EU FUNDED PROJECT

R&D POLICY ASSESSMENT REPORT

Annexes 1-3

Tbilisi, Georgia

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Table of contents

Annex 1

Bibliometric analysis of Georgian R&D publications

Bibliometrics is an analysis of bibliometric data (the quantity and quality of published research in scientific journals that gives a narrower, but more precise, internationally comparable perspective. It is a well-established method in the evaluation of the strengths of an S&T system.

In 2004, an influential paper entitled **"The Scientific Impact of Nations"** was published in *Nature* by Sir David King, Chief Scientific Advisor, UK. The paper provides an overview of existing literature and data to measure the impact and outcomes from research investment over the past decade in 31 countries. King's analysis focuses almost exclusively on bibliometric data (number of publications and citations) between 1997 and 2001 to obtain a measure of productivity and quality of science. The group of 31countries analyzed (including G-8 nations and 15 member countries of the EU) accounts for 98% of the world's most highly cited papers. King reports that the top eight countries produce 85% of the top one percent of most cited papers.

This report uses the ISI Web of Science database produced by Thomson Scientific to compute bibliometric statistics. It includes the Science Citation Index® (SCI), which provides extensive coverage of high-quality scientific research in the natural sciences, health sciences and engineering and currently indexes approximately 3,700 of the world's leading science and technical journals. Secondly, the Social Sciences Citation Index (SSCI) that includes bibliographic information for over 1,700 of the world's leading social sciences journals and also covers individually selected items from approximately 3,300 of the leading science and technology journals. The journals in these two databases are considered to be the most important peer-reviewed journals in their respective fields and account for more than 80 percent of the world's citations. Data derived from the ISI Web of Science for the period 1980-2005 and the Essential Science Indicators database were used to compile the following materials.

General data on research papers

Despite the notable decline in research staff and R&D funding since obtaining independence at the beginning of 1990's, the number of publications has substantially increased since 1991 in almost all the former Soviet Union countries.

Table 1

Country	1980-1989	1990-1994	1995-1999	Papers per 1 million population 2000	2000-2005	Papers per 1 million population 2005
Armenia	1850	1696	1593	467,2	2479	827,4
Azerbaijan	2091	1668	970	122,8	1253	156,6
Belarus	5677	5840	6281	603,9	6471	630,5
Estonia	1220	1436	2570	1825,3	4098	3085,8
Rep of Georgia	1736	1413	1216	240,3	1781	380,4

Country	1980-1989	1990-1994	1995-1999	Papers per 1 million population 2000	2000-2005	Papers per 1 million population 2005
Kazakhstan	2218	1814	1055	62,8	1344	87,8
Kyrgyzstan	312	276	138	30,4	273	52,2
Latvia	1462	1520	1735	738,3	2220	975,4
Lithuania	1442	1325	2053	572,8	4381	1221,0
Moldova	1322	1227	1006	225,6	1156	258,9
Tajikistan	608	630	208	34,1	220	29,9
Turkmenistan	144	159	64	14,7	48	9,6
Russia	n/a	55871	141719	968,1	162142	1137,0
Ukraine	32410	25645	22002	450,8	25808	552,3
Uzbekistan	2461	2174	1878	77,9	2208	80,6

Source: Ü.Must "Changing publication pattern and collaboration of former Soviet Union states!", Archimedes Foundation.

Graphically the same data are presented on the following charts showing the relative position of each country in the years 1995-2000 and 2001-2005.

Chart1

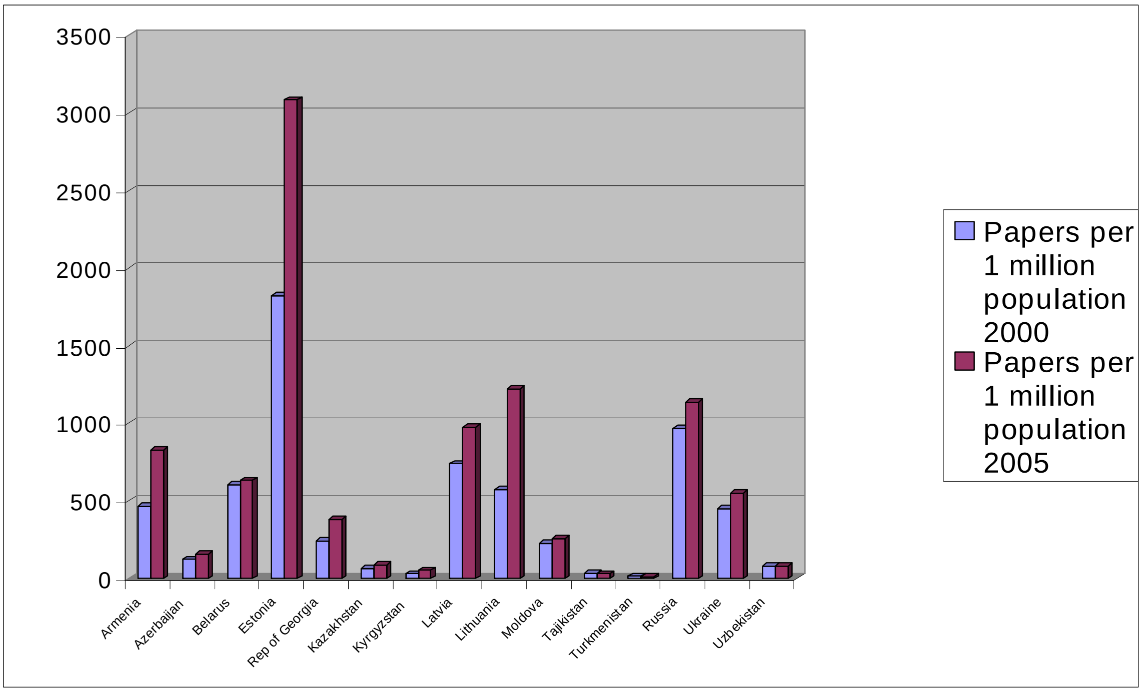
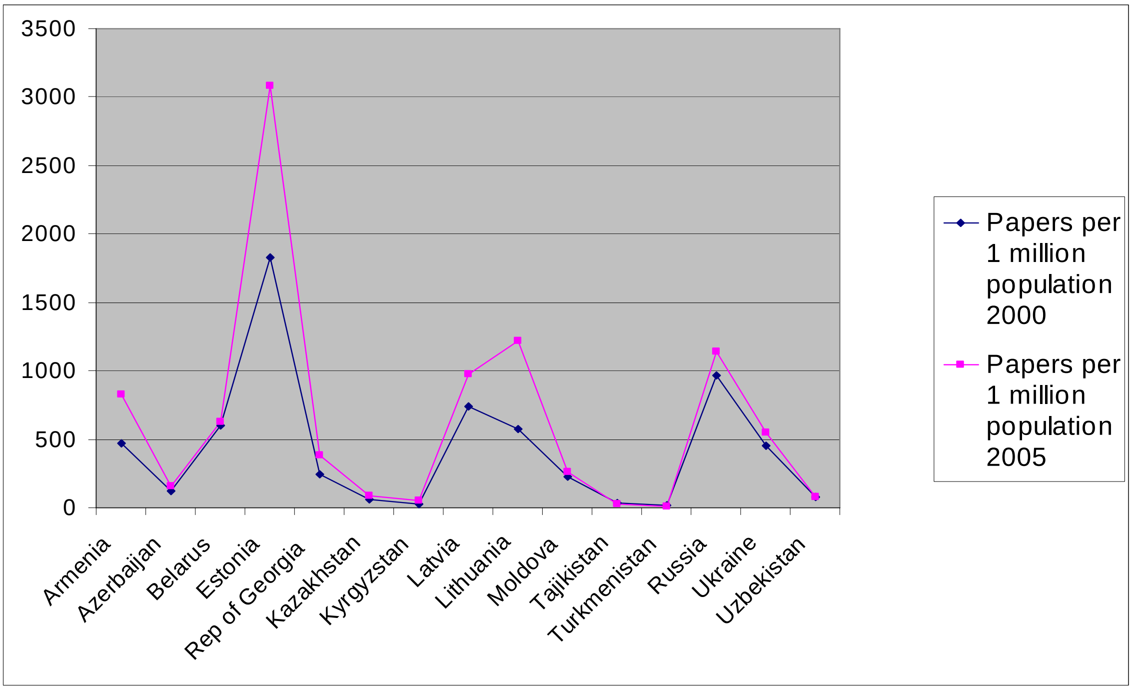


Chart 2



International publications according to the ISI Essential Science Indicators 1996-2006

Research papers

The following table contains comparative data about the total number of research papers indexed by the ISI Web of Science according to research fields. It is important to notice that

a) not all the research fields indexed in the ISI Web of Science are present in the table but only these which contain research papers by Georgia researchers
b) the research papers are attributed to Georgia if the author's official affiliation indicated in the paper is a Georgian R&D or HE institution.

