The status of Indian science and Measures to improve it

K.R. Sreenivasan

The first concern

- 1973, 8th place in scientific output
- 2000, 15th place (13th place in 2007)

Many articles

A. Arunachalam, “Is science in India on the decline?”, *Curr. Sci.* **83**, 107 (2002)

“India’s scientists agonize over fall in publication rate”, *Nature* **419**, 100 (2002)

G. Prathap, “Indian science slows down: The decline of open-ended research”, *Curr. Sci.* **86**, 768 (2004)

“Indian science is in decline, says prime minister”, *Nature* **445**, 134 (2007)

Figure 1

Number of scientific publications in OECD countries in 1995 and 2005 relative to one million population (in 1995 and 2004). Countries listed in order of the number of publications in 2005.

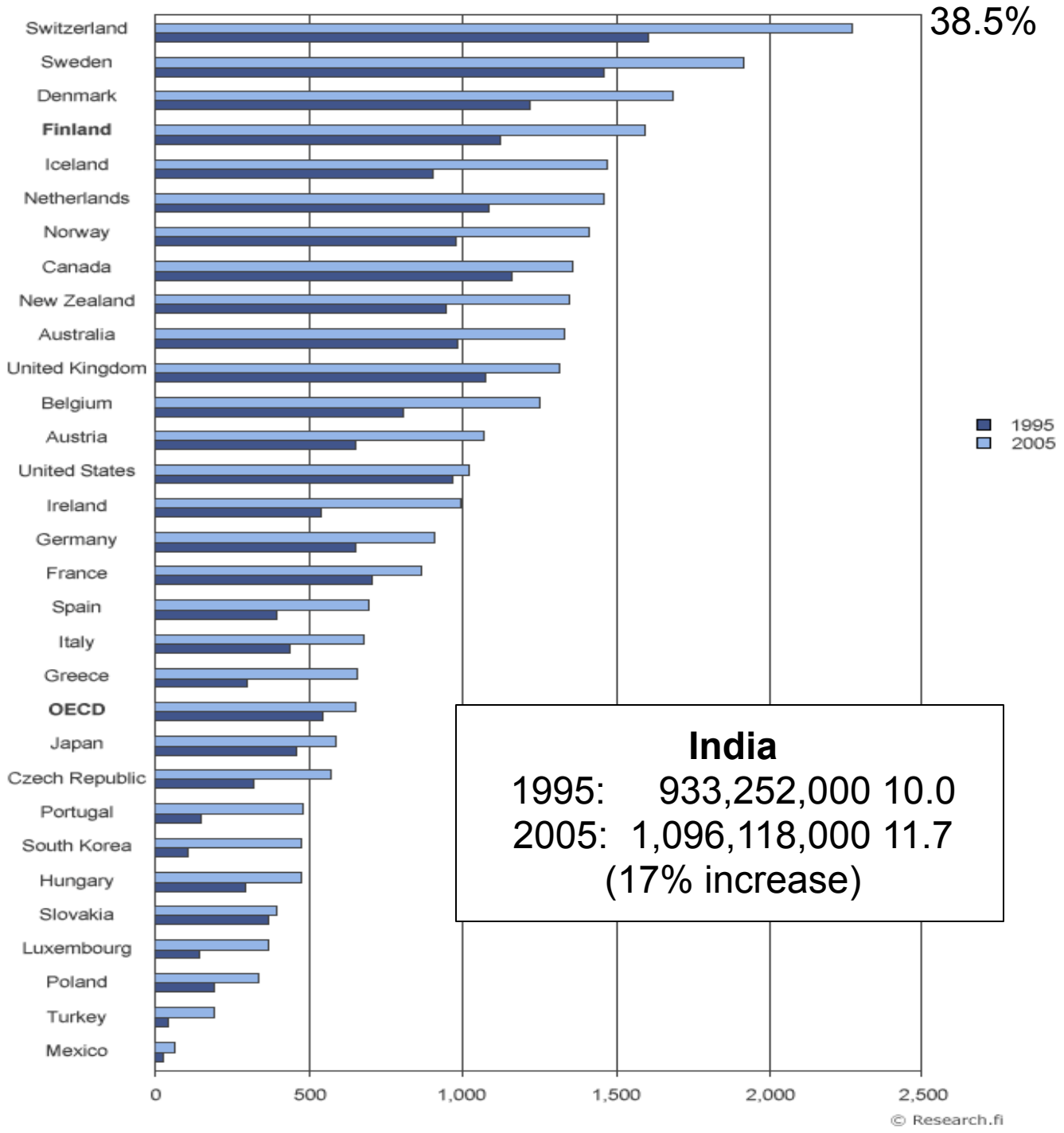


Figure 2

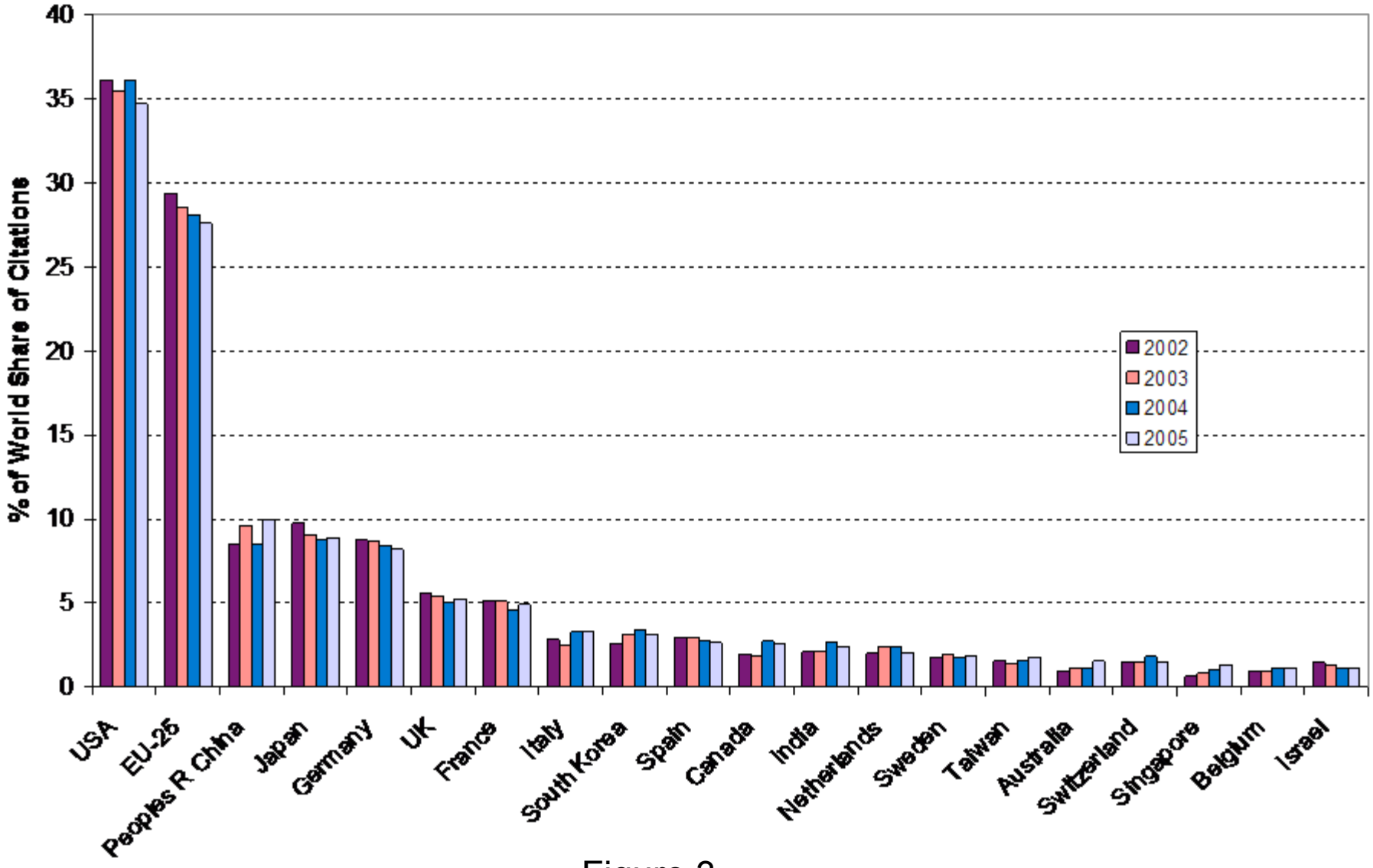

% of World Share of Citations
40
35
30
25
20
15
10
5
0
2002
2003
2004
2005
USA
EU-25
Peoples R China
Japan
Germany
UK
France
Italy
South Korea
Spain
Canada
India
Netherlands
Sweden
Taiwan
Australia
Switzerland
Singapore
Belgium
Israel

Figure 3

Percentage of total papers in all fields among top one per cent most cited

Country	Percentage of papers among top one per cent
United States	1.87
England	1.53
Canada	1.34
Germany	1.27
Australia	1.13
France	1.11
Italy	1.04
Spain	0.82
Japan	0.72
China	0.52
South Korea	0.52
Taiwan	0.44
India	0.33

Figure 4

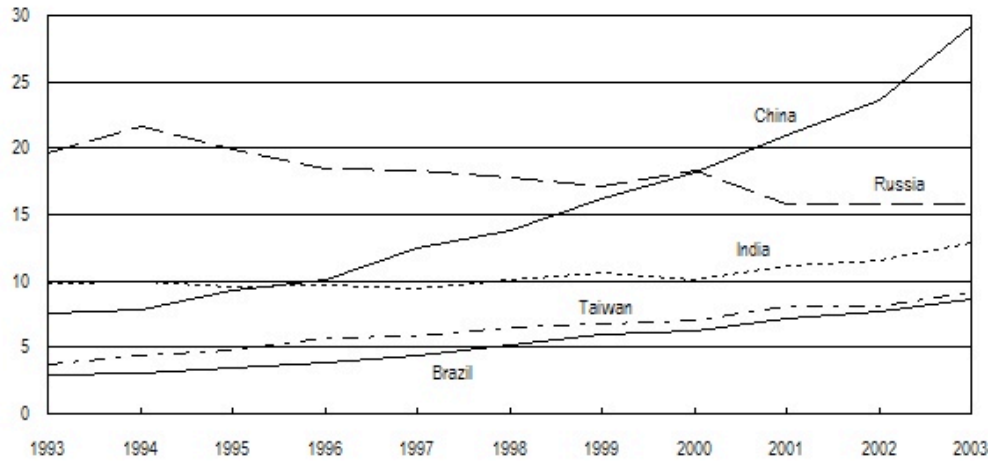
The second concern

"India losing scientific edge to China", *Indian Express,* 10 July 2006

"Indian science loses to China", *Times of India,* 30 June 2007

FIGURE 2. S&E article output of Brazil, China, India, Russia, and Taiwan: 1993–2003

Thousands of articles

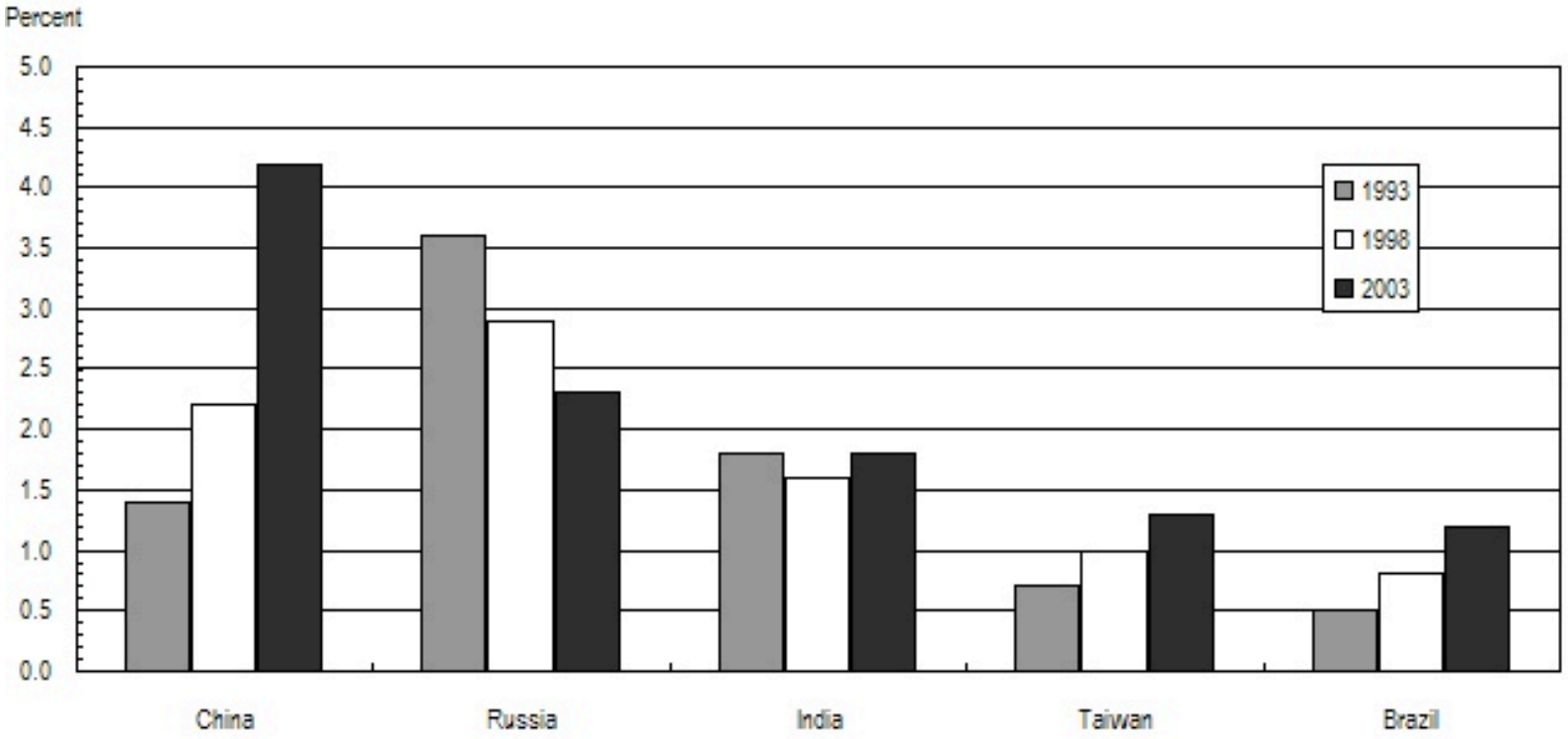


NOTES: For internationally coauthored articles, each country and economy receives fractional credit on the basis of proportion of its participating institutions. China includes Hong Kong.

SOURCES: Thomson ISI, Science Citation Index and Social Sciences Citation Index; http://www.isinet.com/products/citation/; ipIQ, Inc., and National Science Foundation, Division of Science Resources Statistics, special tabulations.

Figure 5

FIGURE 3. S&E world article share of Brazil, China, India, Russia, and Taiwan: 1993, 1998, and 2003



NOTES: Countries and economies listed in order of their world S&E article share in 2003. For internationally coauthored articles, each country and economy receives fractional credit on the basis of proportion of its participating institutions. China includes Hong Kong.

SOURCES: Thomson ISI, Science Citation Index and Social Sciences Citation Index; http://www.isinet.com/products/citation/; iplQ, Inc., and National Science Foundation, Division of Science Resources Statistics, special tabulations.

Figure 6

Figure 7

	% growth rate of publication output
South Korea	24.49
China	17.46
Taiwan	15.96
Singapore	15.80
Turkey	11.16
Portugal	10.80
Hong Kong	10.80
Spain	9.95
Mexico	6.02
Greece	5.72
Bulgaria	-1.58
Hungary	-2.39
India	-3.55
Czechoslovakia/Czech Rep.	-4.32
USSR/Russia	-4.42

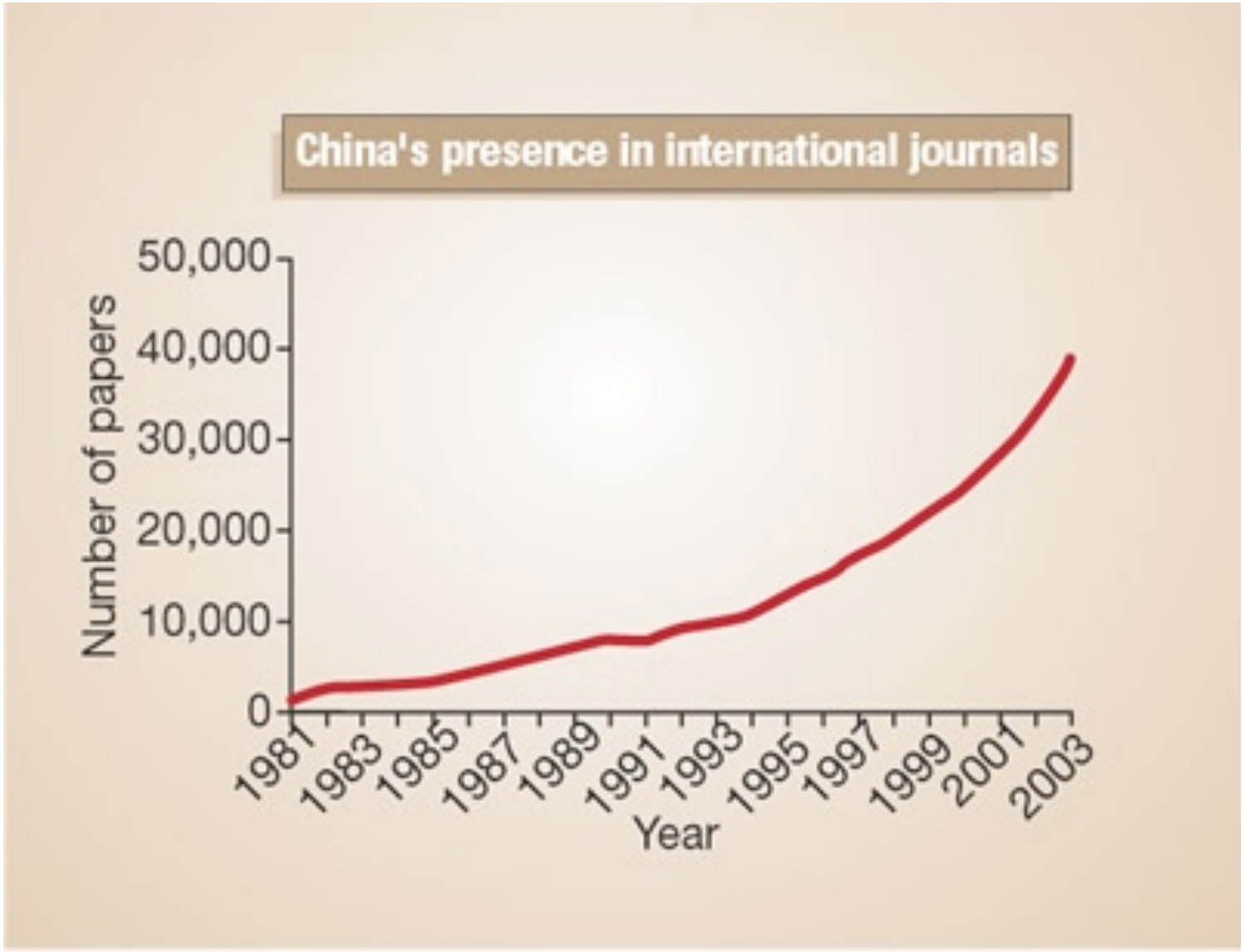

China's presence in international journals
Number of papers
50,000
40,000
30,000
20,000
10,000
0
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
Year

