world, and Turkey should not be satisfied with such a low contribution in science. Excluding assistants and instructors, 40,000 academic staff and 3000 specialists are active in Turkey, which indicate that merely 1% of researchers have attained a level capable to generate highly-cited articles, a considerably low ratio. University of Athens alone has received, with 22,000 citations in 2009, more than the sum of the Hacettepe and İstanbul universities. It is little wonder that only one of Turkish universities (İstanbul U) has made to be barely included in the top 500 universities in the world ranking of Jiao-Tong (5).

At this point I should claim that scientific publications originating from Turkey are not credited with appropriate citations due to the bias prevailing in most Western circles of science. This observation is based on my experience (which I believe is unbiased) in producing scientific articles for over half a century. A main reason to exclude publications having a primary international collaboration is related to avoid major heterogeneity of exposure to citations.

Individual contribution of universities

At the outset it may be pointed to the fact that 6 institutions other than universities, namely TÜBİTAK, GATA, the hospitals Türkiye Yüksek İhtisas, Ankara Numune and Koşuyolu Kalp, and a corporation are taking part in the list of contributors. The first mentioned 2 institutions have generated sufficient highly-cited papers to join the top universities. The cities of Ankara (Hacettepe and Bilkent) as well as İstanbul (İstanbul and İstanbul Tech) are seats to 4 leading universities. The Middle-East Tech and Boğaziçi universities follow closely. Surprisingly, Ege U appears to have had a similar contribution as the Ankara U.

Large variation in the proportion of highly-cited papers was noted in Turkey's top dozen universities, as can be seen in Figure 1. Hacettepe, Ege, and Atatürk universities represented the mean in the proportion of citations to highly-cited papers to total citations. They may be compared with Bilkent, İstanbul, İstanbul Technical (and Boğaziçi) universities, which may be described as weighted more toward quality publications. METU, Ankara, Gazi, and Dokuz Eylül universities relied more on international and Ondokuz Mayıs U on domestic inter-university collaboration than on own domestic capacity for highly-cited publications. METU, receiving lower median citation for highly-cited papers than the other 3 technical universities, must have pursued also a policy to tend to accumulate citation by frequent, lower-cited papers. Together with the İstanbul Technical U, Karadeniz Technical, Ege, and Atatürk U were prominent by highest proportions (0.60 to 0.83, data not shown) of domestic quality papers. This important finding of the current analysis regarding great variation in highly-cited domestic publications among our large universities merits to be seriously considered by authorities and to yield practical implications.

Front-running scientific fields

Engineering, which has nearly a 10% global share of sciences (3), was the most successful field with 10,400 citations and a 20% share. Similarly, geosciences (together with ecology) rank ahead with 58 highly-cited publications, 6000 citations, and nearly a 12% share of citations. Medicine, having acquired a 29.6% share in total citations, represented a slightly-above average level of performance. The relative contribution index, seen graphically in Figure 2, conforms largely to the ranking by total SCI citations of Turkey (2). It appears that engineering and geosciences proper weigh more heavily in the highly-cited than lower cited papers (with relatively fewer top scientists), the reverse being applicable to biological sciences or mathematics.

Five Turkish scientists active in 4 fields who stand out by having contributed most should be acknowledged by name. These are Celal Şengör in geosciences, Hasan Yazıcı in medicine, Zümriye Aksu and Ayhan Demirbaş in chemical engineering as well as Ekmel Özbay in physics.

In evaluating the contribution to science of a country or institution, the internationally co-authored articles are undoubtedly not to be neglected, but it is to be appreciated that the share of our scientists or institutions in such research might be marginal and this might add great difficulty in the proper assessment. Furthermore, papers of the 1970s and 1980s admittedly stand at high disadvantage, compared with those in the past 20 years, by the observed doubling of SCI citations each 15-20 years (3).

Limitations: Highly-cited research often originates from multiple centers, which imposes possibility of misclassifying the institutions. Likewise, topics are often related to several overlapping fields, which potentially introduces errors in misclassifying authors and fields to the respective universities. In order to minimize such errors, institutions and their addresses reported in the data of Citation Report were scrutinized and Citation Report data on the individual scientists were studied as deemed necessary. Authorship definition between basic sciences and engineering is not clearly demarcated, which may have led to allocation differences, especially in the fields of chemistry and ecology. Finally, limitations of citations as a surrogate of scientific performance are recognized (6); its use has been nonetheless mounting, not only in the evaluation of scientific journals (1,3).

Conclusion

Half of active universities in Turkey and 99% of the active academic staff have been unable to produce in the subsequent 5-15 years a publication that received 60 or more citations. With a productivity of a total of 40 papers annually, 47 universities and 6 institutions of the country have contributed to science in the past with about 540 papers of this level. These articles were authored by a total of 335 unique primary researchers. Turkey's share in global publications of this level is estimated to be 1 per mil. A large variance was observed between the ratio of citations to highly-cited and total citations across the major universities. Whereas medicine and chemistry represented slightly above the mean level of contribution, engineering and geosciences have contributed most among the major fields.

Acknowledgement

I am indebted to the Library of the Boğaziçi University, which offered access to their databases.

References

1. King DA. The scientific impact of nations. What different countries get for their research spending. Nature 2004; 430: 311-6.
2. Onat A. Türkiye'de çeşitli bilim alanları ne durumda, nasıl gelişiyor? Cumhuriyet BT 2008; 1086: 20-21.
3. National Science Foundation, Division of Science Resources Statistics. Science and Engineering Indicators 2010. Available from: URL: http://www.nsf.gov/statistics/seind10/c5/c5h.htm
4. Demirel İH, Saraç C, Gürses EA. Editors. Türkiye Bilimsel Yayın Göstergeleri (I) 1981-2006. Ankara: TÜBİTAK-ULAKBIM; 2007.
5. Academic Ranking of World Universities 2009. Available from: URL: http://www.arwu.org/
6. Garfield E. Fortnightly review: How can impact factors be improved? BMJ 1996; 313: 411-13.