Georgia has the highest absolute number of papers in physics followed by chemistry, mathematics, space science and engineering.

Table 2

Research field	Georgia	Armenia	Estonia	Latvia	Finland
CHEMISTRY	329	505	749	772	6128
ENGINEERING	157	297	313	338	4956
ENVIRONMENT/ECOLOGY	32		440	83	3809
GEOSCIENCES	96	51	593	36	1866
MATHEMATICS	314	130	149		1352
PHARMACOLOGY & TOXICOLOGY	24	33	78	25	1482
PHYSICS	989	1560	787	842	6657

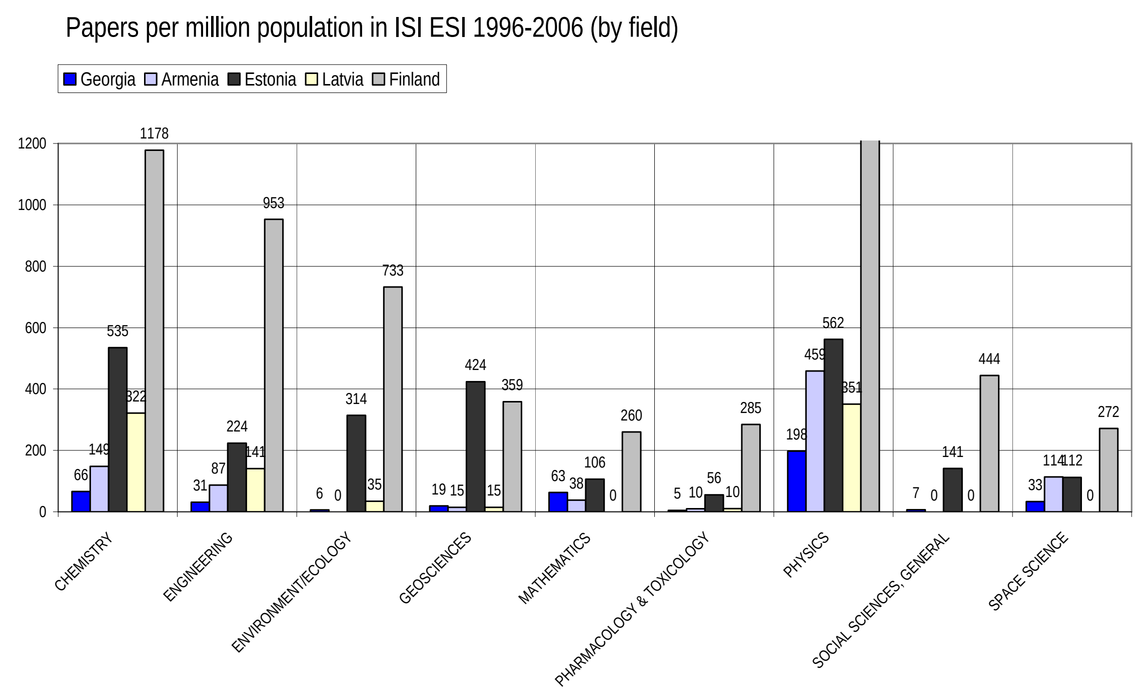
Research field	Georgia	Armenia	Estonia	Latvia	Finland
SOCIAL SCIENCES, GENERAL	33		198		2310
SPACE SCIENCE	166	386	157		1413

Remark: The author would like to thank Kristi Kukk from Archimedes Foundation for her input to this part of the report.

Table 3

Papers per million population	Georgia	Armenia	Estonia	Latvia	Finland
CHEMISTRY	66	149	535	322	1178
ENGINEERING	31	87	224	141	953
ENVIRONMENT/ECOLOGY	6	0	314	35	733
GEOSCIENCES	19	15	424	15	359
MATHEMATICS	63	38	106	0	260
PHARMACOLOGY & TOXICOLOGY	5	10	56	10	285
PHYSICS	198	459	562	351	1280
SOCIAL SCIENCES, GENERAL	7	0	141	0	444
SPACE SCIENCE	33	114	112	0	272

Chart 3



The following charts show the position of Georgia relative to the other 4 countries in Tables 2 and 3. The number of publications per 1 million population brings forward the real R&D capacity of each of the countries considered. Unfortunately, the available statistics do not make it possible to provide the same data per researcher.

Chart 4

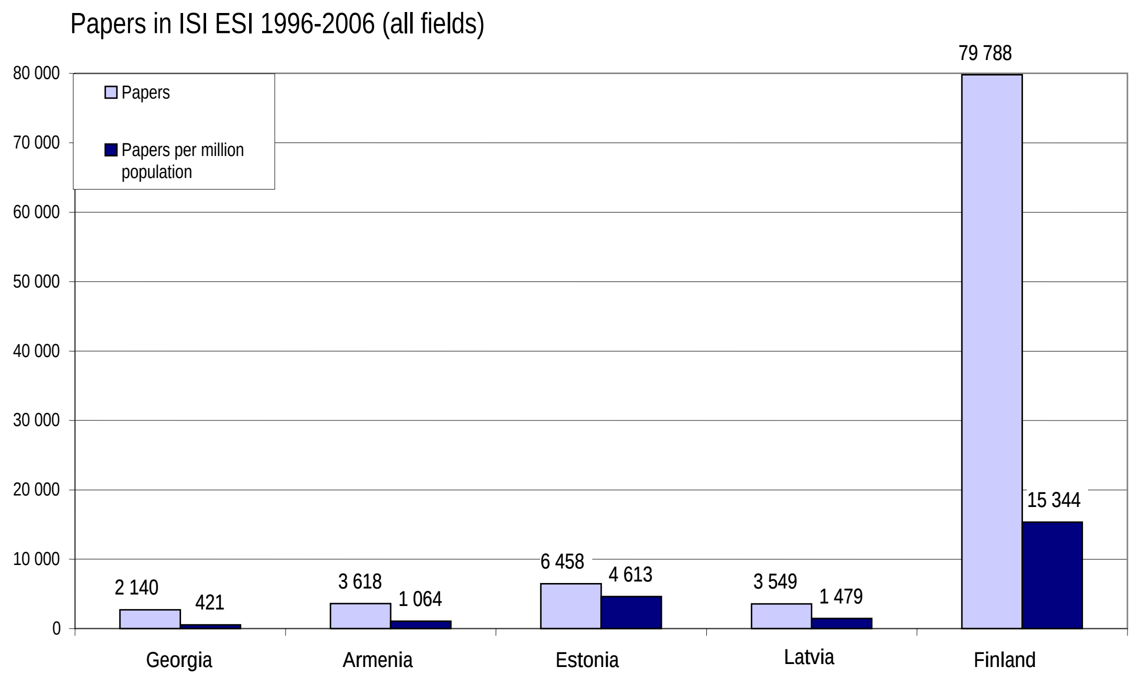
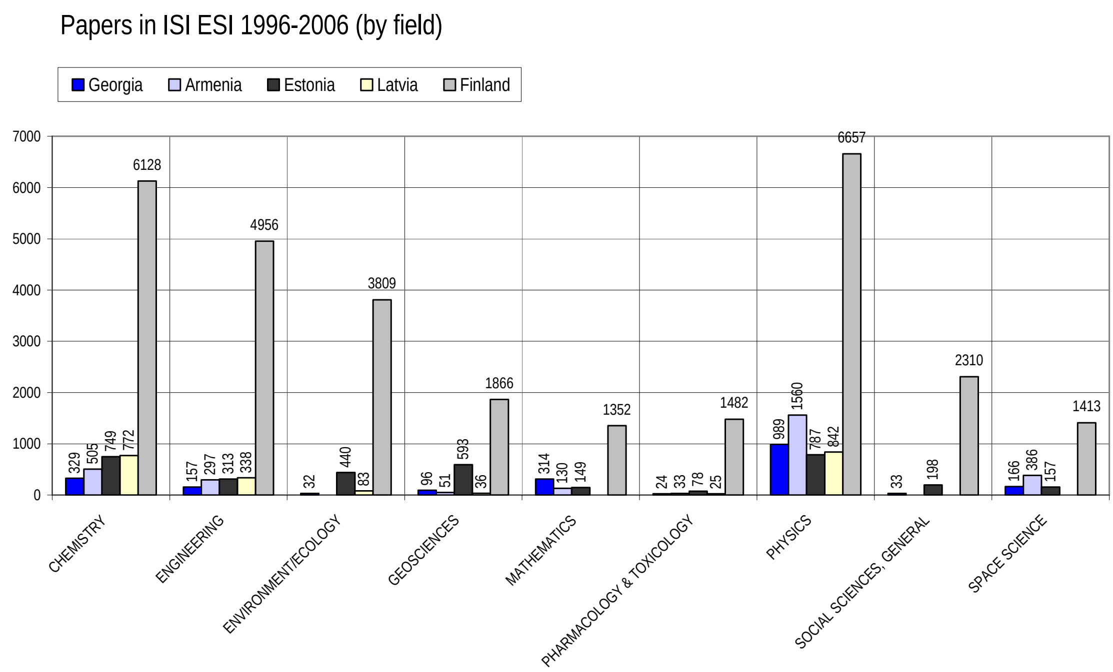