Figure 8

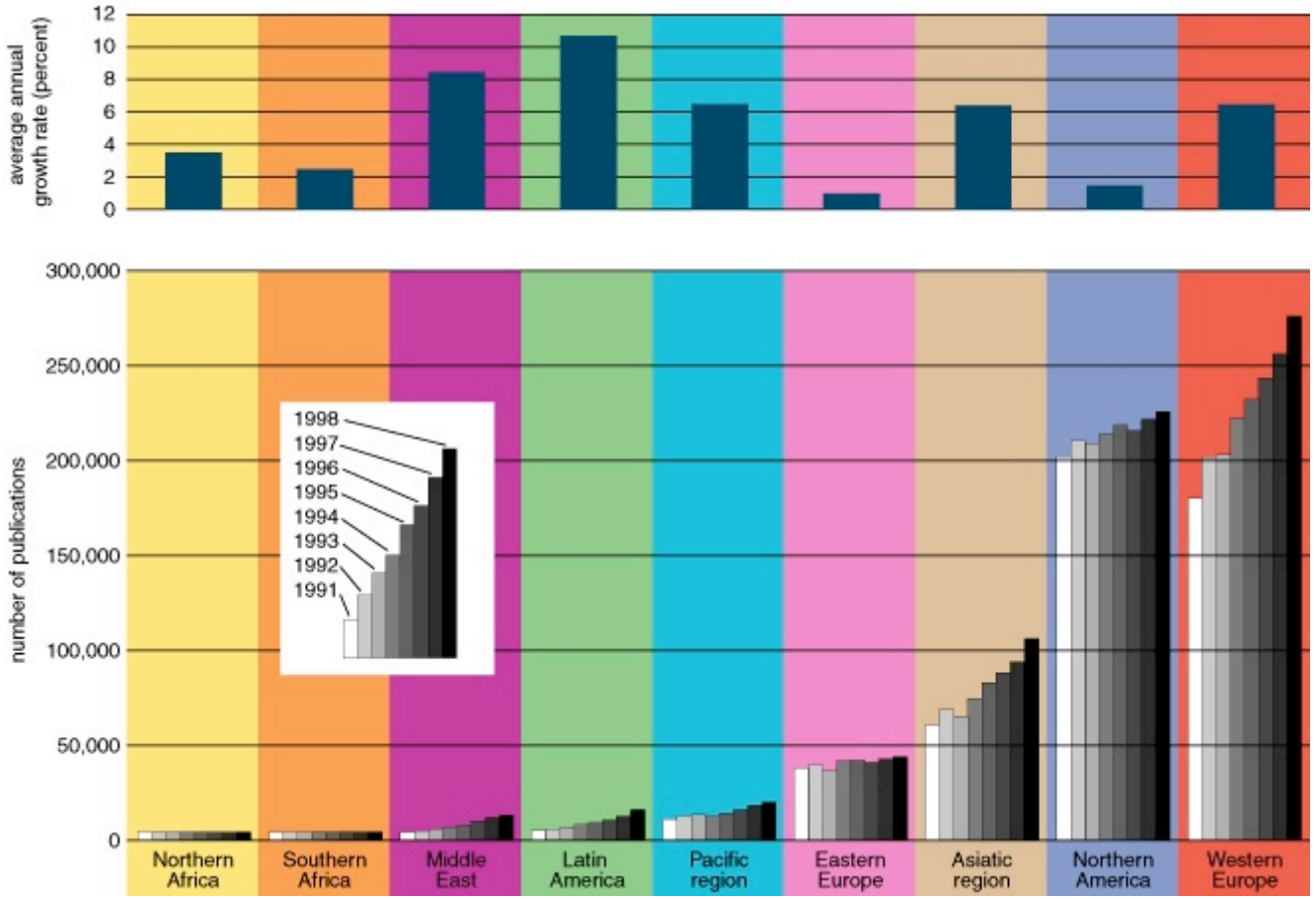

average annual growth rate (percent)
12
10
8
6
4
2
0
number of publications
300,000
250,000
200,000
150,000
100,000
50,000
0
1998
1997
1996
1995
1994
1993
1992
1991
Northern Africa
Southern Africa
Middle East
Latin America
Pacific region
Eastern Europe
Asiatic region
Northern America
Western Europe

Figure 9

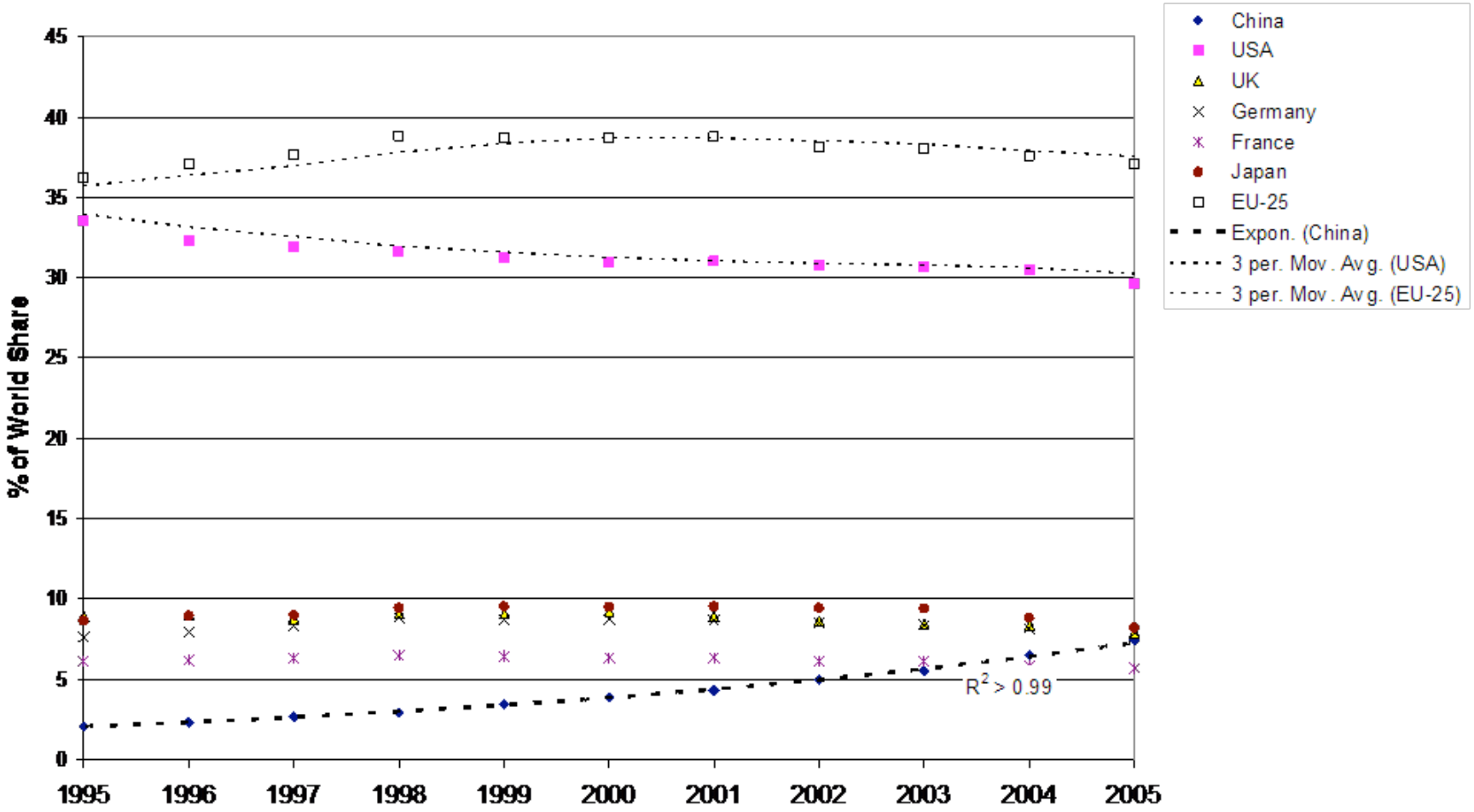

% of World Share
45
40
35
30
25
20
15
10
5
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
$R^2 > 0.99$
China
USA
UK
Germany
France
Japan
EU-25
Expon. (China)
3 per. Mov. Avg. (USA)
3 per. Mov. Avg. (EU-25)

Figure 10

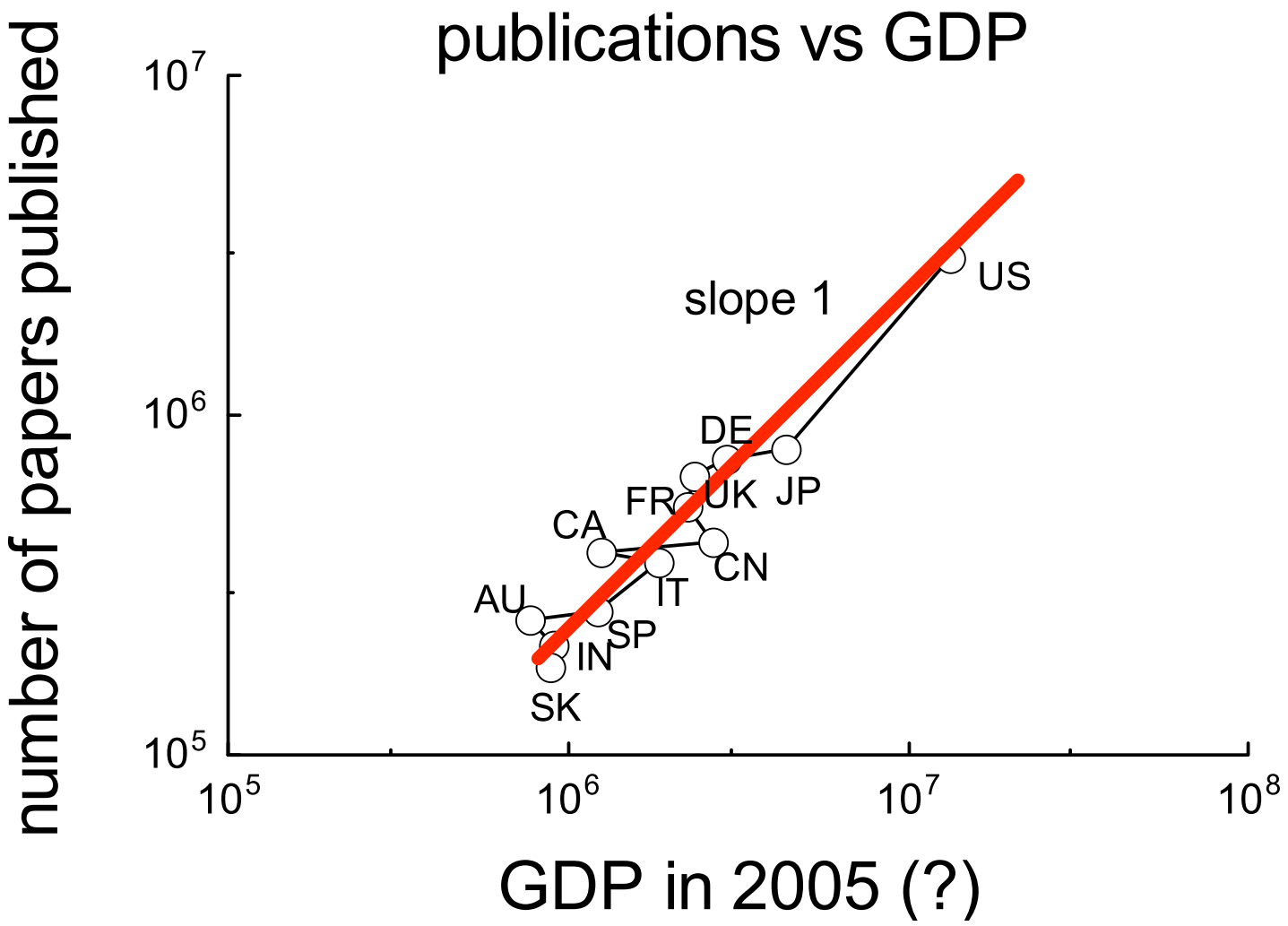

publications vs GDP
number of papers published
GDP in 2005 (?)
slope 1
US
DE
UK
JP
FR
CA
CN
IT
AU
SP
IN
SK
10^5
10^6
10^7
10^8

