Governance of Emerging Technologies in Developing Countries;

The Case of Iran Nanotechnology

Hamidreza Amirinia

About Me !

NOW:

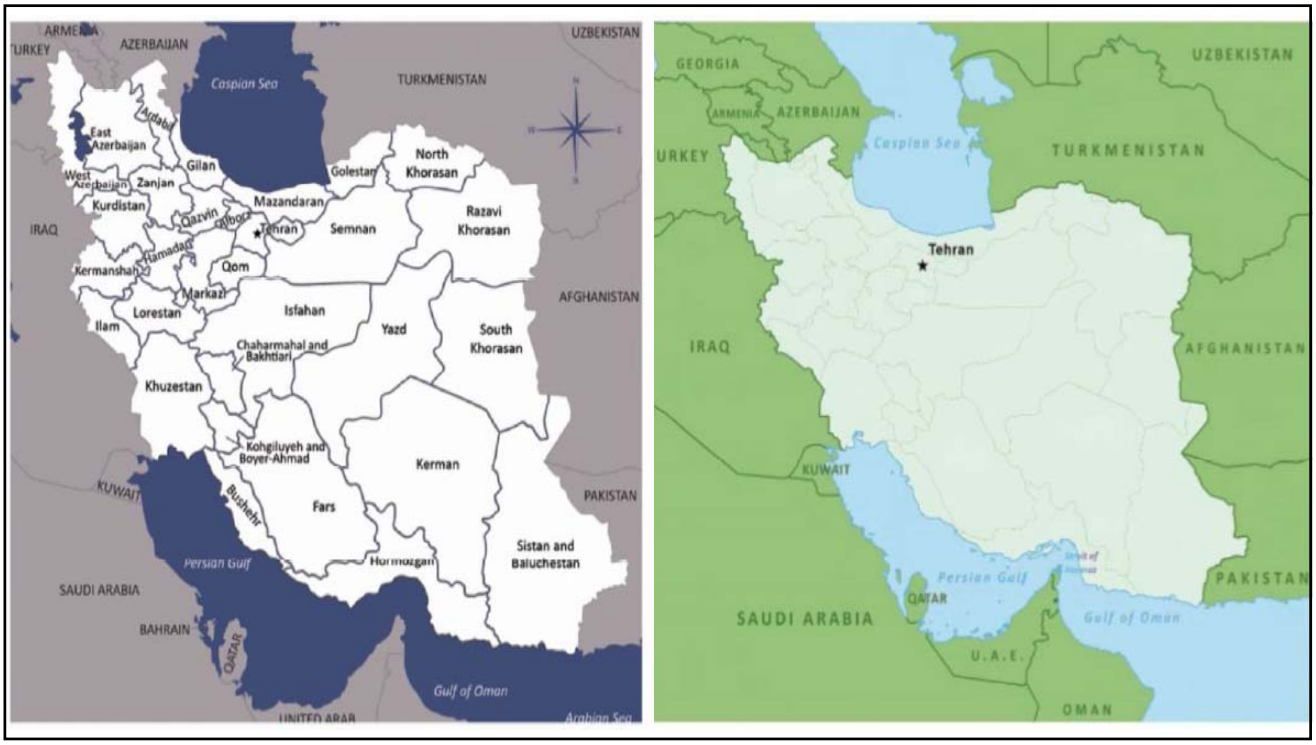
- Head of the International Innovation and Technology Exhibition (INOTEX) and Forum.
- Member of the Steering Headquarter for Implementation of the National Science and Technology Master Plan.
- Advisor to the Secretary of Iranian Supreme Council for Cultural Revolution in International Science and Technology Policy studies.

About Me !