Chart 5



Citations

At the same time the increase in the number of papers was not always matched by the increase in the number of citations. The process of acknowledgement is slow, and we can follow the tendency of increase in numbers of citations only during the last ten years.

Table 4 Total citations

Research field	Georgia	Armenia	Estonia	Latvia	Finland
CHEMISTRY	1656	916	6152	3139	51301
ENGINEERING	341	895	861	730	21332
ENVIRONMENT/ECOLOGY	373		3854	383	37610
GEOSCIENCES	635	436	2458	460	16094
MATHEMATICS	446	152	337		4311
PHARMACOLOGY & TOXICOLOGY	167	157	800	450	14457
PHYSICS	4627	11416	4215	4613	64928
SOCIAL SCIENCES, GENERAL	220		469		9513
SPACE SCIENCE	810	2188	1510		12820

Table 5 Citations per paper

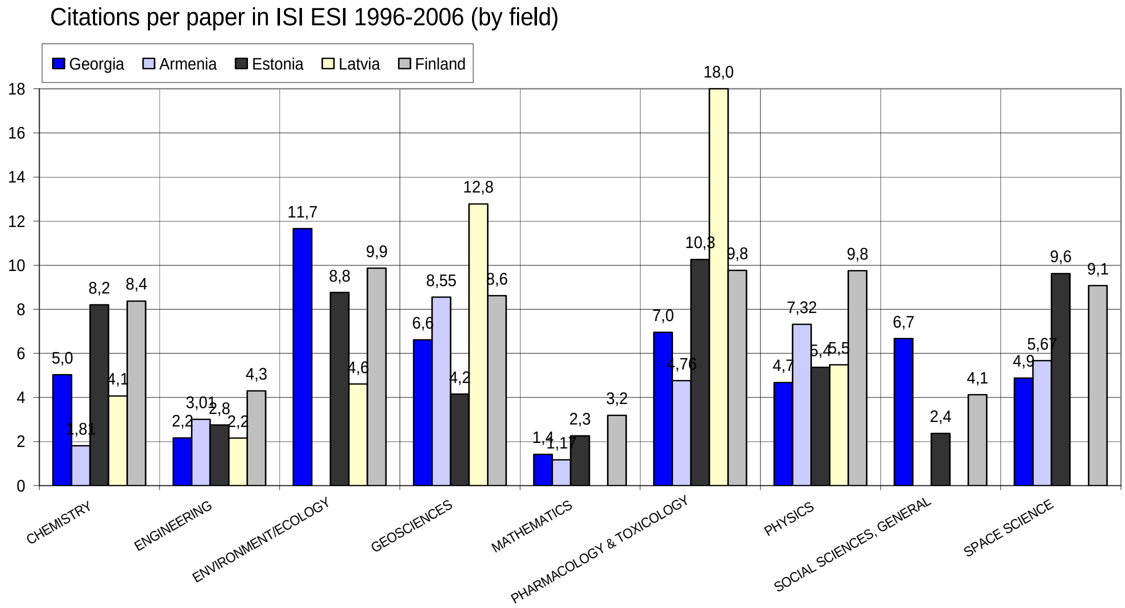
Research field	World average	Georgia	Georgia's % of world average	Arme nia	Estonia	Latvia	Finland
CHEMISTRY	8,39	5,03	60%	1.81	8,21	4,07	8,37
ENGINEERING	3,32	2,17	65%	3.01	2,75	2,16	4,3
ENVIRONMENT /ECOLOGY	8,19	11,66	145%		8,76	4,61	9,87
GEOSCIENCES	7,76	6,61	85%	8,56	4,15	12,78	8,62
MATHEMATICS	2,71	1,42	52%	1.17	2,26		3,19
PHARMACOLOGY & TOXICOLOGY	9,64	6,96	72%	4.76	10,26	18	9,76
PHYSICS	7,34	4,68	63%	7.32	5,36	5,48	9,75
SOCIAL SCIENCES, GENERAL	3,56	6,67	187%		2,37		4,12
SPACE SCIENCE	11,89	4,88	41%	5.67	9,62		9,07

It should be noted that

a) the world average citation strongly differ between research fields, cf 2.71 in mathematics and 11.89 in space science.
b) Georgia exceeds the world average citation levels in environmental and ecological sciences as well as in social sciences.

Chart 6 shows the average number of citations per internationally published paper in different research fields. As Finland in most of the research fields represents the world average or higher citation index it is easy to see where Georgian science in these fields stands compared to the world.

Chart 6

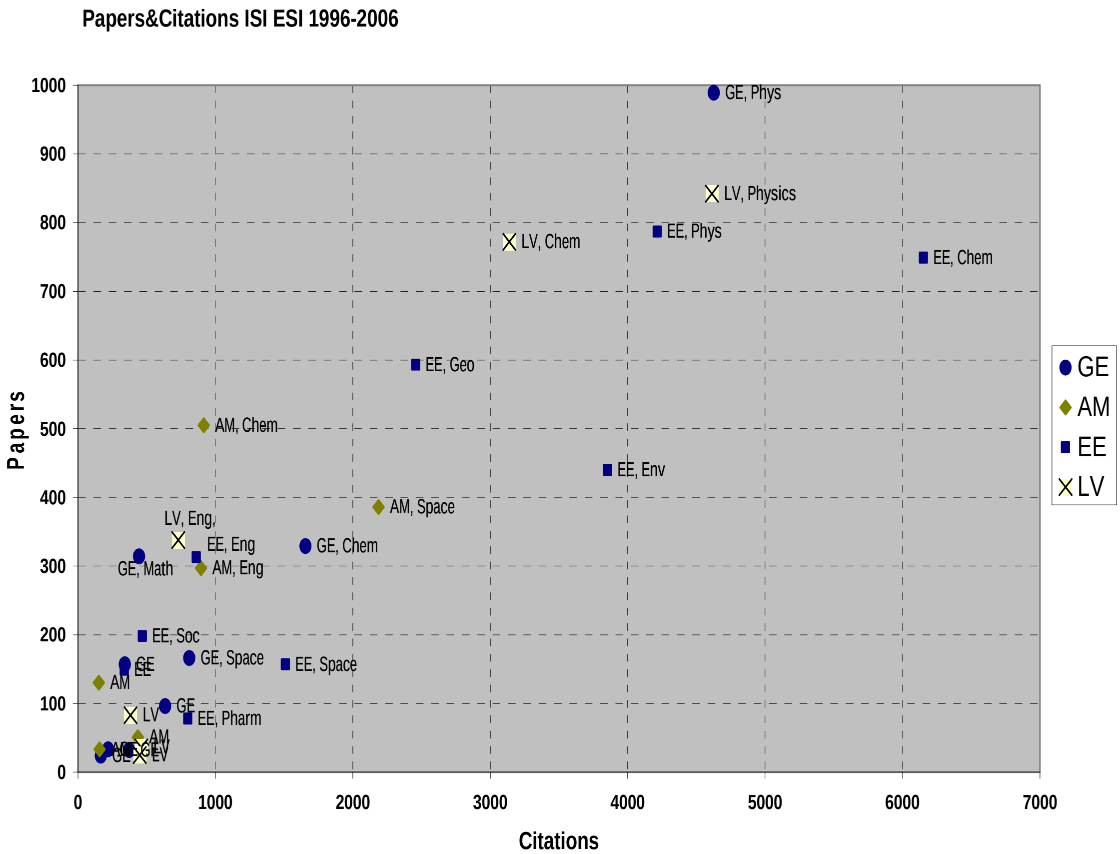


In many cases this tendency does not show advances in specific countries' R&D systems but the existence of a few high level groups of researchers. For example, in the Republic of Georgia the impact of highly cited researchers' output on their country's total performance during the period 1996-2005 was the following: in the Chemistry field 0.95% of papers received 23.5% of citations; in the Environment field 3.33% of papers received 35.1% of citations; in the Geosciences field 1.09% papers received 46.2% of citations and in Space Science 6.25% of papers received 73.8% of citations.