Figure 11

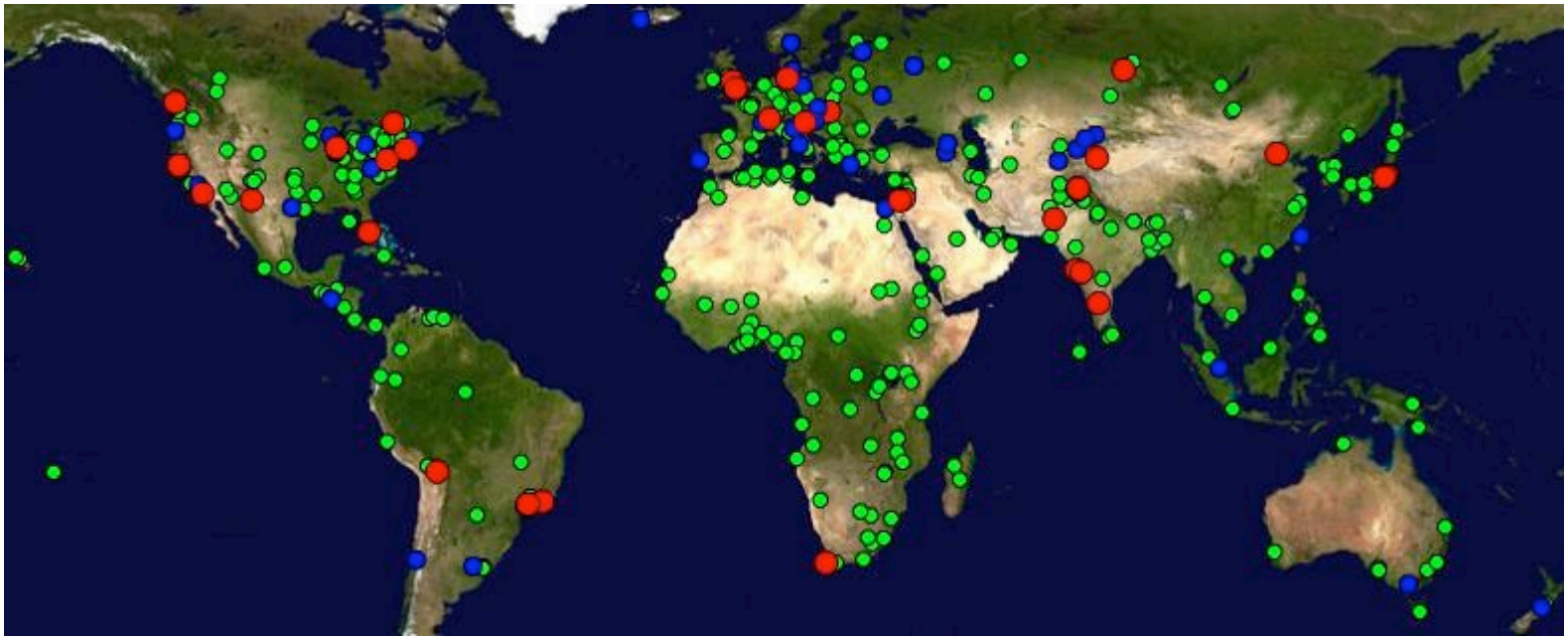


Figure 12

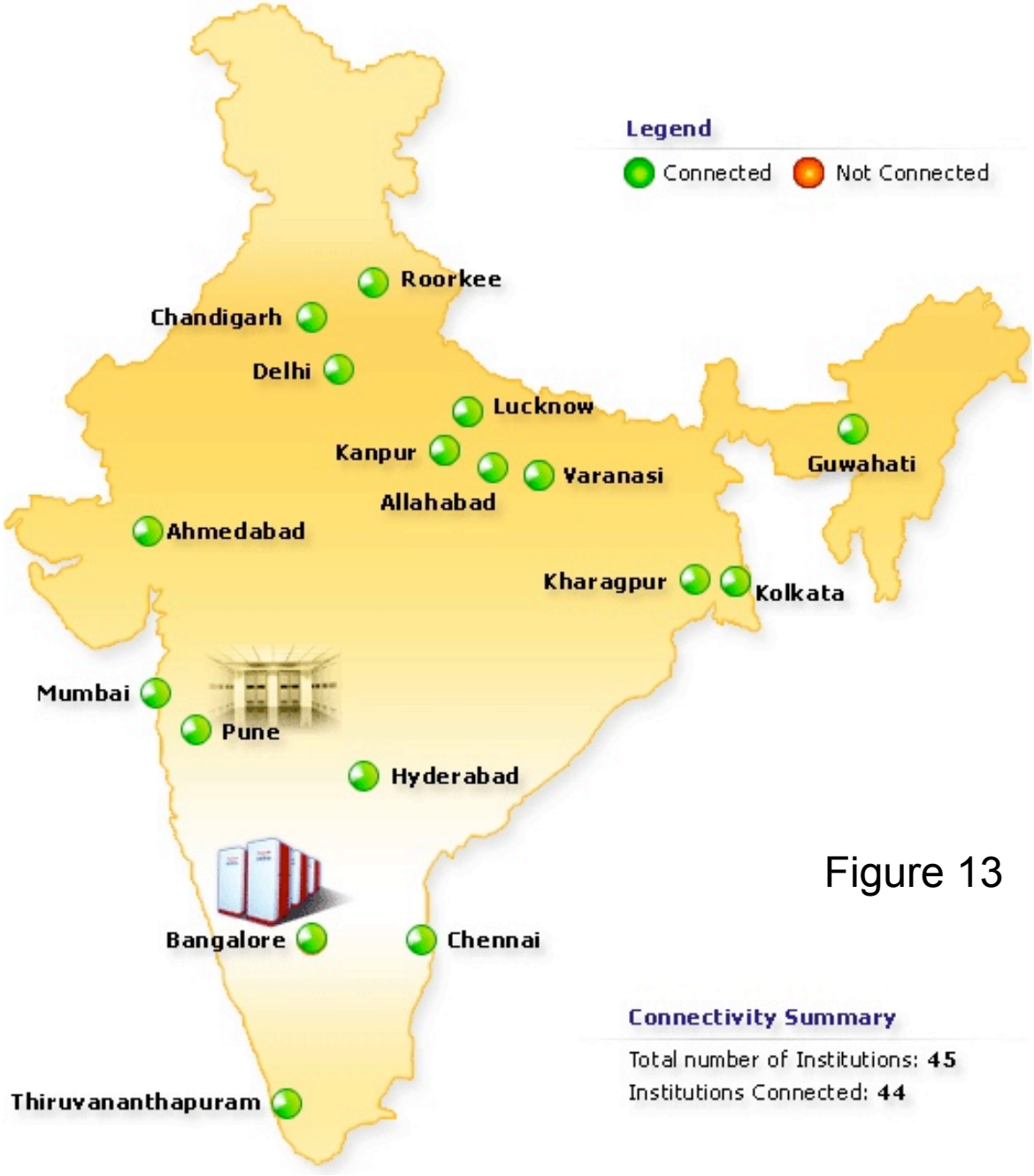
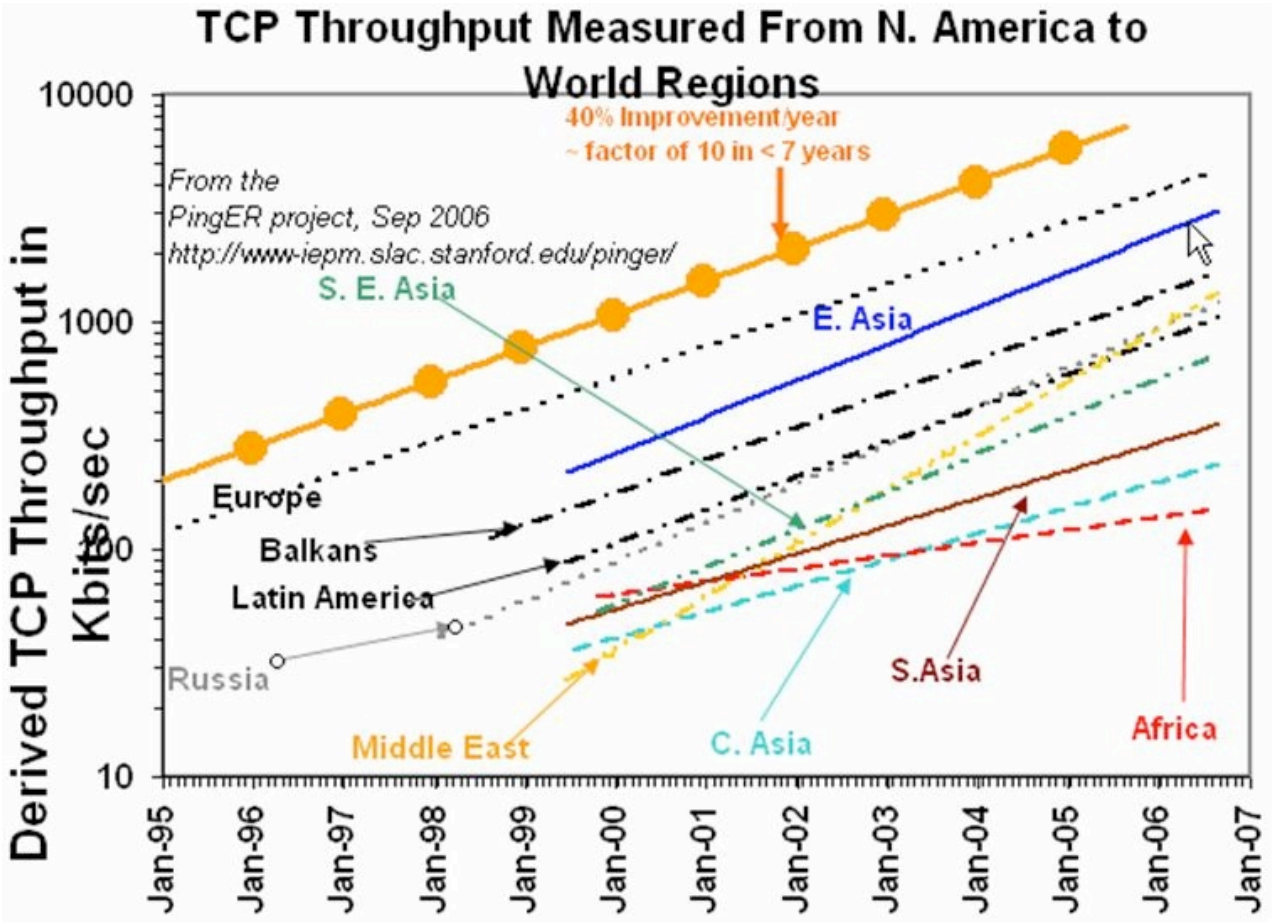

Legend
Connected
Not Connected
Roorkee
Chandigarh
Delhi
Lucknow
Kanpur
Varanasi
Allahabad
Guwahati
Ahmedabad
Kharagpur
Kolkata
Mumbai
Pune
Hyderabad
Bangalore
Chennai
Thiruvananthapuram
Connectivity Summary
Total number of Institutions: 45
Institutions Connected: 44

Figure 13



Throughput ~ 1460Bytes / (RTT*sqrt(loss))
(Mathis et al)

Behind Europe
6 Yrs: Russia, Latin America
7 Yrs: Mid-East, SE Asia
10 Yrs: South Asia
11 Yrs: Cent. Asia
12 Yrs: Africa

South Asia, Central Asia, and Africa are in Danger of Falling Even Farther Behind

Figure 14

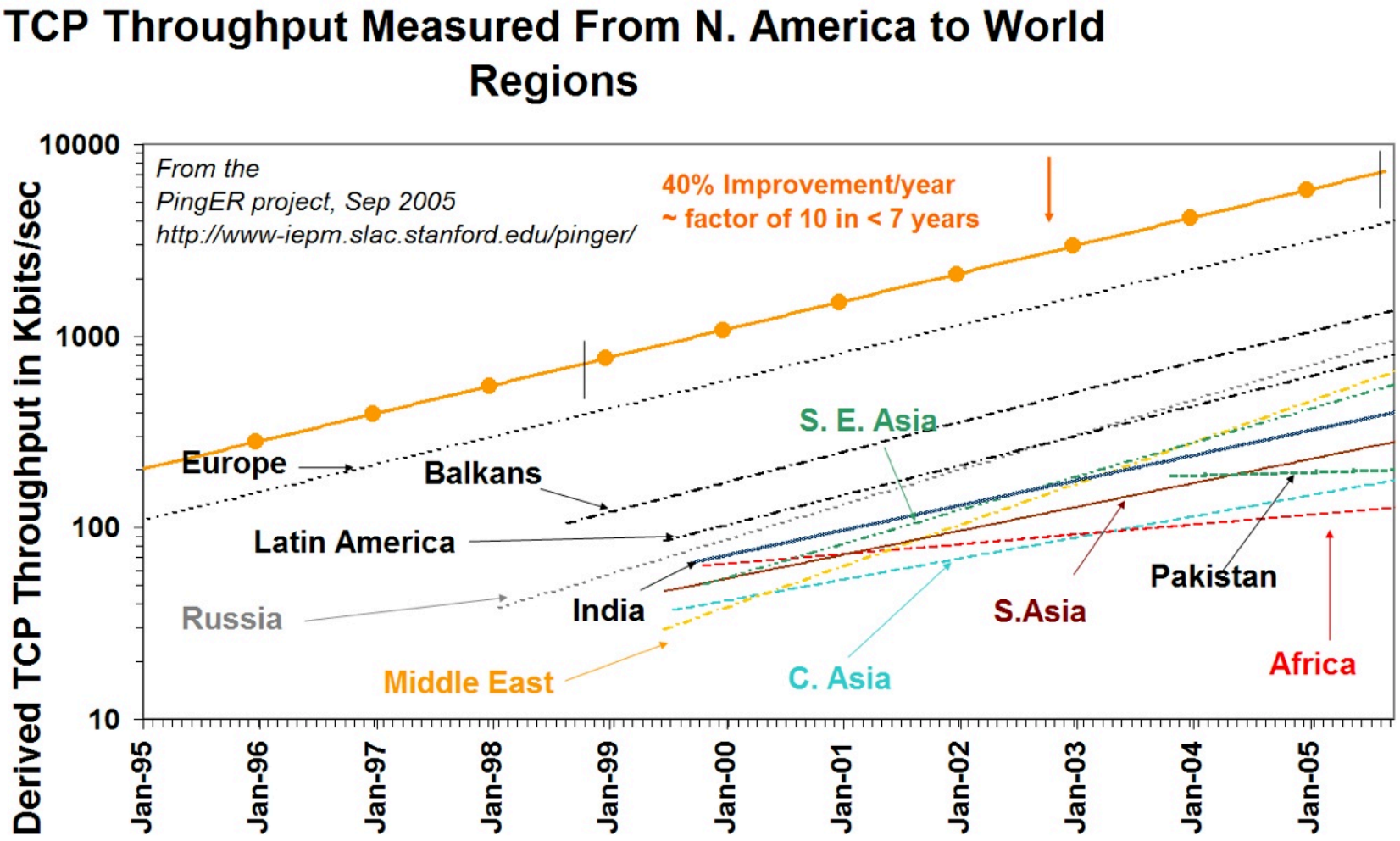


Figure 15: The internet speed as a function of time

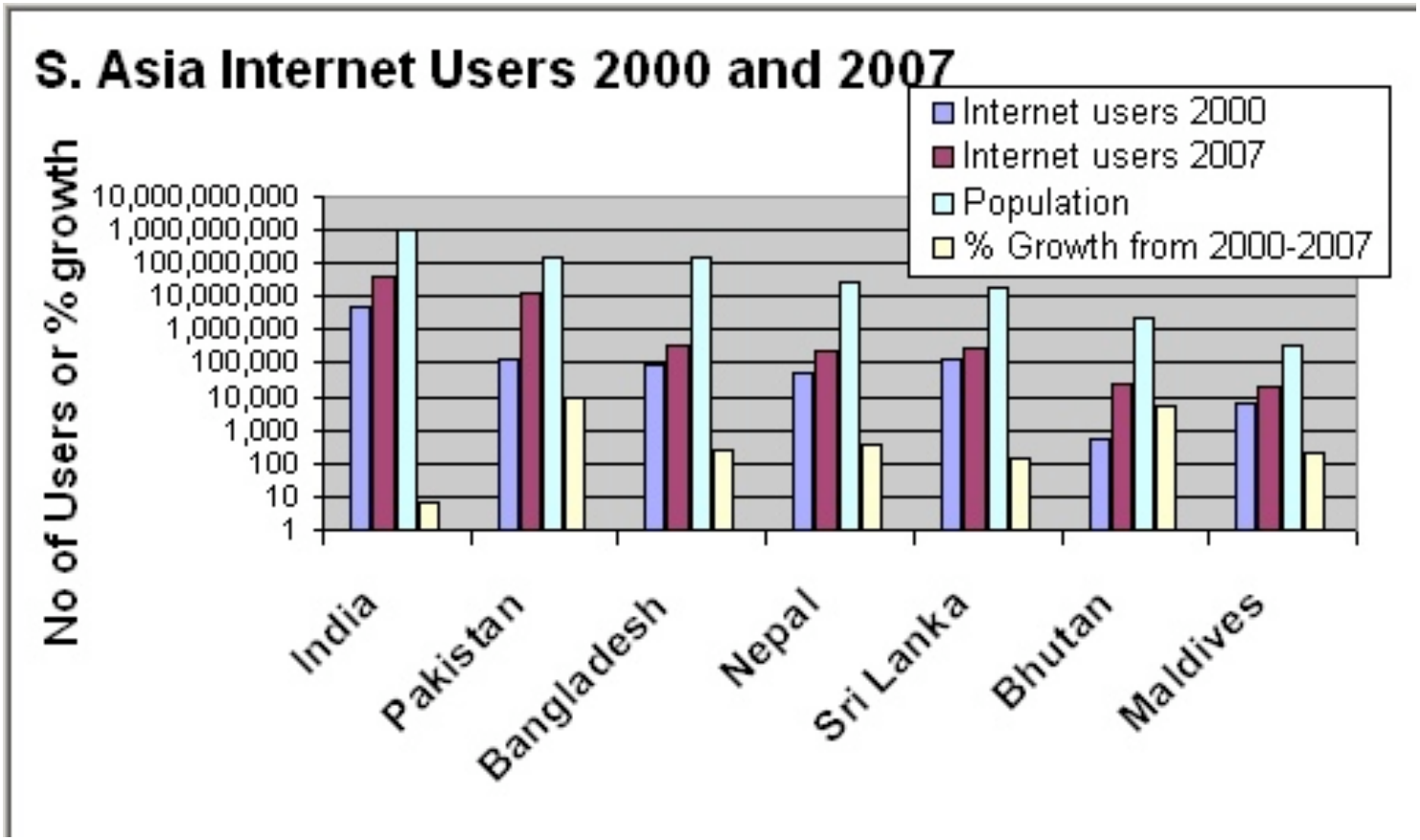

S. Asia Internet Users 2000 and 2007
Internet users 2000
Internet users 2007
Population
% Growth from 2000-2007
No of Users or % growth
10,000,000,000
1,000,000,000
100,000,000
10,000,000
1,000,000
100,000
10,000
1,000
100
10
1
India
Pakistan
Bangladesh
Nepal
Sri Lanka
Bhutan
Maldives

Figure 16

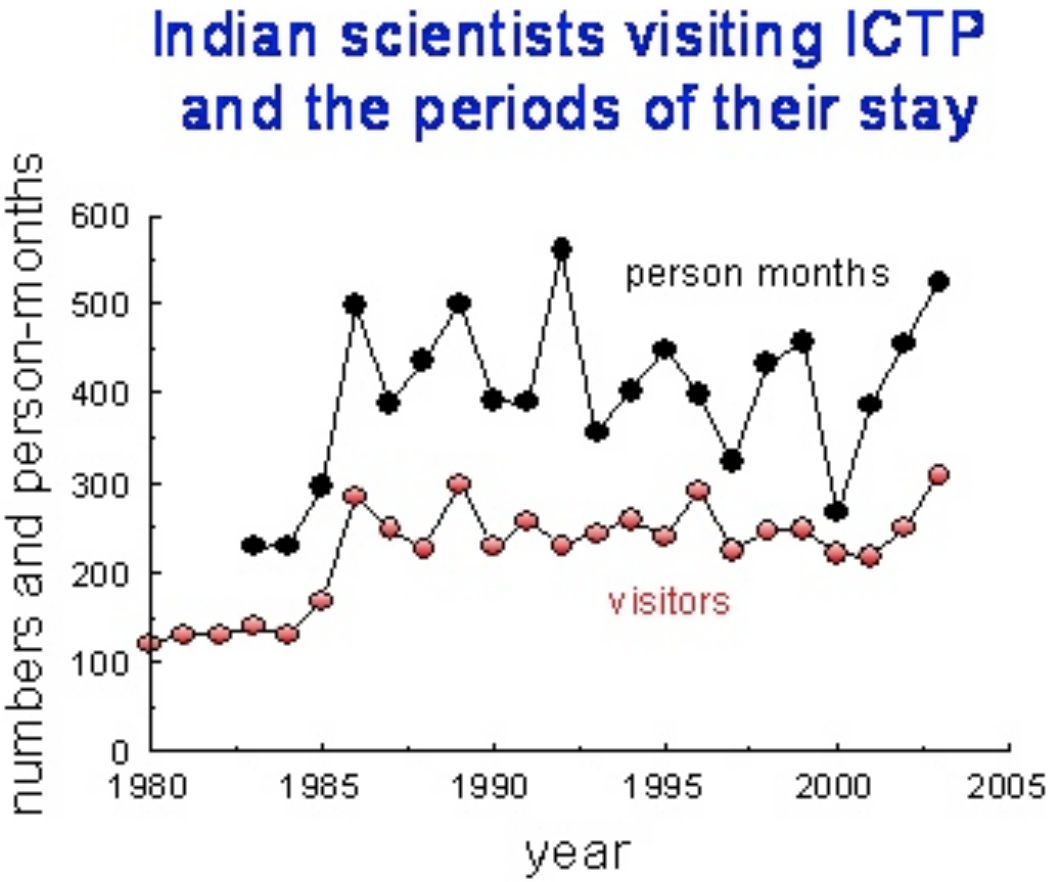

Indian scientists visiting ICTP
and the periods of their stay
numbers and person-months
600
500
400
300
200
100
0
1980
1985
1990
1995
2000
2005
year
person months
visitors

Figure 17

We plan to set up 30 universities and 6,000 model schools and are considering ways to establish a college in each of its 340 districts to improve the quality of education and add to the pool of skilled workforce.

Prime Minister Manmohan Singh

Figure 18

PRODUCTIVITY OF NATIONS BASED ON THEIR PUBLICATION RECORD

Country	No. of publications (1997–2001)	GDP per capita	Publications per GDP per capita	Publications per GDP per capita per year
India	77,201	487	158.52	31.7
China	115,339	989	116.62	23.32
United States	1,265,808	36,006	35.16	7.0
Brazil	43,971	2,593	16.96	3.39
Germany	318,286	24,051	13.23	2.64
United Kingdom	342,535	26,445	12.95	2.59
Japan	336,858	31,407	10.73	2.15
South Africa	18,123	2,299	7.88	1.58
Canada	166,216	22,777	7.30	1.46
Italy	147,023	20,528	7.16	1.43

Source: D. A. King, *Nature* 430, 311–316 (2004).

Figure 19

PRODUCTIVITY OF NATIONS BASED ON THEIR CITATION RECORD

Country per	No. o f citations (1997–2001)	GDP per capita	Citations per GDP per capita	Citations per GDP capita per year
India	188,481	487	387.02	77.40
China	341,519	989	345.32	69.06
United States	10,850,549	36,006	301.35	67.27
United Kingdom	2,500,035	26,445	94.54	18.91
Germany	2,199,617	24,051	91.46	18.29
Brazil	155,357	2,593	59.91	11.98
Japan	1,852,271	31,407	58.98	11.79
Canada	1,164,450	22,777	51.12	10.22
Italy	964,164	20,528	46.97	9.39
Australia	623,636	20,822	29.95	5.99

Source: D. A. King, *Nature* 430, 311–316 (2004).

Figure 20

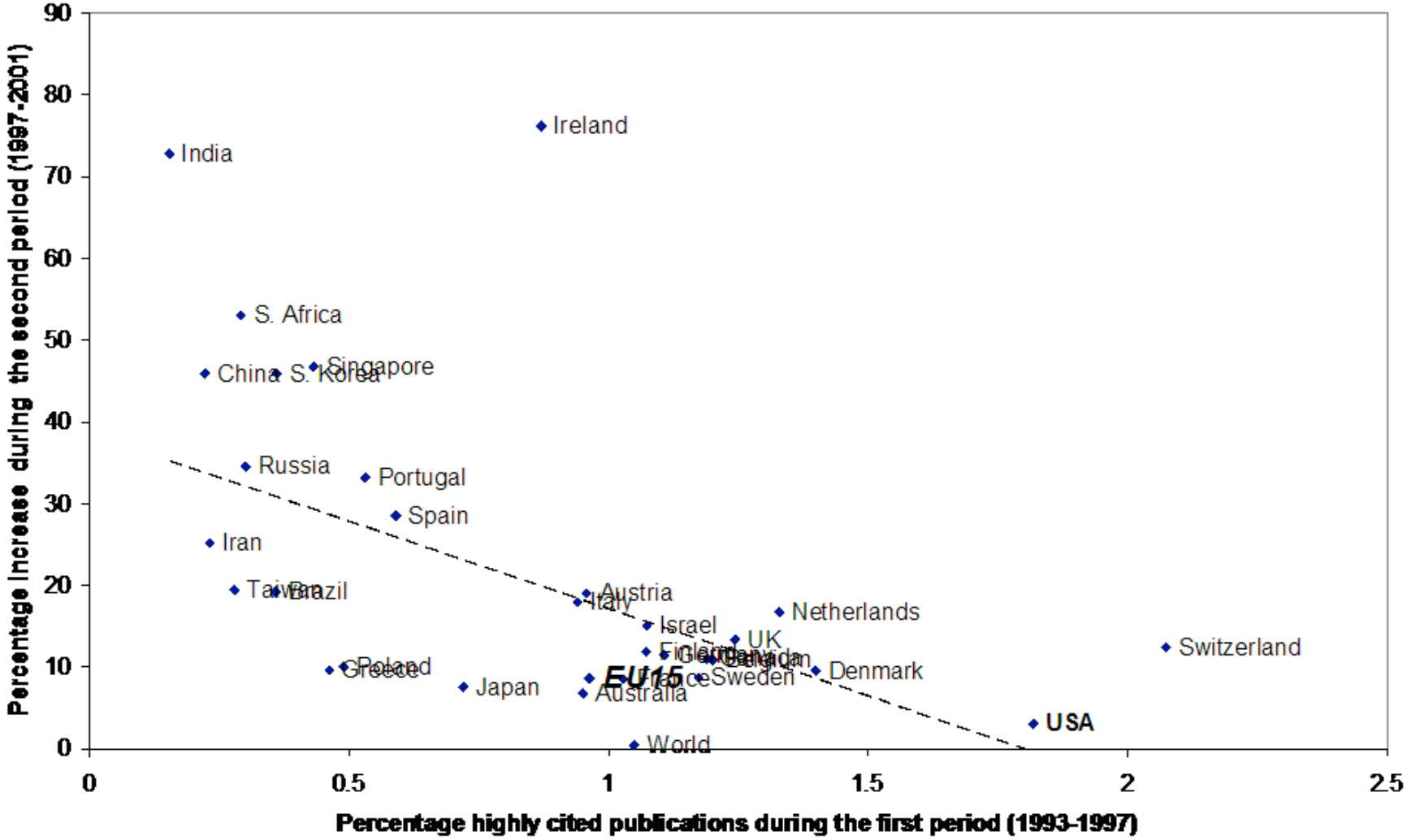

Percentage increase during the second period (1997-2001)
Percentage highly cited publications during the first period (1993-1997)
0
10
20
30
40
50
60
70
80
90
0
0.5
1
1.5
2
2.5
India
Ireland
S. Africa
China
S. Korea
Singapore
Russia
Portugal
Spain
Iran
Taiwan
Brazil
Austria
Italy
Netherlands
Israel
UK
Switzerland
Poland
Greece
Japan
EU15
Sweden
Denmark
Australia
USA
World

Figure 21

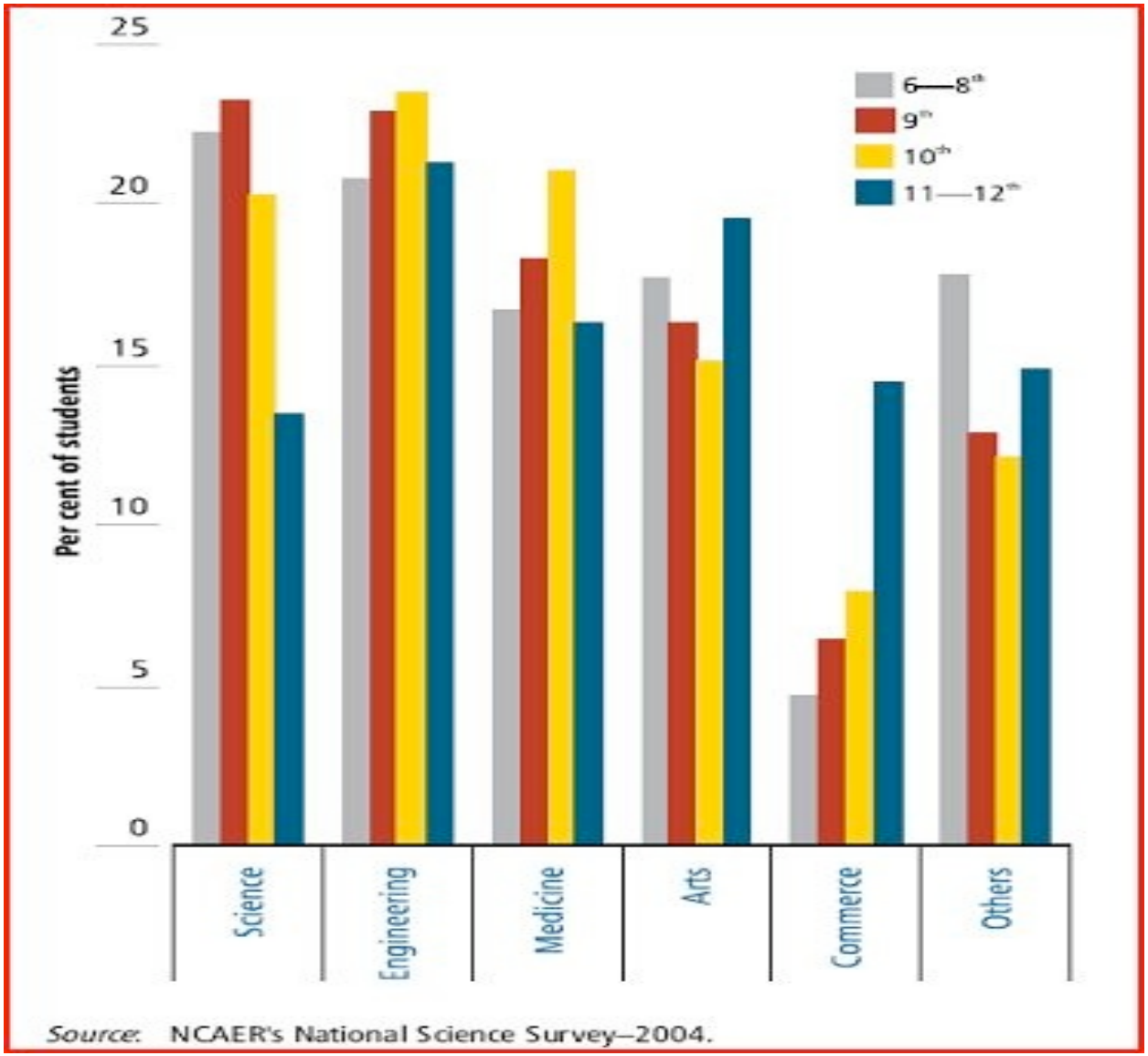


Table 1: Preferred subject for higher education by level of students 2004

Figure 22

Reasons	% of science students (Class 11 & 12)
Interested in science subjects	66.6
Better job opportunities	20.4
Parents' desire	3.3
Interested in doing research in science	1.8
Influenced by the work of scientists	1.3
Quality of science teachers is very good	0.8
Influence of peer group	0.7
Intend to go abroad	0.2
Others	4.8

Source: NCAER's National Science Survey–2004.

Reasons	% of non-science students (Class 11 & 12)
Not interested in science subjects	44.5
Difficult subject	20.4
Higher studies are costly	9.9
Interested in commerce	5.4
Like arts subjects	4.8
No future opportunities	2.1
No science college nearby	2.0
Difficult to get through competitive examination	1.1
Poor quality of teaching at school	1.1
Others	8.9

Source: NCAER's National Science Survey–2004.

Reasons for taking admission in science

Reasons for not taking admission in science

Figure 23

Fields of study	Enrolments (million)			Percentage distribution			Annual growth (%)	
	UGC* 1995–96	UGC 2000–01	NCAER** 2003–04	UGC 1995–96	UGC 2000–01	NCAER 2003–04	1995–2000	2000–2003
Science	1.91	2.62	3.29	28.8	31.1	34.6	6.5	7.9
Natural science	1.26	1.69	1.78	18.9	20.1	18.7	6.1	1.6
Engineering	0.40	0.59	1.07	6.0	7.0	11.2	8.2	21.9
Medicine	0.20	0.27	0.36	3.0	3.2	3.7	5.8	10.1
Agriculture/Veterinary	0.06	0.07	0.09	0.9	0.9	1.0	4.7	7.9
Arts	3.18	3.88	4.65	47.9	45.9	49.0	4.0	6.2
Commerce	1.13	1.51	1.20	16.9	17.8	12.6	6.0	-7.3
Others	0.43	0.44	0.36	6.4	5.2	3.8	0.5	-6.5
Total	6.65	8.44	9.49	100.0	100.0	100.0	4.9	4.0

Source: * University development in India, basic facts & figures (1995–96 to 2000–01), University Grants Commission, Government of India.
** NCAER's National Science Survey–2004.

Gross Enrolment in Higher Education (Graduate +)

Figure 24

TABLE 4. Top 10 countries/economies of citizenship of non-U.S. citizens earning science and engineering doctorates at U.S. institutions: 2006

Country/economy	Doctorate recipients
Top 10	9,048
China[a]	4,323
India	1,524
Korea	1,219
Taiwan	431
Canada	363
Turkey	357
Russia	223
Japan	222
Thailand	199
Romania	187
All others[b]	6,899

[a]Includes Hong Kong.

[b]Includes non-U.S. citizens of unknown country/economy of citizenship.

NOTE: Non-U.S. citizens include individuals holding permanent or temporary U.S. visas.

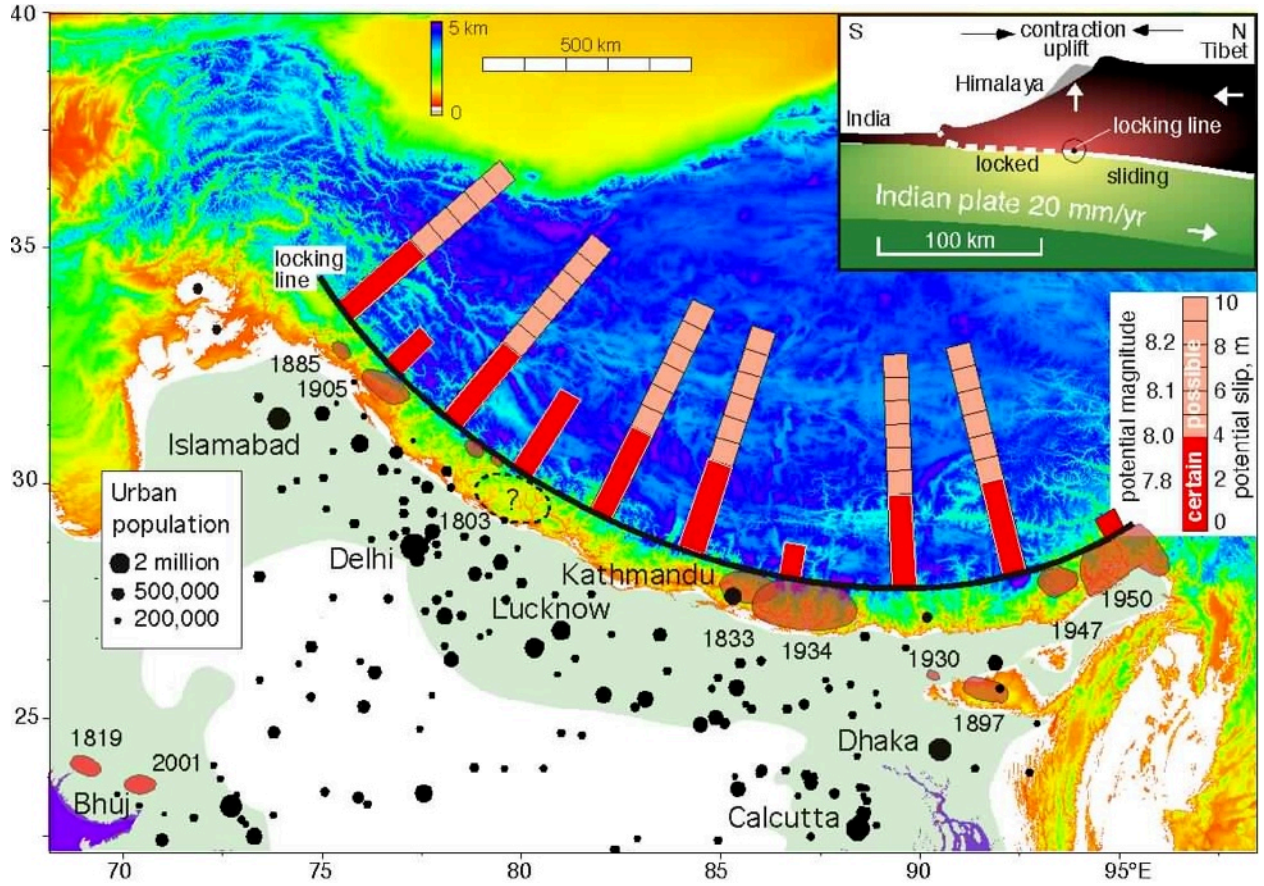
SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Earned Doctorates.

Figure 25

Some issues of sustainability

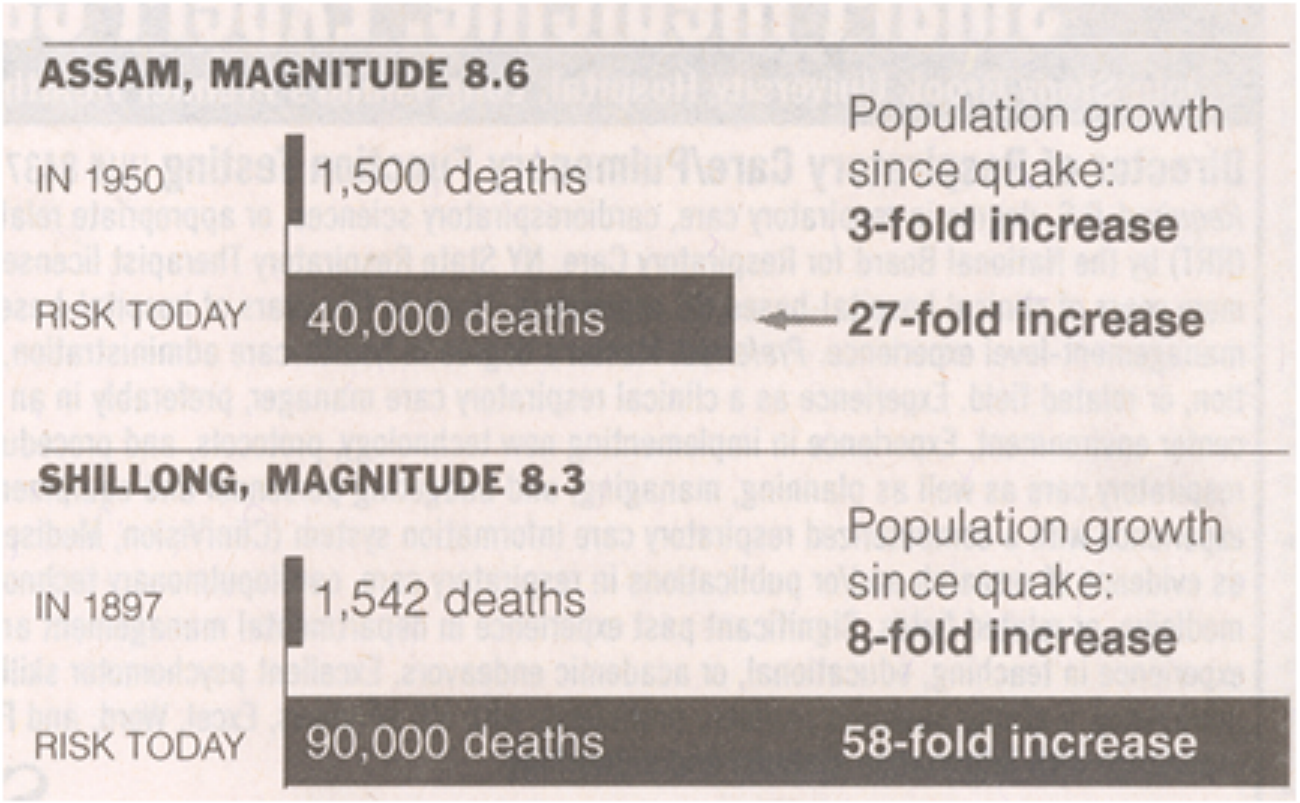
- **Climate changes**
- Greenhouse gases emission
- Population concentration, urban development and transportation
- Diminishing biodiversity
- Pollution and degrading environment
- Related health issues
- Relation between environment, ecology and economics
- **Energy needs and renewable alternatives**
- Waste and recycling
- Land and **water resources**
- **Modeling and prediction of disasters, and disaster preparedness**
- **Conservation of resources on land and in oceans**

Figure 26



Estimated slip potential along the Himalaya and urban populations south of the Himalaya (U.N. sources). Shaded areas with dates next to them surround epicenters and zones of rupture of major earthquakes in the Himalaya and the Kachchh region. Red segments along the bars show the potential slip that has accumulated since the last recorded great earthquake, or since 1800. The pink portions show possible additional slip permitted by ignorance of the preceding historic record. The bars are simply spaced at equal 220-km intervals, the approximate rupture length of the 1950 earthquakes. Black circles show population centers in the region.