The impact of a few high level researchers to their countries' research output is especially noticeable in the case of a small country with a low number of publications, and also in case of countries which do not yet have a stable R&D system The common characteristic of such countries is that they lack R&D funding resources and high-level research infrastructures whereas at the same time they also have small research groups of good quality. High rates of publications in these cases show a capacity to make cooperation links with high quality partners. Therefore, the purpose of presenting the countries by citation per paper basis is not for mapping their ranking but for using it as a facility for finding areas where competitive researchers are engaged.

Chart 7 summons information about both citations and papers in a complex way. In the top right hand corner are represented those research fields which have both numerous international publications and are also highly cited. It clearly demonstrates that physics has so far been by far the strangest research field in Georgia (about 1000 publications and more than 4500 citations). Second strongest publication-wise are chemistry and mathematics (both over 300 publications) but chemistry by far outpaces mathematics by the absolute number of citations (more than 1600 in chemistry and 450 in mathematics) whereas when we look at the average normalised citation index these two fields are quite similar. The left bottom quarter includes the research fields with both low international publications and the low number of citations.

Chart 7



Top cited Georgian research papers by research field

Physics

Title:ANTIFERROMAGNETIC SPIN LADDERS: CROSSOVER BETWEEN SPIN S=1/2 AND S=1 CHAINS
Authors:SHELTON DG; NERSESYAN AA; TSVELIK AM
Addresses: UNIV OXFORD, DEPT PHYS, 1 KEBLE RD, OXFORD OX1 3NP, ENGLAND.GEORGIAN ACAD SCI, INST PHYS, TBILISI 380077, REP OF GEORGIA.
Source:PHYS REV B 53 (13): 8521-8532 APR 1 1996
Total citations: 148

Title:THE PHOTON COLLIDER AT TESLA
Authors:BADELEK B; BLOCHINGER C; BLUMLEIN J; BOOS E; BRINKMANN R; BURKHARDT H; BUSSEY P; CARIMALO C; CHYLA J; CIFTCI AK; DECKING W; DE ROECK A; FADIN V; FERRARIO M; FINCH A; FRAAS H; FRANKE F; GALYNSKII M; GAMP A; GINZBURG I; GODBOLE R; GORBUNOV DS; GOUNARIS G; HAGIWARA K; HAN L; HEUER RD; HEUSCH C; ILLANA J; ILYIN V; JANKOWSKI P; JIANG Y; JIKIA G; JONSSON L; KALACHNIKOW

M; KAPUSTA F; KLANNER R; KLASSEN M; KOBAYASHI K; KON T; KOTKIN G; KRAMER M; KRAWCZYK M; KUANG YP; KURAEV E; KWIECINSKI J; LEENEN M; LEVCHUK M; MA WF; MARTYN H; MAYER T; MELLES M; MILLER DJ; MTINGWA S; MUHLLEITNER M; MURYN B; NICKLES PV; ORAVA R; PANCHERI G; PENIN A; POTYLITSYN A; POULOSE P; QUAST T; RAIMONDI P; REDLIN H; RICHARD F; RINDANI SD; RIZZO T; SALDIN E; SANDNER W; SCHONNAGEL H; SCHNEIDMILLER E; SCHREIBER HJ; SCHREIBER S; SCHULER KP; SERBO V; SERYI A; SHANIDZE R; DA SILVA W; SOLDNER-REMBOLD S; SPIRA M; STASTO AM; SULTANSOY S; TAKAHASHI T; TELNOV V; TKABLADZE A; TRINES D; UNDRUS A; WAGNER A; WALKER N; WATANABE I; WENGLER T; WILL I; WIPF S; YAVAS O; YOKOYA K; YURKOV M; ZARNECKI AF; ZERWAS P; ZOMER F

Source:INT J MOD PHYS A 19 (30): 5097-5186 DEC 10 2004

Addresses:
Tbilisi State Univ, GE-380086 Tbilisi, Rep of Georgia.

Total citations: 18

Chemistry

Title:ENANTIOSEPARATIONS IN CAPILLARY ELECTROMIGRATION TECHNIQUES: RECENT DEVELOPMENTS AND FUTURE TRENDS
Authors:CHANKVETADZE B; BLASCHKE G
Source:J CHROMATOGR A 906 (1-2): 309-363 JAN 12 2001
Addresses: Univ Munster, Inst Pharmaceut Chem, Hittorfstr 58-62, D-48149 Munster, Germany.; Univ Munster, Inst Pharmaceut Chem, D-48149 Munster, Germany.
Tbilisi State Univ, Sch Chem, Mol Recognit & Separat Sci Lab, GE-380028 Tbilisi, Rep of Georgia.

Total citations: 151

Title:SEPARATION SELECTIVITY IN CHIRAL CAPILLARY ELECTROPHORESIS WITH CHARGED SELECTORS
Authors:CHANKVETADZE B
Source:J CHROMATOGR A 792 (1-2): 269-295 DEC 19 1997
Addresses: Univ Munster, Inst Pharmaceut Chem, Hittorfstr 58-62, D-48149 Munster, Germany.
Tbilisi State Univ, Dept Chem, GE-380028 Tbilisi, Rep of Georgia.
Total citations: 135

Title:ENANTIOMER SEPARATION OF DRUGS BY CAPILLARY ELECTROMIGRATION TECHNIQUES
Authors:BLASCHKE G; CHANKVETADZE B
Source:J CHROMATOGR A 875 (1-2): 3-25 APR 14 2000

Addresses: Univ Munster, Inst Pharmaceut Chem, Hittorfstr 58-62, D-48149 Munster, Germany.; Univ Munster, Inst Pharmaceut Chem, D-48149 Munster, Germany. Tbilisi State Univ, Sch Chem, Mol Recognit & Separat Sci Lab, GE-380028 Tbilisi, Rep of Georgia.
Total citations: 109

Geosciences

Title:GLOBAL POSITIONING SYSTEM CONSTRAINTS ON PLATE KINEMATICS AND DYNAMICS IN THE EASTERN MEDITERRANEAN AND CAUCASUS

Authors:MCCLUSKY S; BALASSANIAN S; BARKA A; DEMIR C; ERGINTAV S; GEORGIEV I; GURKAN O; HAMBURGER M; HURST K; KAHLE H; KASTENS K; KEKELIDZE G; KING R; KOTZEV V; LENK O; MAHMOUD S; MISHIN A; NADARIYA M; OUZOUNIS A; PARADISSIS D; PETER Y; PRILEPIN M; REILINGER R; SANLI I; SEEGER H; TEALEB A; TOKSOZ MN; VEIS G

Source:J GEOPHYS RES-SOLID EARTH 105 (B3): 5695-5719 MAR 10 2000

Addresses:
Dept Geodesy & Cartog Georgia, Tbilisi, Rep of Georgia.

Total citations: 300

Environment/ecology

Title:POSITIVE INTERACTIONS AMONG ALPINE PLANTS INCREASE WITH STRESS
Authors:CALLAWAY RM; BROOKER RW; CHOLER P; KIKVIDZE Z; LORTIE CJ; MICHALET R; PAOLINI L; PUGNAIRE FI; NEWINGHAM B; ASCHEHOUG ET; ARMAS C; KIKODZE D; COOK BJ
Source:NATURE 417 (6891): 844-848 JUN 20 2002
Addresses:
Georgian Acad Sci, Inst Bot, GE-380007 Tbilisi, Rep of Georgia.