Figure 27



New York Times: Jan 2, 2005

Figure 28

TABLE 2. International coauthorship of S&E articles of Brazil, China, India, Russia, and Taiwan, by region and country: 1996 and 2003

(Percent)

	Brazil		China		India		Russia		Taiwan	
Region/country	1996	2003	1996	2003	1996	2003	1996	2003	1996	2003
Internationally coauthored S&E articles (number)	2,090	3,794	3,341	9,132	1,719	3,187	5,827	8,363	1,103	2,178
Coauthorship share										
United States	35.7	33.2	32.8	33.1	34.9	28.2	19.5	18.5	65.6	44.8
European Union	41.7	40.4	31.9	27.1	39.3	36.4	58.8	58.3	11.4	13.4
Asia-10	3.9	5.1	19.9	24.8	9.1	20.0	5.0	9.7	15.3	31.4
Latin America	8.0	10.1	0.9	0.9	1.7	2.2	1.6	1.8	0.6	0.6
Former USSR	2.6	2.4	1.2	1.3	3.0	3.1	6.4	4.0	1.1	3.1
Other	8.1	8.8	13.3	12.9	12.0	10.1	8.7	7.8	6.0	6.7

NOTES: Internationally coauthored articles have at least one collaborating institution from outside of indicated country/economy. Coauthorship share is a region's/country's/economy's fractional share of indicated country's/economy's international S&E articles. Asia-10 consists of China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCES: Thomson ISI, Science Citation Index and Social Sciences Citation Index; http://www.isinet.com/products/citation/; ipIQ, Inc., and National Science Foundation, Division of Science Resources Statistics, special tabulations.

Figure 29

TABLE 3. Intraregional coauthorship share of internationally coauthored S&E articles of China, India, and Taiwan, by country: 1996 and 2003

	China			India			Taiwan		
	Collaborating	Percent share		Collaborating	Percent share		Collaborating	Percent share	
Rank	country/economy	1996	2003	country/economy	1996	2003	country/economy	1996	2003
1	Japan	13.0	14.4	Japan	6.1	10.2	Japan	7.3	11.7
2	Singapore	1.6	3.3	South Korea	0.3	2.7	China	5.0	11.0
3	South Korea	1.6	2.8	China	1.2	2.5	India	0.3	3.2
4	Taiwan	1.9	2.7	Taiwan	0.1	2.3	South Korea	0.7	2.6
5	India	0.5	0.8	Malaysia	0.5	0.9	Singapore	1.4	2.2
	Share of Asia-10	19.9	24.8	Share of Asia-10	9.1	20.0	Share of Asia-10	15.3	31.4
Internationally coauthored S&E articles (number)		3,341	9,132		1,719	3,187		1,103	2,178

NOTES: Internationally coauthored articles have at least one collaborating institution from outside of indicated country/economy. Coauthorship share is a region's/country's/economy's fractional share of indicated country's/economy's international S&E articles. Asia-10 consists of China, India, Indonesia, Japan, Malaysia, Philippines, Singapore, South Korea, Taiwan, and Thailand. China includes Hong Kong.

SOURCES: Thomson ISI, Science Citation Index and Social Sciences Citation Index; http://www.isinet.com/products/citation/; ipIQ, Inc., and National Science Foundation, Division of Science Resources Statistics, special tabulations.

Figure 30

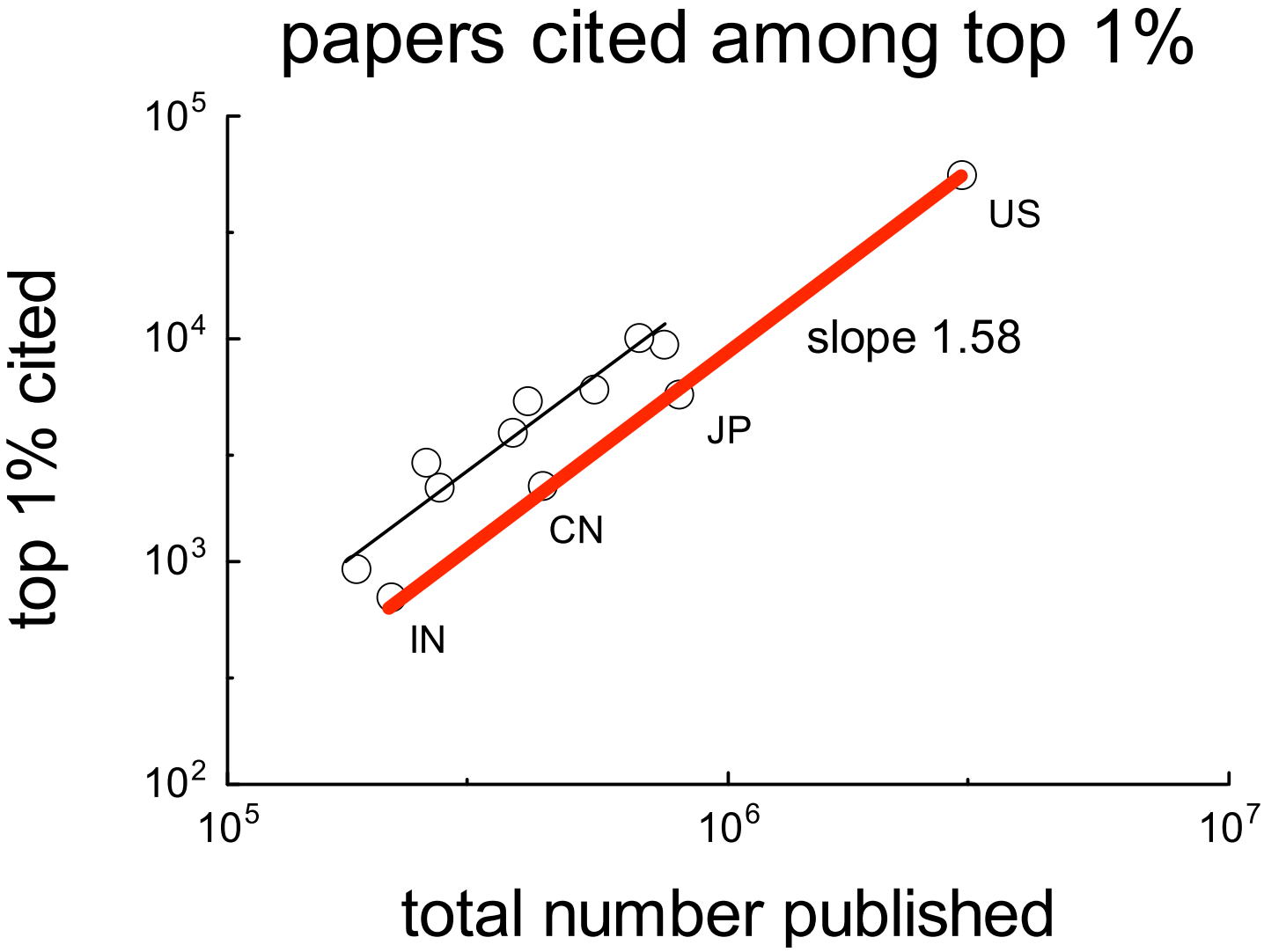

papers cited among top 1%
top 1% cited
total number published
10^5
10^4
10^3
10^2
10^5
10^6
10^7
US
slope 1.58
JP
CN
IN

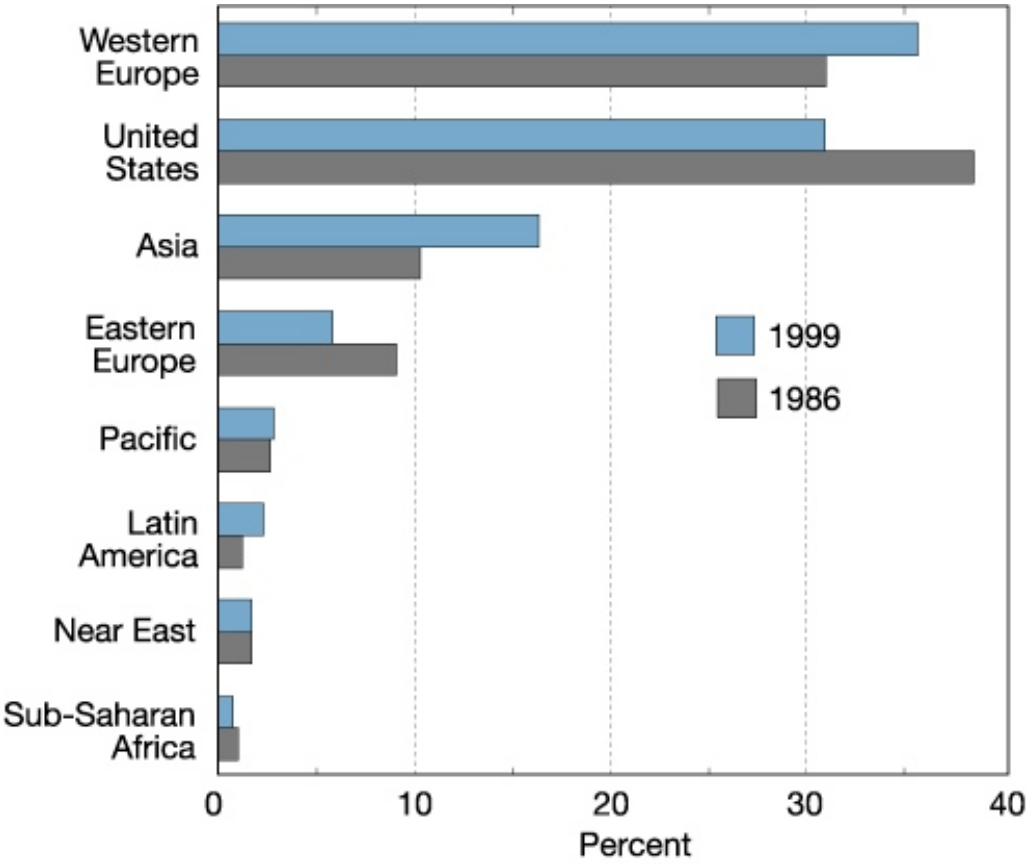
Figure 31

The end

Science of sustainability

Scientific publications: regional share of world output

37%
34%
16%
5%
2%
5%



2006 (rough)

NSF 2002

TABLE 1. International S&E article collaboration of Brazil, China, India, Russia, and Taiwan: Selected years, 1993–2003

Country/economy	1993	1995	1997	1999	2001	2003
Brazil						
Total S&E articles	3,708	4,550	5,653	7,552	9,078	10,779
Internationally coauthored articles	1,459	1,906	2,301	2,898	3,369	3,794
Internationally coauthored as share of total (%)	39.3	41.9	40.7	38.4	37.1	35.2
China						
Total S&E articles	8,907	10,916	14,622	18,922	24,638	34,110
Internationally coauthored articles	2,395	2,966	3,784	5,026	6,703	9,132
Internationally coauthored as share of total (%)	26.9	27.2	25.9	26.6	27.2	26.8
India						
Total S&E articles	10,546	10,469	10,352	11,792	12,561	14,529
Internationally coauthored articles	1,414	1,591	1,660	2,166	2,685	3,187
Internationally coauthored as share of total (%)	13.4	15.2	16.0	18.4	21.4	21.9
Russia						
Total S&E articles	21,912	23,109	22,053	21,306	20,356	20,630
Internationally coauthored articles	4,035	5,515	6,506	7,281	7,774	8,363
Internationally coauthored as share of total (%)	18.4	23.9	29.5	34.2	38.2	40.5
Taiwan						
Total S&E articles	4,107	5,421	6,500	7,607	9,115	10,448
Internationally coauthored articles	754	1,038	1,154	1,419	1,897	2,178
Internationally coauthored as share of total (%)	18.4	19.1	17.8	18.7	20.8	20.8

NOTES: Internationally coauthored articles have at least one collaborating institution from outside of indicated country/economy. China includes Hong Kong.

SOURCES: Thomson ISI, Science Citation Index and Social Sciences Citation Index; http://www.isinet.com/products/citation/; ipIQ, Inc., and National Science Foundation, Division of Science Resources Statistics, special tabulations.

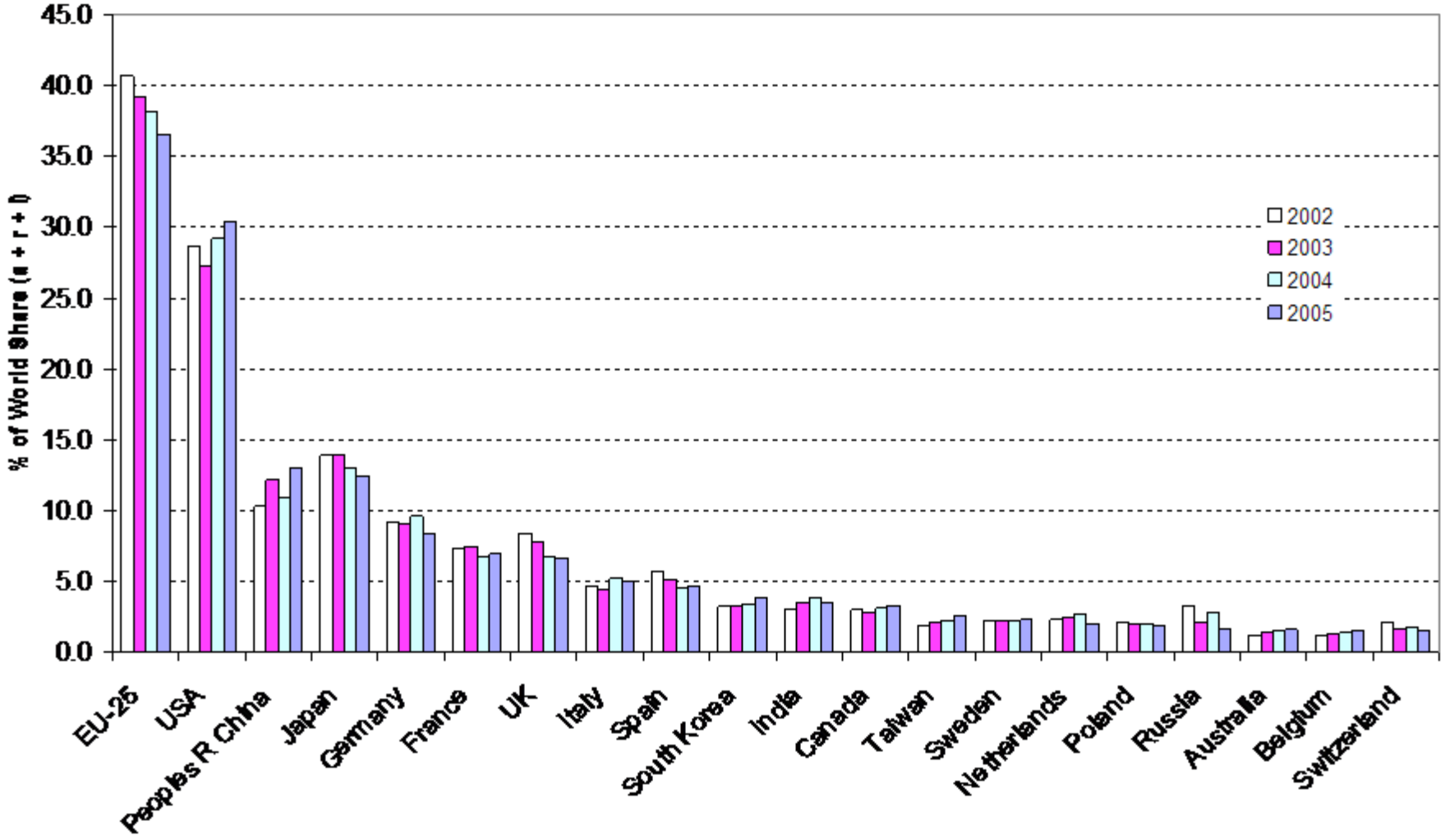

45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
% of World Share (e + r + i)
2002
2003
2004
2005
EU-25
USA
Peoples R China
Japan
Germany
France
UK
Italy
Spain
South Korea
India
Canada
Taiwan
Sweden
Netherlands
Poland
Russia
Australia
Belgium
Switzerland

Figure 3

Scientific papers published and GDP

United States	2,907,592	13,201,819
Japan	790,510	4,340,133
Germany	742,917	2,906,681
England	660,808	2,345,015
France	535,629	2,230,721
China	422,993	2,668,071
Canada	394,727	1,251,463
Italy	369,138	1,844,749
Spain	263,469	1,223,988
Australia	248,189	768,178
India	211,063	906,268
South Korea	180,329	888,024
Taiwan	124,940	

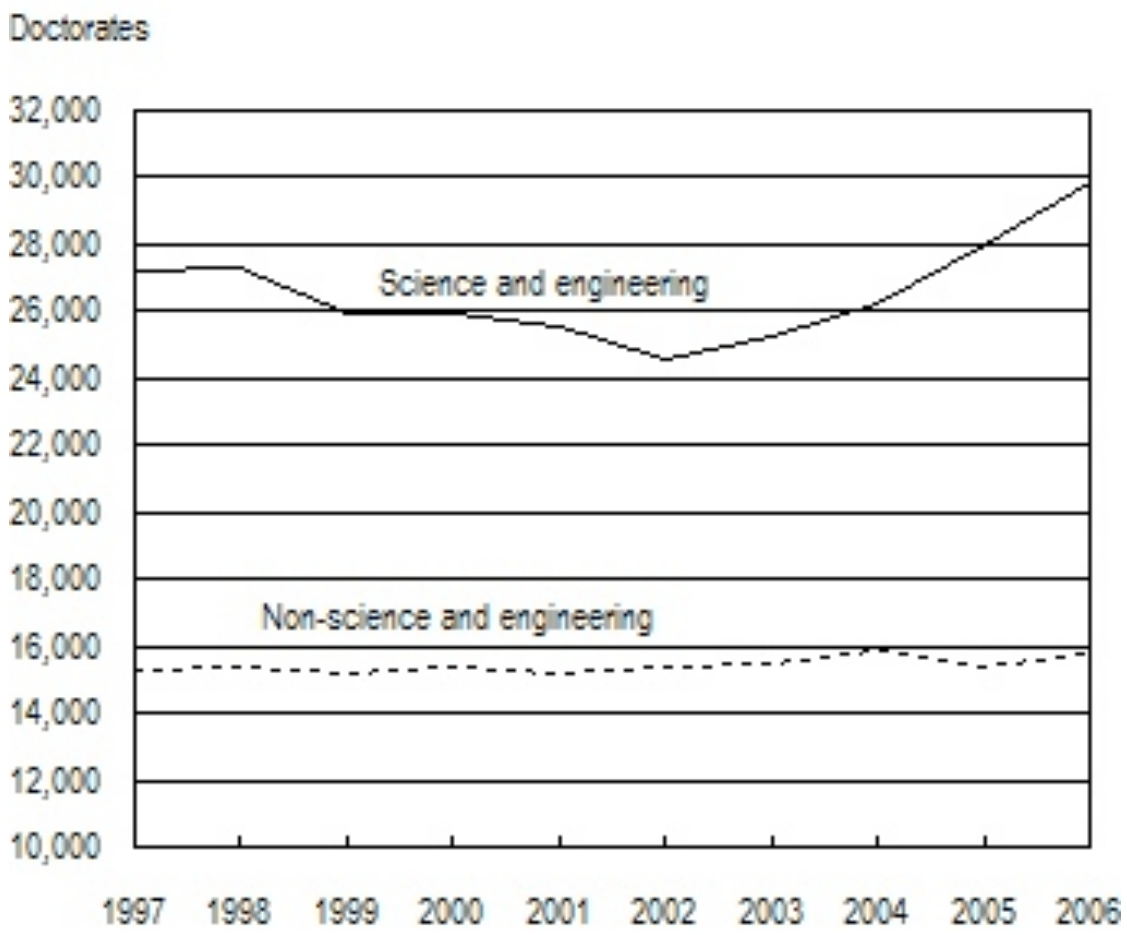
Total papers among top one per cent most cited in all fields

Country	Papers among top one per cent most cited
United States	54,516
England	10,090
Germany	9,427
France	5,967
Japan	5,662
Canada	5,301
Italy	3,825
Australia	2,804
China	2,189
Spain	2,155
South Korea	929
India	694
Taiwan	550

Switzerland	1.19
USA	1.01
Germany	0.82
UK	0.80
France	0.76
Israel	0.74
Italy	0.71
Australia	0.67
Chile	0.50

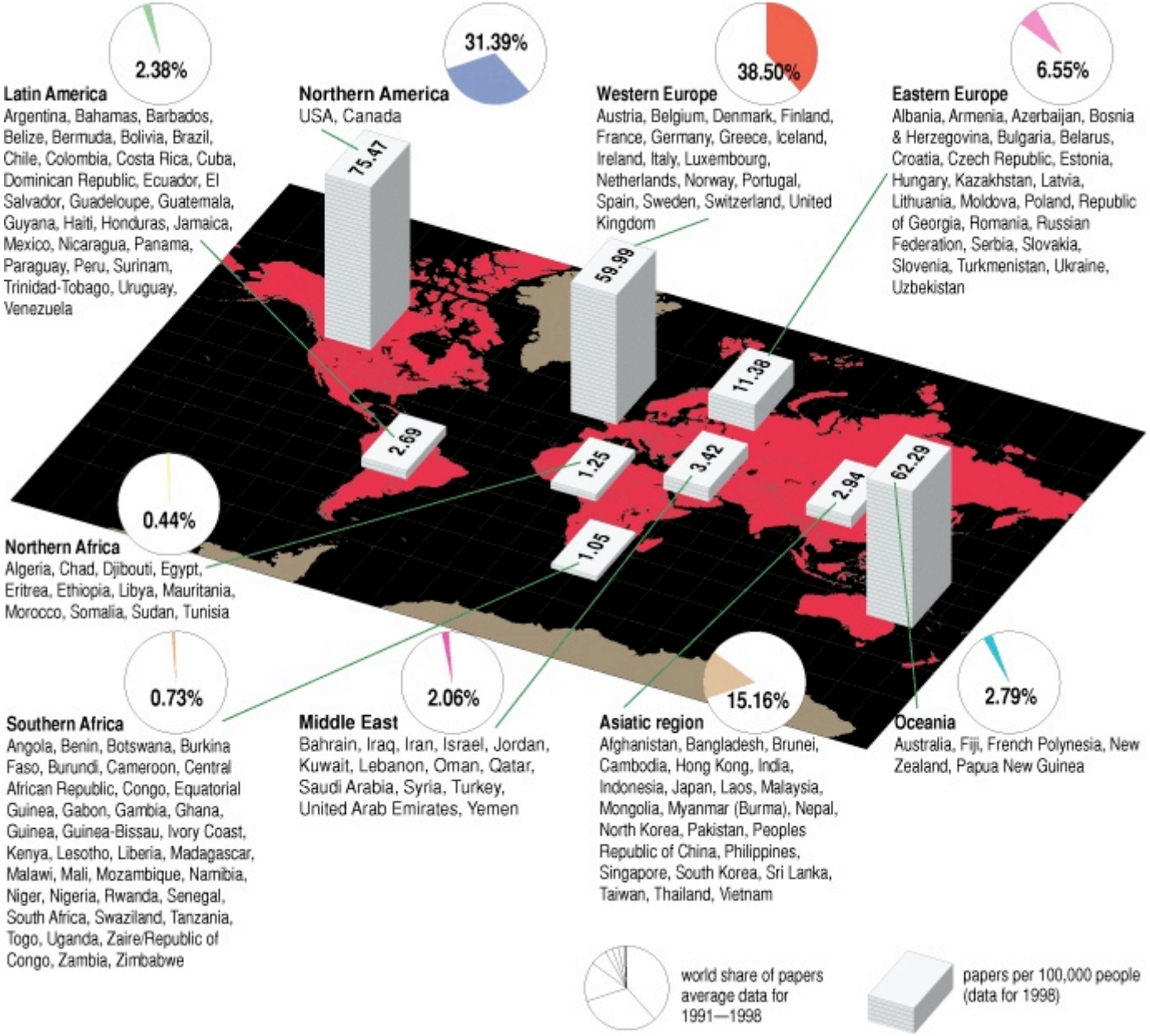
Share of citations/share of publications

FIGURE 1. Doctorates awarded in science and engineering and non-science and engineering fields: 1997–2006



NOTE: See table 1 for fields of study included.

SOURCE: National Science Foundation/Division of Science Resources Statistics, Survey of Earned Doctorates, 2006.


2.38%
Latin America
Argentina, Bahamas, Barbados, Belize, Bermuda, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Surinam, Trinidad-Tobago, Uruguay, Venezuela
31.39%
Northern America
USA, Canada
75.47
38.50%
Western Europe
Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom
59.99
6.55%
Eastern Europe
Albania, Armenia, Azerbaijan, Bosnia & Herzegovina, Bulgaria, Belarus, Croatia, Czech Republic, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Moldova, Poland, Republic of Georgia, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Turkmenistan, Ukraine, Uzbekistan
11.36
2.69
1.25
3.42
2.94
62.29
1.05
0.44%
Northern Africa
Algeria, Chad, Djibouti, Egypt, Eritrea, Ethiopia, Libya, Mauritania, Morocco, Somalia, Sudan, Tunisia
0.73%
Southern Africa
Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Congo, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Swaziland, Tanzania, Togo, Uganda, Zaire/Republic of Congo, Zambia, Zimbabwe
2.06%
Middle East
Bahrain, Iraq, Iran, Israel, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syria, Turkey, United Arab Emirates, Yemen
15.16%
Asiatic region
Afghanistan, Bangladesh, Brunei, Cambodia, Hong Kong, India, Indonesia, Japan, Laos, Malaysia, Mongolia, Myanmar (Burma), Nepal, North Korea, Pakistan, Peoples Republic of China, Philippines, Singapore, South Korea, Sri Lanka, Taiwan, Thailand, Vietnam
2.79%
Oceania
Australia, Fiji, French Polynesia, New Zealand, Papua New Guinea
world share of papers
average data for
1991—1998
papers per 100,000 people
(data for 1998)

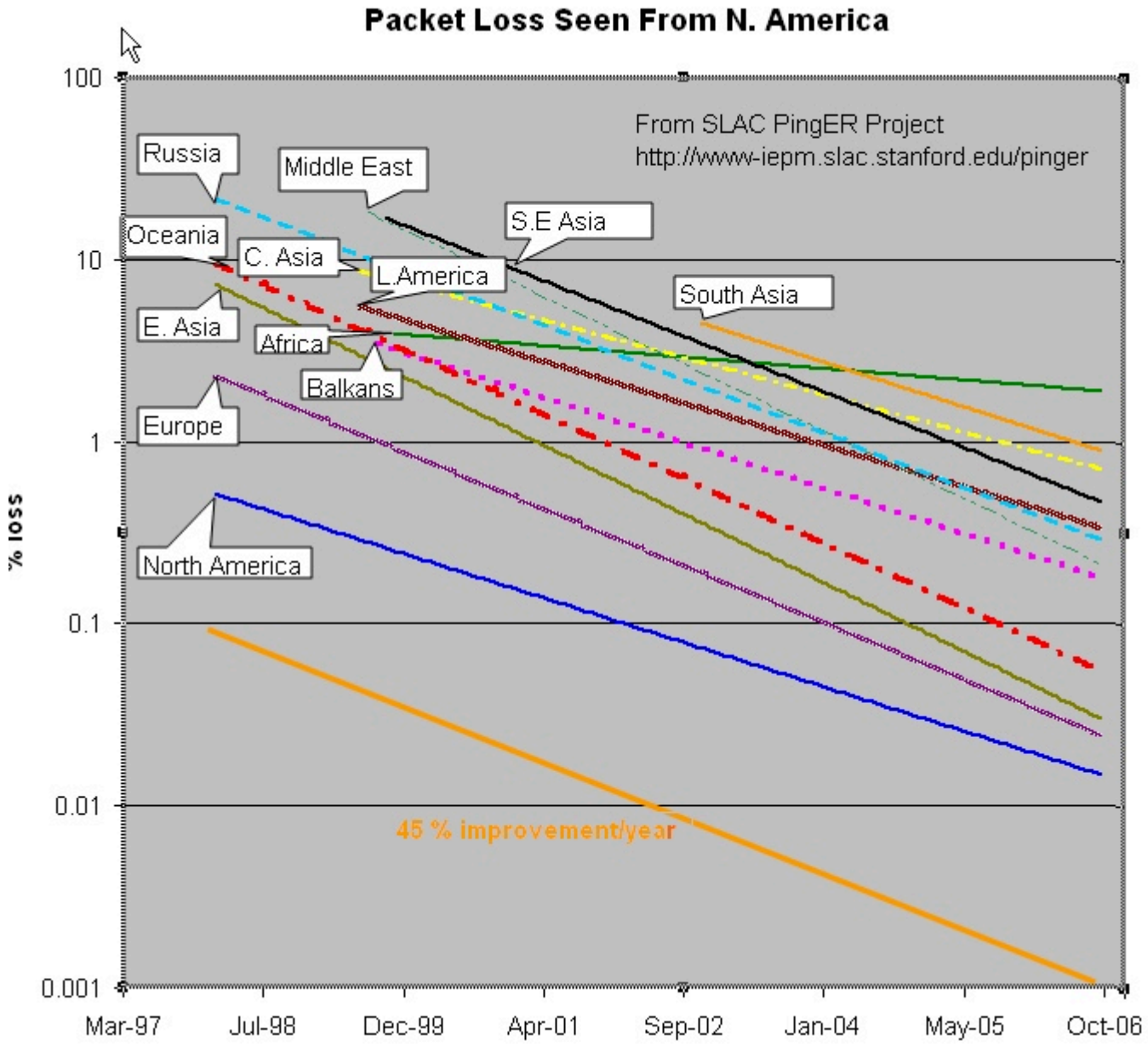
Scientists on the decline of Indian science

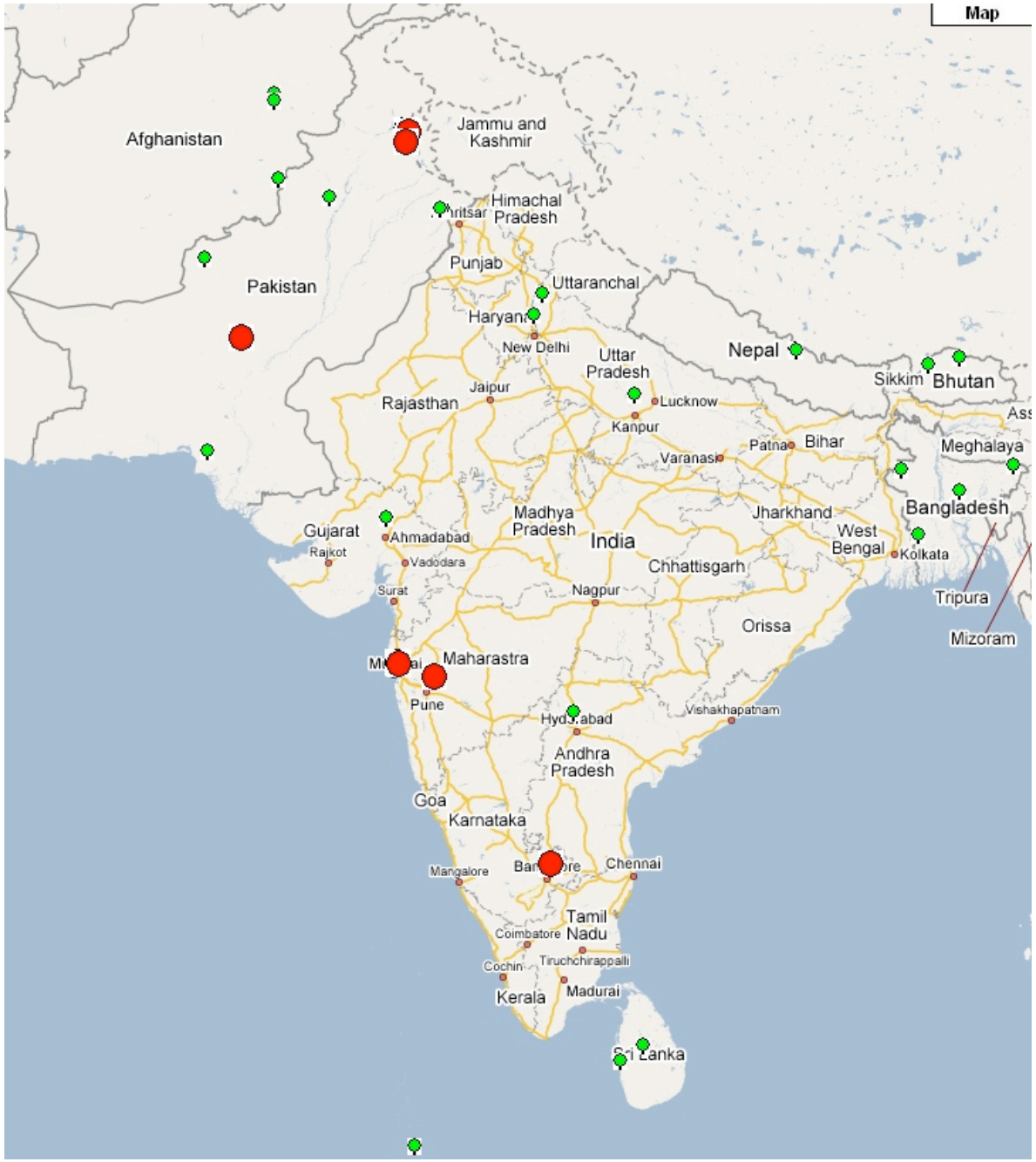
A. Arunachalam, Curr. Sci. 83, 107 (2002); 83, 353 (2002); 84, 259 (2003); 85, 1391 (2003); 86, 629 (2004); 86, 1197 (2004)

K. Satyanarayana & N.C. Jain, Curr. Sci. 85, 1391 (2003)

S.M. Dhawan & B.M. Gupta, Curr. Sci. 86, 1194 (2004)