Total citations: 142

Engineering

Title:ANKE, A NEW FACILITY FOR MEDIUM ENERGY HADRON PHYSICS AT COSY-JULICH
Authors:BARSOV S; BECHSTEDT U; BOTHE W; BONGERS N; BORCHERT G; BORGS W; BRAUTIGAM W; BUSCHER M; CASSING W; CHERNYSHEV V; CHILADZE B; DIETRICH J; DROCHNER M; DYMOV S; ERVEN W; ESSER R; FRANZEN A; GOLUBEVA Y; GOTTA D; GRANDE T; GRZONKA D; HARDT A; HARTMANN M; HEJNY V; VON HORN L; JARCZYK L; JUNGHANS

H; KACHARAVA A; KAMYS B; KHOUKAZ A; KIRCHNER T; KLEHR F; KLEIN W; KOCH HR; KOMAROV VI; KONDRATYUK L; KOPTEV V; KOPYTO S; KRAUSE R; KRAVTSOV P; KRUGLOV V; KULESSA P; KULIKOV A; LANG N; LANGENHAGEN N; LEPGES A; LEY J; MAIER R; MARTIN S; MACHARASHVILI G; MERZLIAKOV S; MEYER K; MIKIRTYCHIANTS S; MULLER H; MUNHOFEN P; MUSSGILLER A; NEKIPELOV M; NELYUBIN V; NIORADZE M; OHM H; PETRUS A; PRASUHN D; PRIETZSCHK B; PROBST HJ; PYSZ K; RATHMANN F; RIMARZIG B; RUDY Z; SANTO R; SCHIECK HPG; SCHLEICHERT R; SCHNEIDER A; SCHNEIDER C; SCHNEIDER H; SCHWARZ U; SEYFARTH H; SIBIRTSEV A; SIELING U; SISTEMICH K; SELIKOV A; STECHEMESSER H; STEIN HJ; STRZALKOWSKI A; WATZLAWIK KH; WUSTNER P; YASHENKO S; ZALIKHANOV B; ZHURAVLEV N; ZWOLL K; ZYCHOR I; SCHULT OWB; STROHER H

Source:NUCL INSTRUM METH PHYS RES A 462 (3): 364-381 APR 21 2001
Addresses: Tbilisi State Univ, High Energy Phys Inst, GE-380086 Tbilisi, Rep of Georgia.
Total citations: 54

Social sciences, general

Title:EARLIEST PLEISTOCENE HOMINID CRANIAL REMAINS FROM DMANISI, REPUBLIC OF GEORGIA: TAXONOMY, GEOLOGICAL SETTING, AND AGE

Authors:GABUNIA L; VEKUA A; LORDKIPANIDZE D; SWISHER CC; FERRING R; JUSTUS A; NIORADZE M; TVALCHRELIDZE M; ANTON SC; BOSINSKI G; JORIS O; DE LUMLEY MA; MAJSURADZE G; MOUSKHELISHVILI A
Source:SCIENCE 288 (5468): 1019-1025 MAY 12 2000

Addresses:
Republ Georgia Natl Acad Sci, GE-380007 Tbilisi, Rep of Georgia.
Republ Georgia State Museum, Dept Geol & Paleontol, GE-380007 Tbilisi, Rep of Georgia.
Total citations: 100

Title:A NEW SKULL OF EARLY HOMO FROM DMANISI, GEORGIA
Authors:VEKUA A; LORDKIPANIDZE D; RIGHTMIRE GP; AGUSTI J; FERRING R; MAISURADZE G; MOUSKHELISHVILI A; NIORADZE M; DE LEON MP; TAPPEN M; TVALCHRELIDZE M; ZOLLIKOFER C
Source:SCIENCE 297 (5578): 85-89 JUL 5 2002

Addresses: Georgian Acad Sci, Georgian State Museum, 3 Purtseladze St, GE-380007 Tbilisi, Rep of Georgia.
Georgian Acad Sci, Georgian State Museum, GE-380007 Tbilisi, Rep of Georgia.
Georgian Acad Sci, Inst Paleobiol, GE-380004 Tbilisi, Rep of Georgia.

Georgian Acad Sci, Inst Geog, GE-380093 Tbilisi, Rep of Georgia.
Georgian Acad Sci, Archeol Ctr, GE-380002 Tbilisi, Rep of Georgia.
Georgian Acad Sci, Inst Geol, GE-380093 Tbilisi, Rep of Georgia.

Total citations: 55

Title:ANATOMICAL DESCRIPTIONS, COMPARATIVE STUDIES AND EVOLUTIONARY SIGNIFICANCE OF THE HOMININ SKULLS FROM DMANISI, REPUBLIC OF GEORGIA
Authors:RIGHTMIRE GP; LORDKIPANIDZE D; VEKUA A
Source:J HUM EVOL 50 (2): 115-141 FEB 2006

Addresses: Georgian Acad Sci, Inst Paleobiol, GE-380004 Tbilisi, Rep of Georgia.
Georgian Natl Museum, GE-380007 Tbilisi, Rep of Georgia.
Total citations: 3

Clinical medicine

Title:LOW DOSE MIFEPRISTONE AND TWO REGIMENS OF LEVONORGESTREL FOR EMERGENCY CONTRACEPTION: A WHO MULTICENTRE RANDOMISED TRIAL

Authors:VON HERTZEN H; PIAGGIO G; DING JH; CHEN JL; SONG S; BARTFAI G; NG E; GEMZELL-DANIELSSON K; OYUNBILEG A; WU SC; CHENG WY; LUDICKE F; PRETNAR-DAROVEC A; KIRKMAN R; MITTAL S; KHOMASSURIDZE A; APTER D; PEREGOUDOV A; WHO RES GRP POST-OVULATORY METHODS
Source:LANCET 360 (9348): 1803-1810 DEC 7 2002
Addresses: Zhordania Inst Human Reprod, Tbilisi, Rep of Georgia.

Total citations: 103

Title:RANDOMIZED, DOUBLE-BLIND, PLACEBO-CONTROLLED TRIAL OF RECOMBINANT HUMAN ERYTHROPOIETIN, EPOETIN BETA, IN HEMATOLOGIC MALIGNANCIES
Authors:OSTERBORG A; BRANDBERG Y; MOLOSTOVA V; IOSAVA G; ABDULKADYROV K; HEDENUS M; MESSINGER D; EPOETIN BETA HEMATOLOGY STUDY GRP
Source:J CLIN ONCOL 20 (10): 2486-2494 MAY 15 2002
Addresses: Inst Hematol & Transfusiol, Tbilisi, Rep of Georgia.

Total citations: 95

Annex 2

View from abroad and literature survey

There are not too many relevant international publications including internationally comparable indicators of important aspects of S&T where Georgia has been represented.

A RAND Corporation report " *Science and Technology Collaboration: Building Capacity in Developing Countries?*", 2001, was already mentioned above (cf 1.3). Another Rand Corporation report where the S&T capacity of Georgia is analysed in detail was published in 2006:

The Global Technology Revolution 2020 In-Depth Analysis: Bio/Nano/Materials/Information Trends, Drivers, Barriers and Social Implications. Santa Monica: RAND Corporation.

The RAND Corporation experts analysed various emerging **technology applications (TA)** that may become feasible by 2020, and the absorption capacity of different countries all over the world to implement these technology applications. Technology applications affect society through the functions that they accomplish (e.g., health, food, shelter, climate control, transportation, communication, computation). The accelerating pace of technology development is important because it has brought new functions to large numbers of people worldwide (e.g., communication and information searching via the Internet), has improved the speed and accuracy of existing functions (e.g., lab-on-a-chip bioassays, functional Magnetic Resonance Imaging (fMRI) for medical diagnostics), and is producing a variety of multifunctional applications (e.g., wearable computers).

Of the 56 TAs that emerged in the review and analysis of the technical foresights, the following "top 16," based on this net assessment index, formed a representative group that allowed evaluation of worldwide variation in technology implementation and its relevance to significant societal problems and issues:

1. Cheap solar energy
2. Rural wireless communications
3. Communication devices for ubiquitous information access anywhere, anytime
4. Genetically modified (GM) crops
5. Rapid bioassays
6. Filters and catalysts for water purification and decontamination;
7. Targeted drug delivery
8. Cheap autonomous housing
9. Green manufacturing
10. Ubiquitous RFID[*] tagging of commercial products and individuals
11. Hybrid vehicles
12. Pervasive sensors
13. Tissue engineering

[*] **RFID=Radio-frequency identification** is an automatic identification method, relying on storing and remotely retrieving data using devices called RFID tags or transponders. An RFID tag is an object that can be attached to or incorporated into a product, animal, or person for the purpose of identification using radio waves. Chip-based RFID tags contain silicon chips and antennas. Passive tags require no internal power source, whereas active tags require a power source.

14. Improved diagnostic and surgical methods
15. Wearable computers
16. Quantum cryptography

After having established these 16 TAs, experts within and outside RAND Corporation were consulted for their assessment of the impact of TAs in different regions of the world.. Motivated by the extent of regional variation, as well as significant differences between countries within regions, we identified 29 representative countries that allowed analysis of international variations in TAs and implementation across the globe. These countries were selected to reflect diversity in physical size, natural conditions, and location (e.g., large versus small, tropical versus temperate, land-locked versus island); population size and demographics (e.g., high birth rate versus low birth rate, rapidly aging versus youthful); level of economic development and types of economy (e.g., developed versus developing, market capitalist versus controlled economy); types of government (e.g., competitive liberal democracies versus authoritarian regimes); and science and technology (S&T) capacity levels (e.g., scientifically advanced versus scientifically lagging). While these criteria are not independent of each other, together they represent the principal geographical, social, economic, political, and scientific characteristics of international variation.

Within each region of the world, we identified several candidate countries, then eliminated highly similar countries within a region. Countries across regions were then compared with each other to remove those that might be represented by others. Georgia was one of the 29 countries selected to represent Europe.

Table 3.5
Selected Countries Across Regions of the World

Asia	Oceania	North Africa and the Middle East	Europe[a]	Africa	North America	Central and South America and the Caribbean
China	Australia	Egypt	Georgia	Cameroon	Canada	Brazil
India	Fiji	Iran	Germany	Chad	Mexico	Chile
Indonesia		Israel	Poland	Kenya	United States	Colombia
Japan		Jordan	Russia	South Africa		Dominican Republic
South Korea			Turkey			
Nepal						
Pakistan						

Technology implementation requires know-how and capacity to adopt, disseminate, and implement for practical uses. Scientific knowledge, technical skills, and means to provide sustainable access to and use of technology are essential. Those societies with a higher level of science and technology (S&T) capacity will be better able to implement TAs and to produce their own technological innovation or advance technology to offer better solutions to their problems.

Building S&T capacity requires investment in R&D. Funding for the education and training of scientists and engineers, scientific research and technology development activities, promotion of technology transfer to commercial applications, and dissemination of technology into the marketplace might come from public or private sources. However, R&D investment does not exist in a vacuum. It must compete with other spending priorities of the state and of private investors, who look for opportunities with high return on investment. Countries in which government policies are hostile to economic activities, politics are unstable, and the level of R&D capacity is extremely low generally are not attractive places for investment that would promote R&D capacity building. Development assistance groups might step in to transfer technology, but their efforts to make technology implementation sustainable and to produce the expected outcomes for the intended beneficiaries would likely be constrained by political and economic hurdles.

Indeed, S&T capacity building is a long-term and cumulative process that requires not only financial investment, but also a host of other inputs and conditions to establish, maintain, and generate benefits for society. A positive correlation is evident between those that spend a larger share of their gross national product (GNP) in R&D and those that are more able to acquire and implement the Tas.A RAND study for the World Bank produced an S&T index based on a number of S&T indicators.

It is quite clear that a positive correlation exists between a country's rank in the S&T Capacity Index and its level of economic development. The RAND S&T Capacity Index was compiled taking into consideration the number of scientists and engineers in a country, its R&D investment relative to GNP, and many other factors. Building S&T capacity requires a sustained level of investment over time, as well as supportive political, economic, and social conditions. Many countries that ranked low according to the RAND S&T Capacity Index will have to do a great deal to create these conditions and garner the resources to raise their S&T capacity level.

A great number of the TAs examined in this study will require societies to invest considerable resources to bring these technologies to technical maturity, disseminate them, and develop an environment conducive to their implementation. These R&D investments range from building world-class research laboratories, high-speed computers, and hospital facilities to training service technicians and technology extension officers.

RAND S&T Capacity Index Scores for Selected Countries

	Selected Countries	**S&T Index Score**
1.	United States	5.03
2.	Japan	3.08
3.	Germany	2.12
4.	Canada	2.08
5.	Israel	1.53
6.	South Korea	1.49
7.	Australia	1.33
8.	Russia	0.89
9.	Poland	0.19
10.	China	0.10
11.	Brazil	0.10
12.	South Africa	0.04

	Selected Countries	S&T Index Score
13.	India	0.04
14.	Chile	–0.11
15.	Mexico	–0.14
16.	Pakistan	–0.15
17.	Turkey	–0.17
18.	Colombia	–0.22
19.	Iran	–0.22
20.	Egypt	–0.29
21.	Indonesia	–0.30
22.	Jordan	–0.35
23.	Nepal	–0.40
24.	Georgia	–0.44
25.	Kenya	–0.46
26.	Dominican Republic	–0.48
27.	Cameroon	–0.49
28.	Chad	–0.51

It is important to make a distinction between the capacity to *acquire* TAs and the capacity to *implement* them. A nation might acquire a TA through domestic R&D efforts, through technology transfer, through international R&D collaboration, or through simple purchasing via importation of commercial off-the-shelf systems from other countries. Hence, the capacity to acquire a technology reflects the S&T capacity of that nation, particularly its ability to conduct R&D activities or import know-how. However, the capacity to acquire TAs does not necessarily imply the capacity to successfully implement those TAs.

Using technology requires more than the ability to do research or import know-how. A nation must be able to match a TA to a problem and put that TA in the hands of users. Further, users must be able to sustain that use over time. This might require financing to access the TA, infrastructure to support its use, and skilled workers to maintain it. Finally, individual users and the society as a whole must be able to benefit from the use of the TA and be willing to support its implementation.

To accomplish all this, a country will need a certain level of institutional, human, and physical capacity. Institutional capacity includes the quality and reach of governance in a country, a banking and financial system that works, an honest and functioning judiciary, and working educational and health systems. Human capacity covers the quality and quantity of educated and skilled personnel available in a society. Physical capacity includes the quality and quantity of roads, airports, seaports, schools, hospitals, research laboratories and libraries, water treatment plants, grid electricity, and other infrastructure. A society's institutional, human, and physical capacity is reflected in the drivers and barriers discussed previously. For example, a society that is short of laws to promote technology use, of financial mechanisms to enable technology acquisition, and of political stability and good governance to reduce uncertainties in economic decisionmaking would present a very hostile environment for technology implementation.182

Drivers and Barriers to Implementing Technology Applications

Input from regional experts clearly suggested that many TAs can help to alleviate problems confronting countries around the world but that technology adoption and implementation will not be easy for most countries; for example, the lack of infrastructure will be a critical hurdle. Thus, technical maturity and feasibility are necessary, but not sufficient, conditions for the implementation of TAs. Many other factors will determine whether a TA will be implemented, how it will be implemented, whom it benefits, and whether its use can be sustained over time and can produce expected outcomes. This section will delineate and describe the drivers and barriers to the implementation of TAs – and the relationships among them – to illustrate the complex policy, political, social, and economic landscape in which technology implementation occurs.

Drivers are the motivations or forces that will enable policymakers, as well as individual users, to choose a technology to meet a certain need and to acquire capacity to sustain the application of that technology. **Barriers** are the opposites of drivers: They are hindrances to the implementation of TAs. Drivers and barriers frequently stem from the same sources. Their main difference lies in whether the source is available or absent (e.g., funding and a technologically savvy population), its nature relative to the technology (e.g., public opinion and laws), the problem(s) that the TA is expected to address in that particular decision environment, and the potential for negative or unanticipated consequences.

Knowing the drivers and barriers and the relationships among them will better enable decision-makers to implement beneficial TAs in a manner that fully addresses significant ethical, safety, and public concerns. In this study, we identified ten major types of drivers and barriers to technology implementation:

1. Cost and financing
2. Laws and policies
3. Social values, public opinion, and politics
4. Infrastructure
5. Privacy concerns
6. Resource use and environmental health
7. R&D investment
8. Education and literacy
9. Population and demographics
10. Governance and political stability.

Note: a short description of these 10 drivers and barriers is provided at the end of this chapter.