G. Prathap, Curr. Sci. 86, 768 (2004)

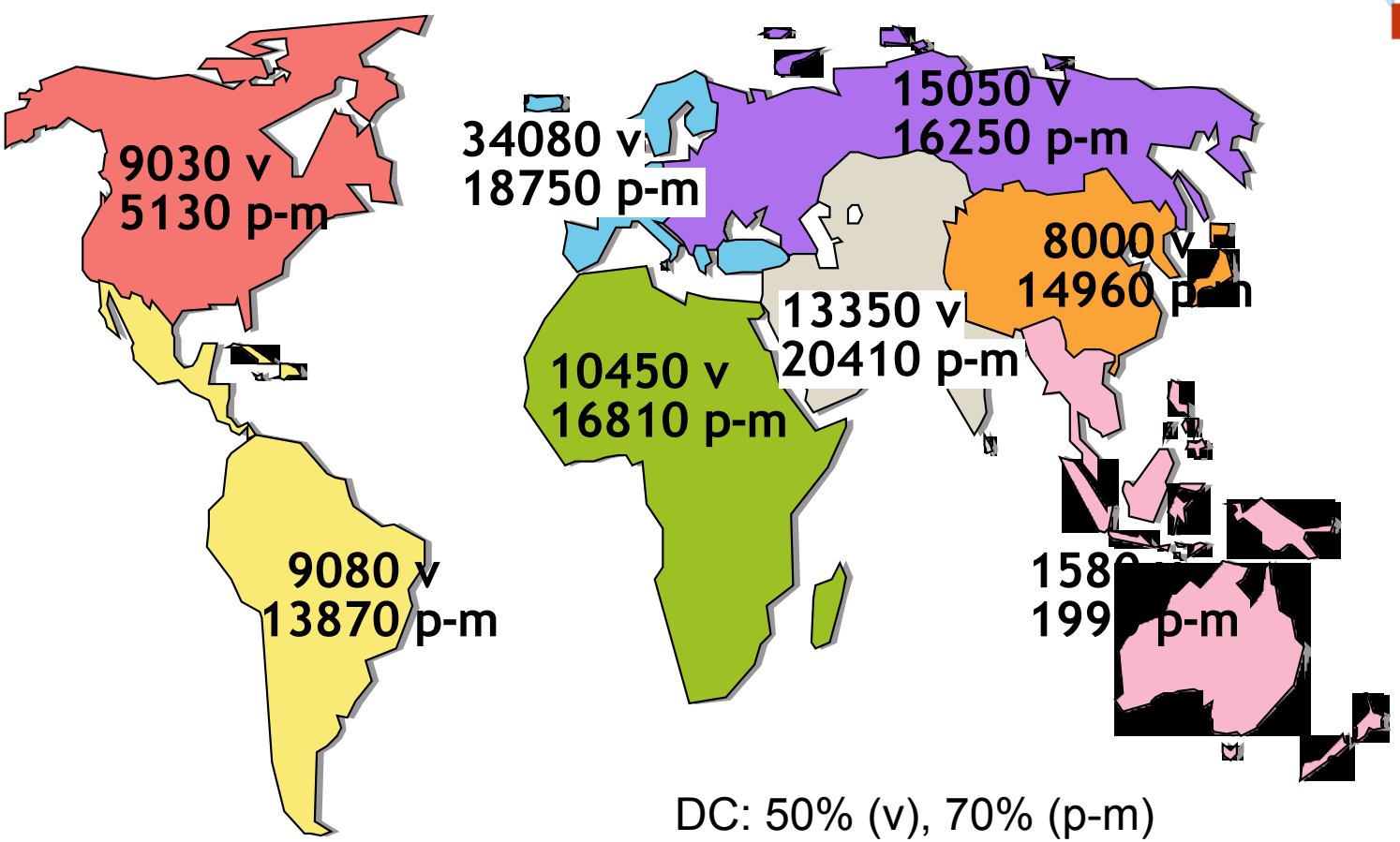

Packet Loss Seen From N. America
From SLAC PingER Project
http://www-iepm.slac.stanford.edu/pinger
% loss
100
10
1
0.1
0.01
0.001
Mar-97
Jul-98
Dec-99
Apr-01
Sep-02
Jan-04
May-05
Oct-06
Russia
Middle East
S.E Asia
Oceania
C. Asia
L.America
South Asia
E. Asia
Africa
Balkans
Europe
North America
45 % improvement/year


Map
Afghanistan
Jammu and Kashmir
Himachal Pradesh
Punjab
Pakistan
Uttaranchal
Haryana
New Delhi
Nepal
Uttar Pradesh
Sikkim
Bhutan
Jaipur
Rajasthan
Lucknow
Kanpur
Patna
Bihar
Meghalaya
Varanasi
Bangladesh
Jharkhand
Madhya Pradesh
India
West Bengal
Gujarat
Ahmadabad
Kolkata
Rajkot
Vadodara
Chhattisgarh
Surat
Nagpur
Tripura
Orissa
Mizoram
Maharastra
Pune
Vishakhapatnam
Andhra Pradesh
Goa
Karnataka
Mangalore
Chennai
Tamil Nadu
Coimbatore
Tiruchchirappalli
Cochin
Madurai
Kerala
Sri Lanka

One or more great earthquakes may be overdue in a large section of the Himalayan region. India and southern Tibet are moving towards each other by two meters a century. The strain is not deforming the rock much but is accumulating instead. Up to 50 million people could be at risk across Bangladesh, Bhutan, India, Nepal and Pakistan.

Five major earthquakes have struck India in the last decade but according to geologists the worst may be yet to come. Earthquakes of magnitudes between 8.1 and 8.3 may occur.

ICTP VISITORS STATISTICS, 1970-2006



DC: 50% (v), 70% (p-m)

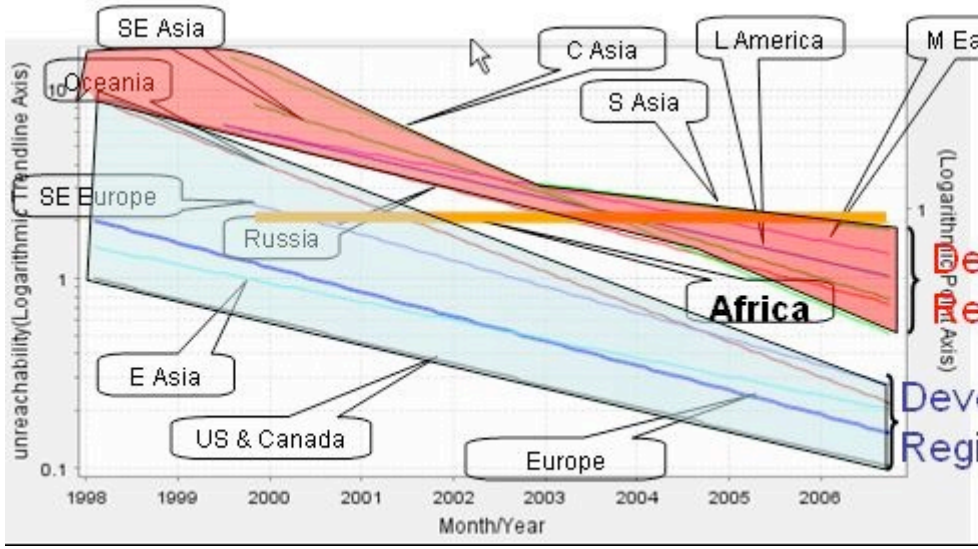
area	visitors	p-m
North America	9030	5130
Latin America	9080	13870
Western Europe	34080	18750
Eastern Europe	15050	16250

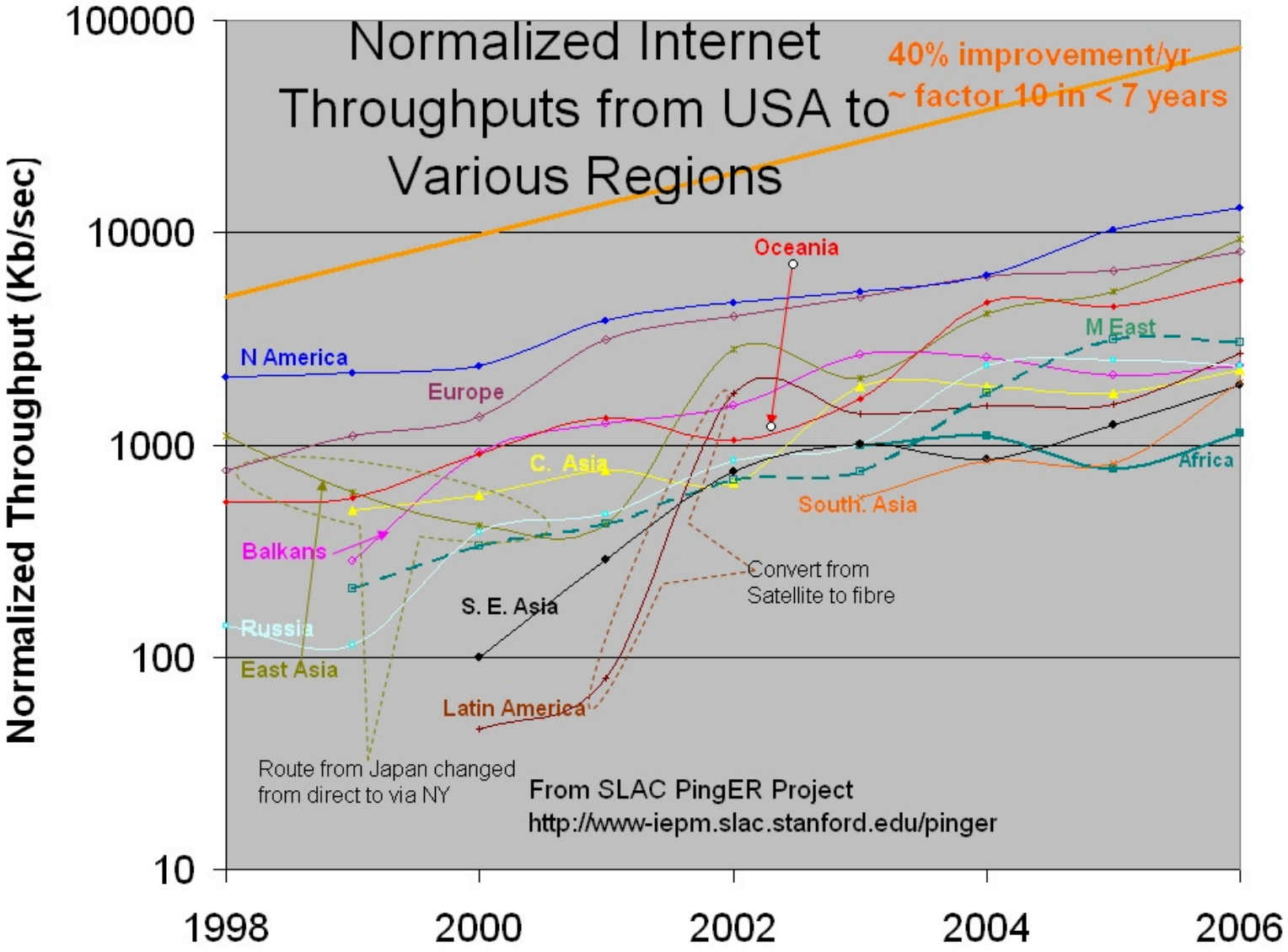
area	visitors	p-m
Africa	10450	16810
Middle East and South Asia	13350	20410
South East Asia and the Pacific	1580	1990
Far East	8000	14960

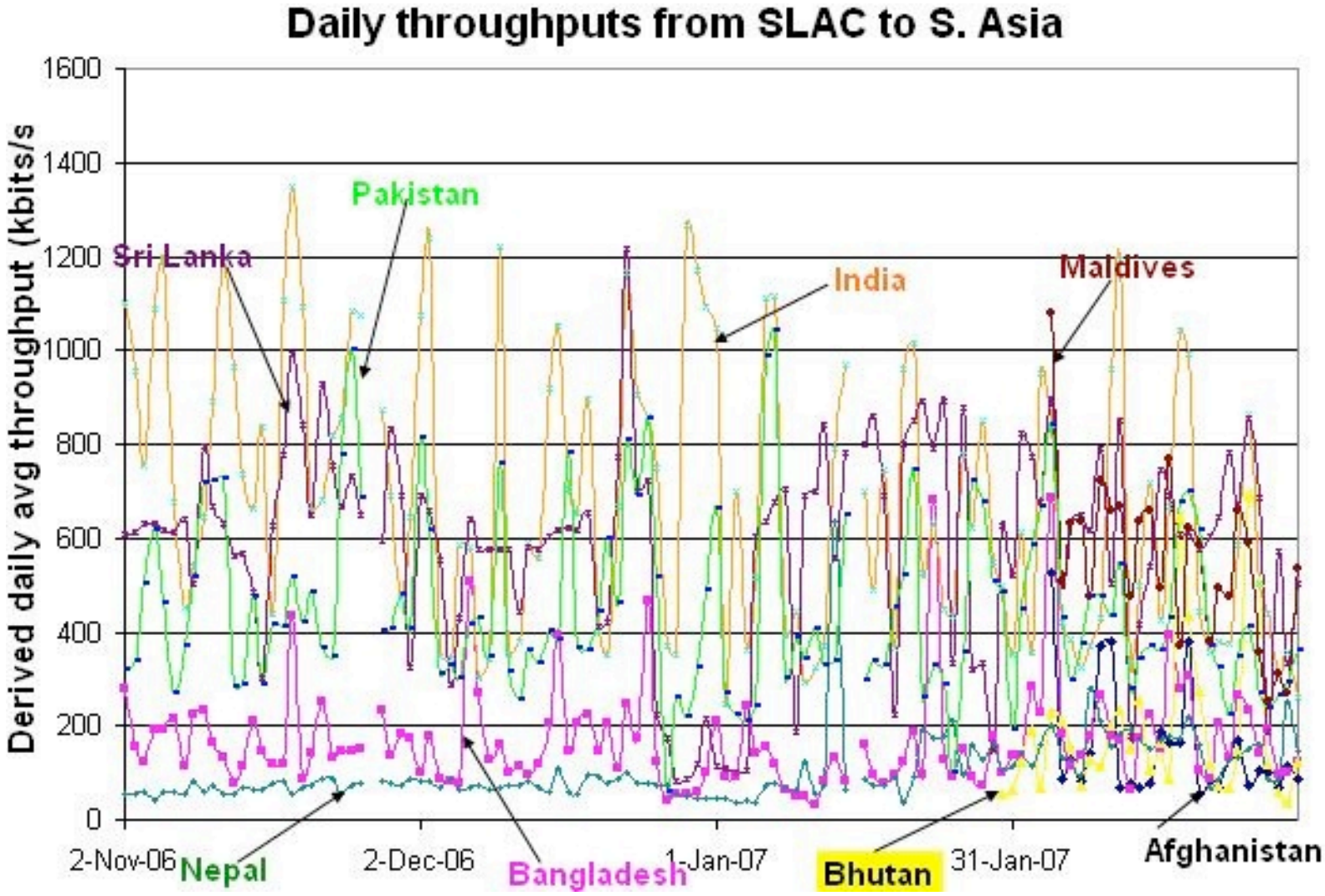
v=visitors p-m=person-months

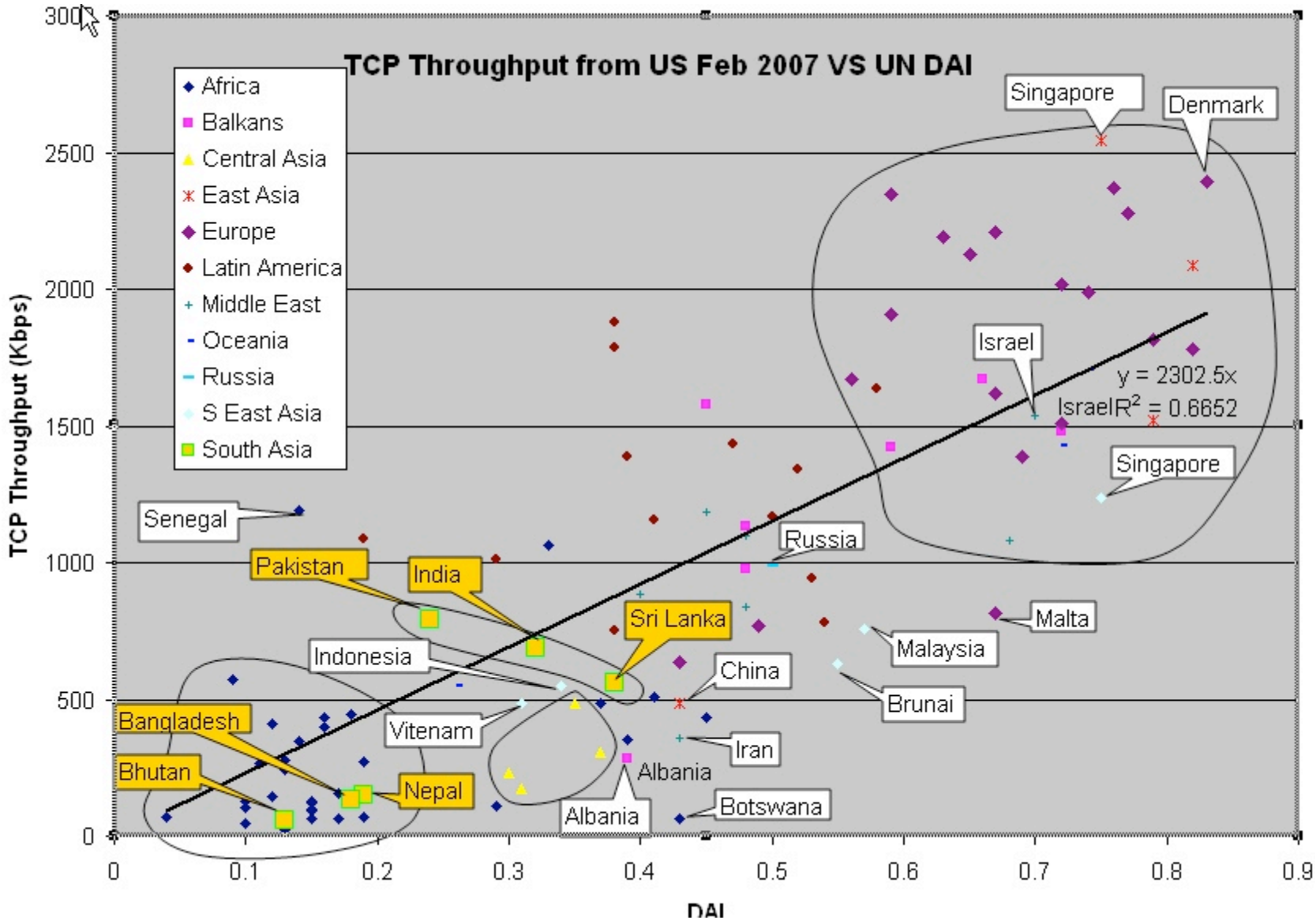
Unreachability

- All pings of a set fail ≡ unreachable
- Shows fragility, ~ distance independent
- Developed regions US, Canada, Europe, Oceania, E Asia lead
  - Factor of 10 improvement in 8 years
- Africa, S. Asia followed by M East & L. America worst off