Determining Country Capacity to Acquire Technology Applications and Their Drivers and Barriers (pp 65-66)

We assessed the capacity of these 29 selected countries to acquire the top 16 technology applications. This assessment used the data that determined the indicators and rankings in the United Nations' Human Development IndexI, the RAND S&T Capacity Index, the World Bank's Knowledge Economy Index, and data from the Central Intelligence Agency's *World Factbook.* To make a final assessment of capacity to acquire for each representative country, we combined the data from the indicators, rankings, and indices with our assessment of the relative level of capacity demanded by each of the top 16 TAs. This produced a basic "tool kit" of TAs that each country has to draw from to address highlighted problems and issues. For example, the United States, which has capacity to acquire all 16 TAs, will have 16 TAs with which to address problems and issues, whereas Nepal will only have five. Table 3.6 shows the number of top 16 TAs for our 29 selected countries, arranged in four groups according to the demand that these TAs make (according to Table 3.4) on a country's S&T capacity, infrastructure, user sophistication, and other country characteristics.

Table 3.6
Groups of Selected Countries by Number of Top 16 Technology Applications

14 to 16 TAs (Very High Demand)	10 to 12 TAs (High Demand)	6 to 9 TAs (Medium Demand)	1 to 5 TAs (Low Demand)
Australia (16)	China (12)	Brazil (9)	Cameroon (5)
Canada (16)	India (12)	Chile (9)	Chad (5)
Germany (16)	Poland (12)	Colombia (8)	Dominican Republic (5)
Israel (16)	Russia (12)	Indonesia (9)	Egypt (5)
Japan (16)		Mexico (9)	Fiji (5)
South Korea (16)		South Africa (9)	Georgia (5)
United States (16)		Turkey (9)	Iran (5)
			Jordan (5)
			Kenya (5)
			Nepal (5)
			Pakistan (5)

The first group comprises countries with the capacity to acquire 14 to 16 TAs:

Australia, Canada, Germany, Israel, Japan, South Korea, and the United States. As economically and scientifically advanced nations, they have the institutional, human, and physical capacity necessary to acquire all top 16 TAs.

The second group comprises countries capable of acquiring 10 to 12 TAs: China, India, Poland, and Russia. S&T capacity indicators for these countries suggest a considerable level of scientific and technological proficiency.

The third group comprises countries with the capacity to acquire 6 to 9 TAs: Brazil, Chile, Colombia, Indonesia, Mexico, South Africa, and Turkey. These countries have more-limited S&T capacity and generally rank lower in their economic and social development indicators.

The last group of countries has the least capacity to acquire TAs described in this study. Eleven of our 29 selected countries fall into this group: Cameroon, Chad, the Dominican Republic, Egypt, Fiji, Georgia, Iran, Jordan, Kenya, Nepal, and Pakistan.

A low level of S&T capacity and poor standing in other economic development indicators suggest that they will at best be able to acquire only TAs that require a low level of institutional, human, and physical capacity to implement.

Countries in this group have the capacity to acquire only the 5 TAs that require a minimum level of S&T capacity – **cheap solar energy, rural wireless communications, GM crops, filters and catalysts, and cheap autonomous housing**. Although these countries have the capacity to acquire only a small number of TAs, these TAs – if implemented on a broad scale and in a sustainable manner – have the potential to improve livelihood for the vast majority of their populations who live in poverty. (p 91)

The two main drivers for implementing these TAs are *reducing resource input to increase economic competitiveness and the need to respond to pressures from population growth and demographic trends.*

As for barriers to implementing TAs, the countries in this group share the same ones as the preceding groups cost and financing, laws and policies; social values, public opinions, and politics; Infrastructure; Resource use and environmental health; Investment in R&D; Education and literacy; Population and demographics; Governance and stability.

Particularly notable isthat none of these 11 countries has barriers that are simultaneously drivers, as is the case for all the other representative countries. This difference suggests how much further these countries have to go to develop institutional, human, and physical capacity to implement TAs. For them, it is more about building capacity – because there is virtually none – rather than reconciling or modifying what is present with the demands of these TAs.

The lack of money and financial mechanisms to enable implementation of TAs is a major barrier. Foreign assistance might help pay for a few demonstration projects or training and hardware for a number of users in the launch period; however, large-scale diffusion and sustainable implementation of these TAs will ultimately depend on finding ways to finance their use. At the individual level, income gain and creative financial arrangements (e.g., micro-lending) are necessary for individuals to purchase these TAs. At the national level, policymakers have to see value in investing in these TAs and follow through with actions (e.g., budget allocations, laws, awareness campaigns, and enforcement efforts) to promote their implementation in a sustainable manner. In addition to shortage of funds, laws and policies, as well as good governance and stability, are typically in short supply in these countries.

It is important to note that capacity to acquire a TA does not necessarily equal capacity to implement, because the latter requires a threshold level of physical, human, and institutional capacity; financial resources; and the social, political, and sometimes even cultural environment necessary to maintain and sustain widespread use of the TA drivers for and barriers to technology implementation in each of the 29 representative countries.

A short description of drivers and barriers

Cost and Financing

An obvious driver and barrier to the application of any technology is money, whether it is available to acquire the technology, construct the physical infrastructure to support its use, or build the human capacity to deliver, apply, and sustain its use. How much a technology costs is only one of many considerations for government, commercial, and individual decision-makers. Analogous to this is the ability to access funds and the costs of those funds. The economically advanced countries certainly have more resources available than the less-developed ones to enable their acquisition and use of technologies.

At the same time, they have superior ability to access funds. The banking and financial sectors in these countries are well developed and regulated. They have numerous mechanisms through which governments, companies, and individuals can access funds at mutually agreed costs and risks. For most less developed economies, the types of mechanisms available to acquire funds are much more restricted, which further hinders their ability to deploy technologies. Therefore, although cost and financing can generally be barriers to most countries, mechanisms to access funds represent drivers. And those countries that have these mechanisms will be more able to adopt the described TAs. study.

Laws and Policies

Laws and policies can create friendly or hostile environments that can promote or hinder technology implementation and exploitation. The passage of laws and enunciation of policies that explicitly promote or prohibit the use of a technology will significantly influence government, commercial, and individual decisions.

Social Values, Public Opinion, and Politics

Religion, traditions, customs, and social mores can affect how technologies are perceived, and compatibility of a new technology with the values and beliefs of a society can affect its adoption. Such perspectives can shape public opinion and the politics behind debates to define problems and acceptable technological solutions.

Infrastructure

Having such infrastructure as airports, seaports, roads, electrical power and water supply, and telecommunications at a threshold of quality (e.g., no frequent and large scale sudden power interruptions or intermittency in water supply) can be critical to the implementation of TAs. Building infrastructure is a first step, which in many developing countries is carried out with bilateral and multilateral development grants and loans.

However, the more important task is to make infrastructure produce payoffs for the nation, which requires its maintenance and continuous upgrade and expansion over time

Privacy Concerns

Although the desire to protect privacy is a personal preference, it is shaped as much by social values toward privacy as an individual's experience and ideological inclinations. How society views privacy can significantly affect national discussions on the implementation of TAs that have ramifications for privacy protection. Societies that are more open and free and have greater respect for individual rights will likely have more-vibrant debates on the impact of technology on privacy than those that are less open and free, or where assertions of collective good take precedence. It is also important to note that privacy concerns can be a driver for the development of technologies to increase the security of personal information (e.g., through anonymity) or to enable the use of surveillance methods while protecting personal identities.

Resource Use and Environmental Health

The availability and accessibility of natural resources and concerns about environmental health and its impact on humans are important drivers and barriers to technology implementation.

R&D Investment

Technology implementation requires know-how and capacity to adopt, disseminate, and implement for practical uses. Scientific knowledge, technical skills, and means to provide sustainable access to and use of technology are essential. Those societies with a higher level of science and technology (S&T) capacity will be better able to implement TAs and to produce their own technological innovation or advance technology to offer better solutions to their problems.

Building S&T capacity requires investment in R&D. Funding for the education and training of scientists and engineers, scientific research and technology development activities, promotion of technology transfer to commercial applications, and dissemination of technology into the marketplace might come from public or private sources. However, R&D investment does not exist in a vacuum. It must compete with other spending priorities of the state and of private investors, who look for opportunities with high return on investment. Countries in which government policies are hostile to economic activities, politics are unstable, and the level of R&D capacity is extremely low generally are not attractive places for investment that would promote R&D capacity building.

Indeed, S&T capacity building is a long-term and cumulative process that requires not only financial investment, but also a host of other inputs and conditions to establish, maintain, and generate benefits for society. A positive correlation is evident between those that spend a larger share of their gross national product in R&D and those that are more able to acquire and implement the TAs.

Education and Literacy

Education is critical to cultivating a population that is literate and comfortable with, and a workforce able to interface with S&T. But, of course, like other drivers and barriers examined, education and literacy are a necessary, but not a sufficient, requirement for technology implementation. A society must have other elements in place to provide incentives for people to acquire education and opportunities for people to use their knowledge and skills.

At a minimum, having a population that is literate, comfortable with technology, and able to interface with technology will be critical to the implementation of TAs that require even the lowest level of technical know-how. Users also have to welcome the potential benefits of technology and be willing to accept the risks and uncertainties associated with it. Such sentiments are necessary to encourage acceptance and to push for acquiring and applying new technologies. In their absence, potential users are unlikely to embrace new technologies, even if they are supplied free of charge. Also, ignorance, prejudice, and alienation can prevent these potential users from accepting new technologies.

Population and Demographics

Population size and demographics can be a strong driver or barrier to policy decisions. For countries with large and rapidly aging populations, policymakers will want to look for technological solutions that can help to provide care and reduce the cost of medical and health care services. Countries with large young populations, however, will need to generate jobs and economic growth, for which technologies might provide options. Countries with rapidly growing populations, shrinking arable land, or harsh climatic conditions might also seek technological solutions to improve food production and nutrition.

Governance and Stability

Governments that are corrupt and in which abuse of power is rife pose a significant hindrance to development. Countries in which corruption is severe perform poorly economically compared with those in which corruption is limited.

References

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Annex 3

Questionnaire for Georgian R&D Institutions and Universities

(In Russian)

Перечень вопросов для проведения интервью

I Общие сведения об организации/учреждении

Учреждение					
Статус (самостоятельное, член системы АН Грузии, ведомственное, др)					
Руководитель/директор/заведующий					
	2002	**2003**	**2004**	**2005**	**2006, ноябрь**
Научные сотрудники со степенью (всего)					
В том числе со степенью **доктора наук**					
Научные сотрудники без степени					
Технический персонал					
Персонал (всего)					

II. Состояние финансовых ресурсов организации/учреждения, тыс.. лари

Источники финансирования	2003	2004	2005	2006	2007 (план)
Министерство образования и науки					
АН Грузии					
Другие министерства					
Частный бизнес/фирмы Грузии					
Эвропейская Комиссия					
Иностранный частный бизнес/ фирмы					
Международные гранты/программы *					

* Необходимо указать, какие именно международные гранты и программы (кроме Евросоюза) при условии наличия этого источника

III. Научно-исследовательская деятельность

	2002	2003	2004	2005
Общее число публикации, (Количество)				
Из них:				
Научные статьи, реферируемые в базе данных ISI Web of Science				
Статьи в других зарубежных журналах				
Статьи в грузинских научных журналах				
Монографии, опубликованные зарубежными издательствами				
Монографии, публикованные грузинскими издательствами				
Тезисы докладов, реферируемые в базе данных ISI Web of Science				
Другие тезисы докладов				
Патенты				
Гранты				
Премии (государственные или международные)				

IV. Вопросы о состоянии системы научно-исследовательской деятельности Грузии

IV 1. Произошли ли в последние годы какие-либо изменения в сфере научно-исследовательской деятельности в Грузии, которые Вы считаете положительными? (укажите столько вариантов ответов, сколько считаете нужным).

а) Установление связей с мировым научным сообществом.

б) Устранение информационной изоляции от зарубежных стран.

в) Появление возможностей для сотрудничества с зарубежными коллегами.

г) Организация совместных исследований.

д) Развитие новых направлений исследований.

е) Активизация материальной поддержки из различных источников (пожалуйста, укажите, каких именно) ____

ж) Развитие научной деятельности в вузах.

з) Другое (укажите, что именно) ____

и) Позитивных изменений не произошло.

IV 2. Какое было влияние преобразований в течение двух-трёх последних лет, проводимых в стране, на состояние научно-исследовательской деятельности? (укажите столько вариантов ответов, сколько считаете нужным). Для отмеченных Вами факторов укажите степень их проявления.

№ п/п	Проявление влияния (полпжительного или отрицательного)	Степень проявления факторов		
		Сильная	Средняя	Слабая
1	Ослабление/усиление материальной поддержки со стороны государства.			
2	Ослабление/усиление моральной поддержки со стороны государства.			
3	Ограничение/увеличение возможности исследовательской деятельности научных работников.			
4	Негативное/позитивное воздействие на материальное положение работников.			
5	Негативное/позитивное влияние на социальное положение работников.			
6	Уход/приток квалифицированных кадров из отраслей/в отрасли науки и образования.			
7	Падение/повышение статуса интеллектуального труда и недооценка его социальной значимости.			
8	Формирование негативного/позитивного общественного мнения относительно имиджа науки.			
9	Невостребованность/востребованность науки системой высшего образования.			
10	Отсутствие возможности/появление новых возможностей реализации себя как ученого.			
11	Эмиграция/возвращение из-за границы профессионалов			
12	Другое (укажите, что именно)			
13	Негативного/положительного влияния не было			

IV 3. Определите самые актуальные вопросы в сфере развития научно-исследовательской деятельности, которые необходимо решить в первоочередном порядке в вашем учреждении/организации в ближайшие 2-3 года?

IV 4. Очертите самые злободневные («больные») вопросы в сфере научно-исследовательской деятельности, которые есть в вашем учреждении/организации и которые необходимо решить в первоочередном порядке в ближайшие 2-3 года?

IV 5. Какие учреждения/группы и т.д. должны принимать участие в разработке системы управления научно-исследовательской деятельностью в Грузии?

IV 6. Какие основные положения должны быть учтены при разработке системы научно-исследовательской деятельности в Грузии?

IV 7. Оцените по 10-балльной шкале состояние системы управления научно-исследовательской деятельностью в Грузии?
1 – хуже некуда, 10 – просто отлично

V 1. Каковы, по Вашему мнению, сильные и слабые стороны существующей системы поддержки научно-исследовательской деятельности в Грузии, а также возможности и угрозы, влияющие на нее?

Сильные стороны	Слабые стороны

V 2. Каковы, по Вашему мнению, возможности и угрозы существующей системы поддержки научно-исследовательской деятельности в Грузии?

Возможности	Угрозы

V 3. Как, по Вашему мнению, должна быть построена СИСТЕМА УПРАВЛЕНИЯ научно-исследовательской деятельностью Грузии? А именно (УРОВЕНЬ УПРАВЛЕНИЯ, УЧАСТНИКИ ПРОЦЕССА УПРАВЛЕНИЯ И Т.Д.):

V 4. Перечислите обстоятельства, которые противодействуют строительству эффективной системы управления научно-исследовательской деятельностью в Грузии?

V 5. Как, по Вашему мнению, должна быть построена СИСТЕМА ФИНИСИРОВАНИЯ научно-исследовательской деятельности Грузии? А именно: (УРОВЕНЬ УПРАВЛЕНИЯ, УЧАСТНИКИ ПРОЦЕССА УПРАВЛЕНИЯ И Т.Д.):

V 6. Перечислите обстоятельства, которые противодействуют строительству эффективной системы финансирования научно-исследовательской деятельности в Грузии?

V 7. В общем контексте состояния науки в Грузии, какие отрасли научного знания Вы бы охарактеризовали как:

Очень перспективные____

Менее перспективные____

Мало перспективные ____

V 8. Какие, по Вашему мнению, самые слабые звенья в цепи создания инновации (от идеи до готового продукта) в Грузии? (Укажите столько вариантов, сколько считаете нужным).

а) Генерирование новых идей.

б) Экономический анализ новых идей.

в) Отбор наиболее актуальных идей.

г) Анализ осуществимости идеи.

д) Разработка идеи, оценка производственных мощностей.

е) Бизнес-анализ: потенциальный рынок, цена, риски и т.д.

ж) Тестирование.

з) Коммерциализация.

и) Финансовая поддержка.

к) Другое (укажите, что именно)____

V 9. Какие самые важные вопросы и темы, связанные с формированием системы управления научно-исследовательской деятельностью, Вы хотели бы обсуждать на семинарах, проводимых совместно с иностранными экспертами?