Normalized Internet Throughputs from USA to Various Regions
40% improvement/yr
~ factor 10 in < 7 years
Normalized Throughput (Kb/sec)
100000
10000
1000
100
10
1998
2000
2002
2004
2006
N America
Europe
Oceania
M East
Africa
South. Asia
C. Asia
Balkans
Russia
East Asia
S. E. Asia
Latin America
Convert from Satellite to fibre
Route from Japan changed from direct to via NY
From SLAC PingER Project
http://www-iepm.slac.stanford.edu/pinger


Daily throughputs from SLAC to S. Asia
Derived daily avg throughput (kbits/s
1600
1400
1200
1000
800
600
400
200
0
2-Nov-06
2-Dec-06
1-Jan-07
31-Jan-07
Pakistan
Sri Lanka
India
Maldives
Nepal
Bangladesh
Bhutan
Afghanistan


TCP Throughput from US Feb 2007 VS UN DAI
TCP Throughput (Kbps)
DAI
Africa
Balkans
Central Asia
East Asia
Europe
Latin America
Middle East
Oceania
Russia
S East Asia
South Asia
y = 2302.5x
IsraelR² = 0.6652
Singapore
Denmark
Israel
Singapore
Senegal
Russia
Pakistan
India
Sri Lanka
Malta
Malaysia
Indonesia
China
Brunai
Bangladesh
Vitenam
Iran
Bhutan
Albania
Nepal
Albania
Botswana
0
500
1000
1500
2000
2500
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

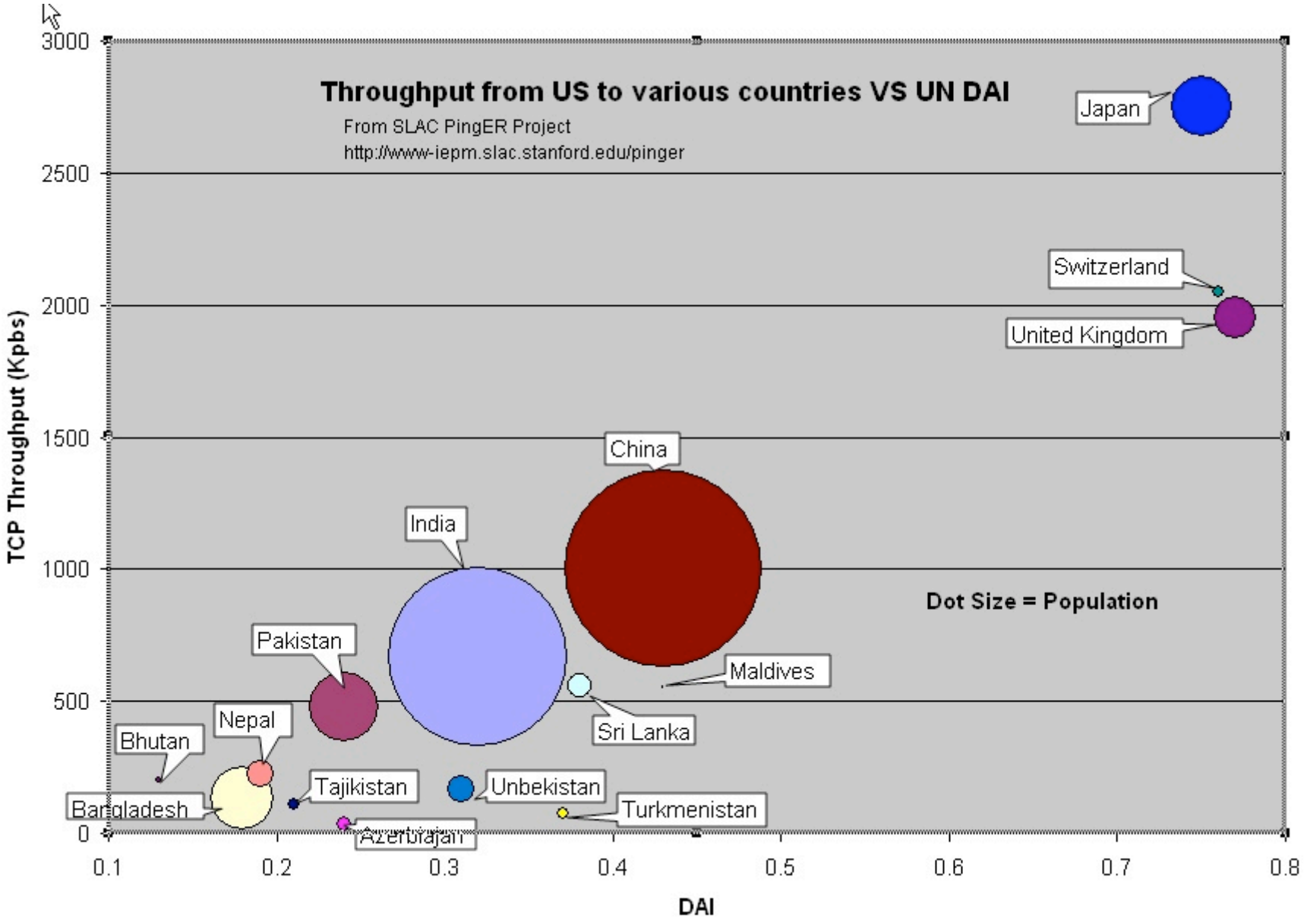
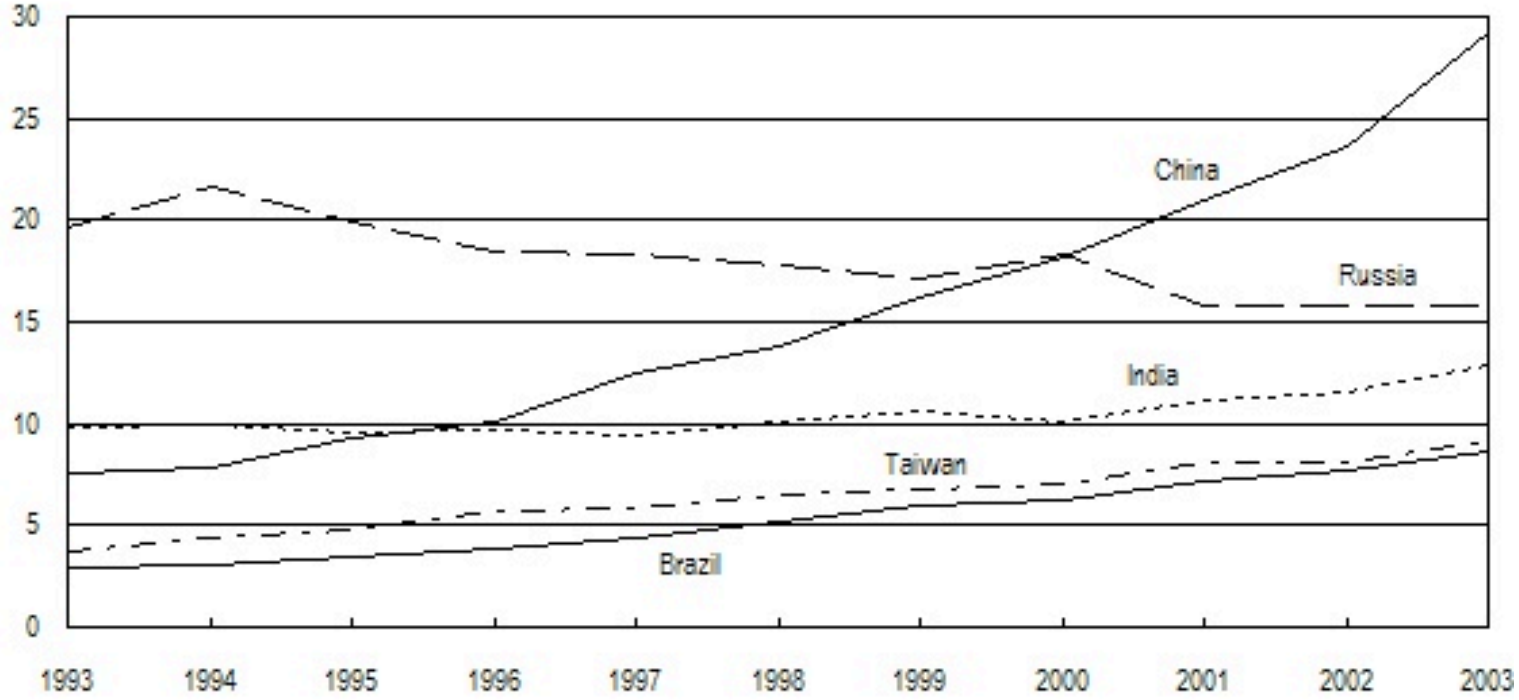

Throughput from US to various countries VS UN DAI
From SLAC PingER Project
http://www-iepm.slac.stanford.edu/pinger
TCP Throughput (Kpbs)
DAI
Dot Size = Population
Japan
Switzerland
United Kingdom
China
India
Pakistan
Maldives
Sri Lanka
Nepal
Bhutan
Bangladesh
Tajikistan
Unbekistan
Turkmenistan
Azerbaijan
3000
2500
2000
1500
1000
500
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8

FIGURE 2. S&E article output of Brazil, China, India, Russia, and Taiwan: 1993–2003

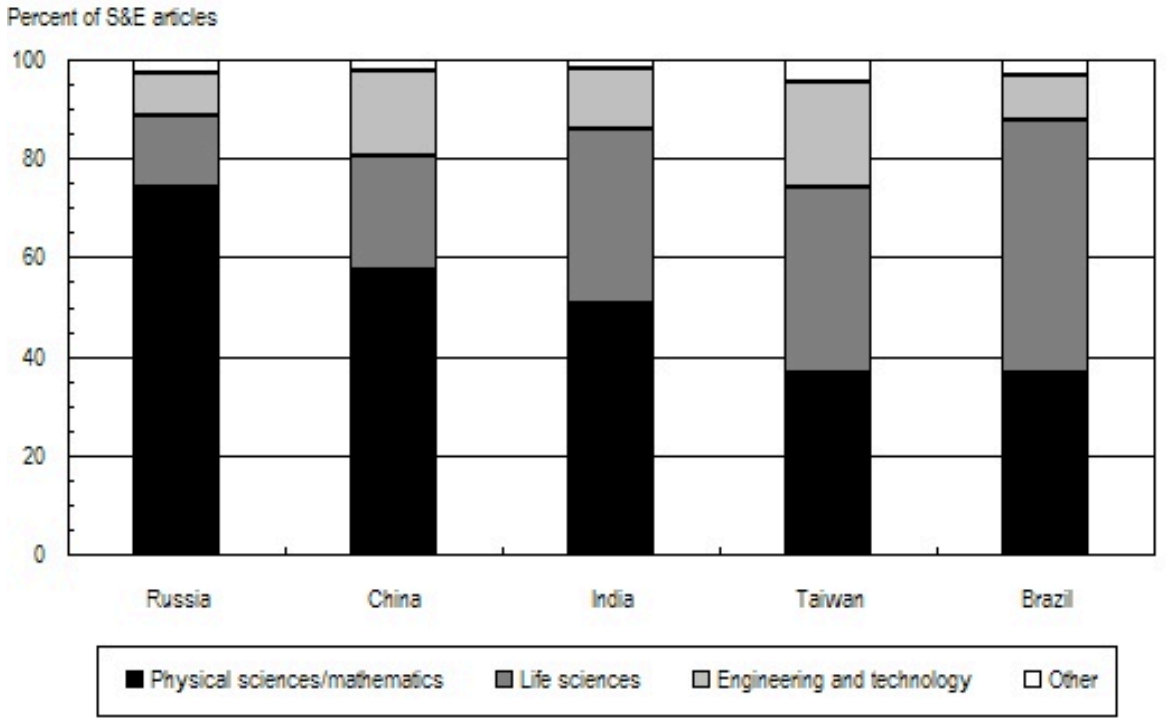
Thousands of articles



NOTES: For internationally coauthored articles, each country and economy receives fractional credit on the basis of proportion of its participating institutions. China includes Hong Kong.

SOURCES: Thomson ISI, Science Citation Index and Social Sciences Citation Index; http://www.isinet.com/products/citation/; ipIQ, Inc., and National Science Foundation, Division of Science Resources Statistics, special tabulations.

FIGURE 4. S&E article portfolio of Brazil, China, India, Russia and Taiwan: 2003

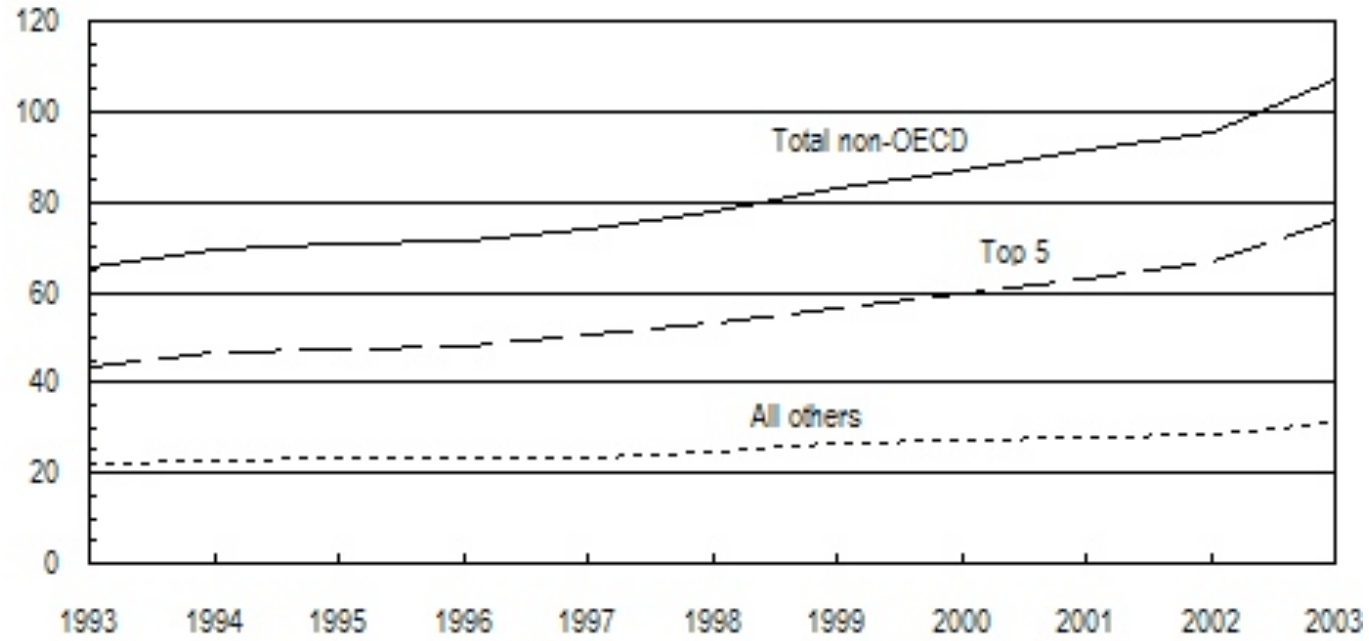


NOTES: Countries and economies ranked by their S&E article share of physical sciences/mathematics. Physical sciences consist of chemistry, physics, and earth and space sciences. Earth and space sciences includes astronomy. Life sciences consists of clinical medicine, biomedical research, and biology. Biology includes agricultural sciences. Engineering and technology includes computer sciences. Other consists of social sciences, psychology, health sciences, and professional fields. For internationally coauthored articles, each country and economy receives fractional credit on the basis of proportion of its participating institutions. China includes Hong Kong.

SOURCES: Thomson ISI, Science Citation Index and Social Sciences Citation Index; http://www.isinet.com/products/citation/; ipIQ, Inc., and National Science Foundation, Division of Science Resources Statistics, special tabulations.

Country	1984-1989		1990-1995	
	Rank	% share	Rank	% share
U.S.	1	36.52	1	35.82
UK	2	9.21	2	9.24
Japan	3	7.37	3	8.67
Germany	4	6.22	4	7.42
France	5	5.17	5	5.88
USSR/ Russia	6	6.85	6	4.97
Canada	7	4.66	7	4.77
Italy	8	2.69	8	3.49
Australia	9	2.27	9	2.40
Netherlands	10	2.01	10	2.40
Spain	11	1.21	11	2.08
India	12	2.22	12	1.94
Sweden	13	1.84	13	1.90
Switzerland	14	1.44	14	1.67
China	15	0.81	15	1.38
Israel	16	1.18	16	1.17
Belgium	17	0.96	17	1.10
Poland	18	0.97	18	0.97
Denmark	19	0.89	19	0.96
Finland	20	0.67	20	0.78

FIGURE 1. S&E article output of non-OECD countries and economies: 1993–2003



OECD = Organisation of Economic Co-operation and Development.

NOTES: The top 5, Brazil, China, India, Russia, and Taiwan, are the non-OECD countries and economies that had the largest S&E article output. For internationally coauthored articles, each region/country/economy receives fractional credit on the basis of proportion of its participating institutions.

SOURCES: Thomson ISI, Science Citation Index and Social Sciences Citation Index; http://www.isinet.com/products/citation/; ipIQ, Inc., and National Science Foundation, Division of Science Resources Statistics, special tabulations.