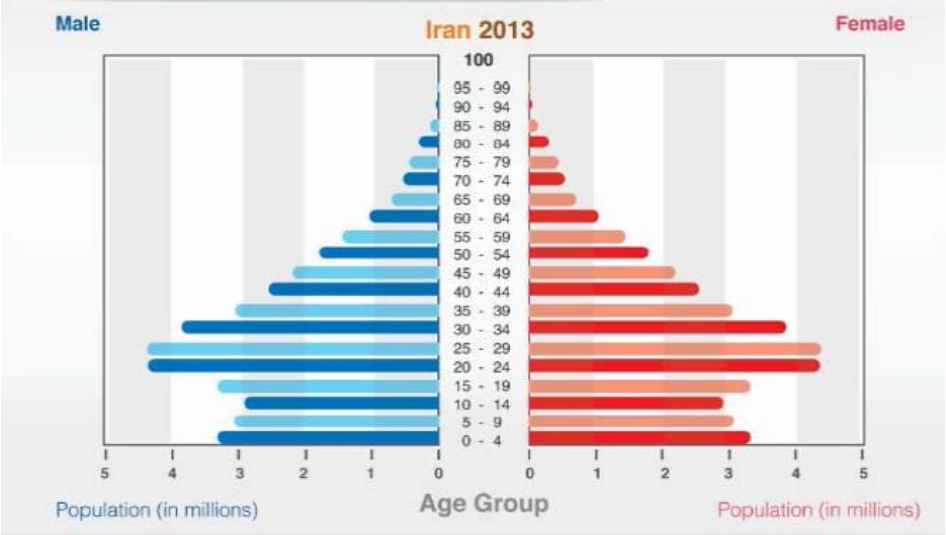
Former…

- Advisor to Iran Vice-President for Science and Technology (up to 2015)
- Head of Center for Innovation & Technology Cooperation , Presidency (2008-2014)
- Member of Iranian National Science and Technology policy Committees for Nanotechnology, Biotechnology, Renewable energy, Herbal Drug, etc., between 2008- 2015.
- Iran Embassy's Science – Industrial Attaché in Moscow from (2005-2008)
- Head of the Engineering Department Technology Cooperation office, Presidency(2003-2005)
- Vice-Chairman of the Technology Cooperation office, Presidency (1998 - 2001).


Iran
at a Glance


ARMENIA
AZERBAIJAN
URKEY
UZBEKISTAN
Caspian Sea
TURKMENISTAN
East Azerbaijan
West Azerbaijan
Ardabil
Gilan
Zanjan
Golestan
North Khorasan
Kurdistan
Mazandaran
Qazvin
Alborz
Tehran
Semnan
Razavi Khorasan
IRAQ
Hamadan
Kermanshah
Qom
Markazi
AFGHANISTAN
Lorestan
Isfahan
Yazd
South Khorasan
Ilam
Chaharmahal and Bakhtiari
Khuzestan
Kohgiluyeh and Boyer-Ahmad
Kerman
KUWAIT
Bushehr
Fars
PAKISTAN
Persian Gulf
Hormozgan
Sistan and Baluchestan
SAUDI ARABIA
BAHRAIN
QATAR
Gulf of Oman
Arabian Sea
GEORGIA
ARMENIA
AZERBAIJAN
Caspian Sea
URKEY
TURKMENISTAN
UZBEKISTAN
Tehran
IRAQ
AFGHANISTAN
KUWAIT
Persian Gulf
PAKISTAN
QATAR
SAUDI ARABIA
Gulf of Oman
U.A.E.
OMAN

Iran's Population by age group and gender

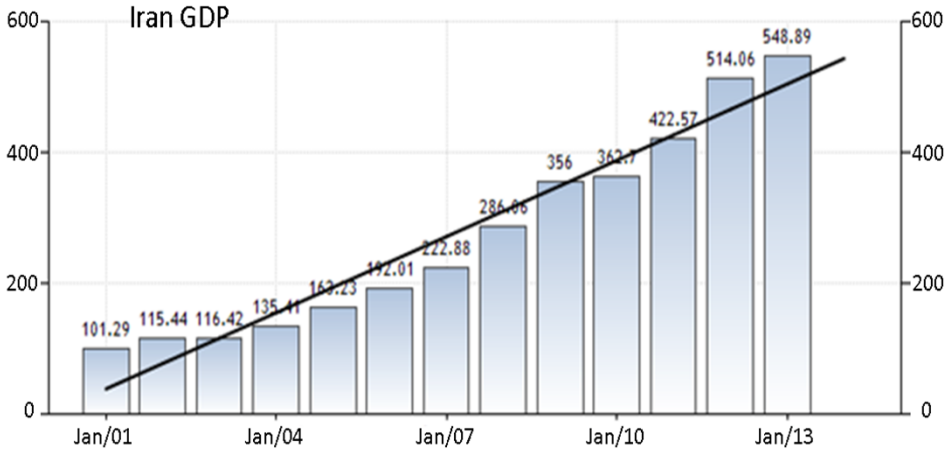


University students in Iran (2011-2012)

Gender	Population
Male	2,213,205
Female	2,191,409
Total	4,404,614

Iran's GDP growth, 2004-2015

Iran's GDP growth, 2001-2013



*The **Monar Jonban** (Shaking Minarets) is a monument located in Isfahan, in central Iran.*

Construction began in the 14th century to cover the grave of Amu Abdollah Soqla.

Its notable feature is that if one of the minarets is shaken, the other minaret will shake as well.

The "Imam Mosque" is a mosque in Isfahan, Iran, standing in south side of Naghsh-e Jahan Square. Built during the Safavid period, ordered by the first Shah Abbas of Persia.

It is regarded as one of the masterpieces of Persian Architecture and an excellent example of Islamic era architecture of Iran.

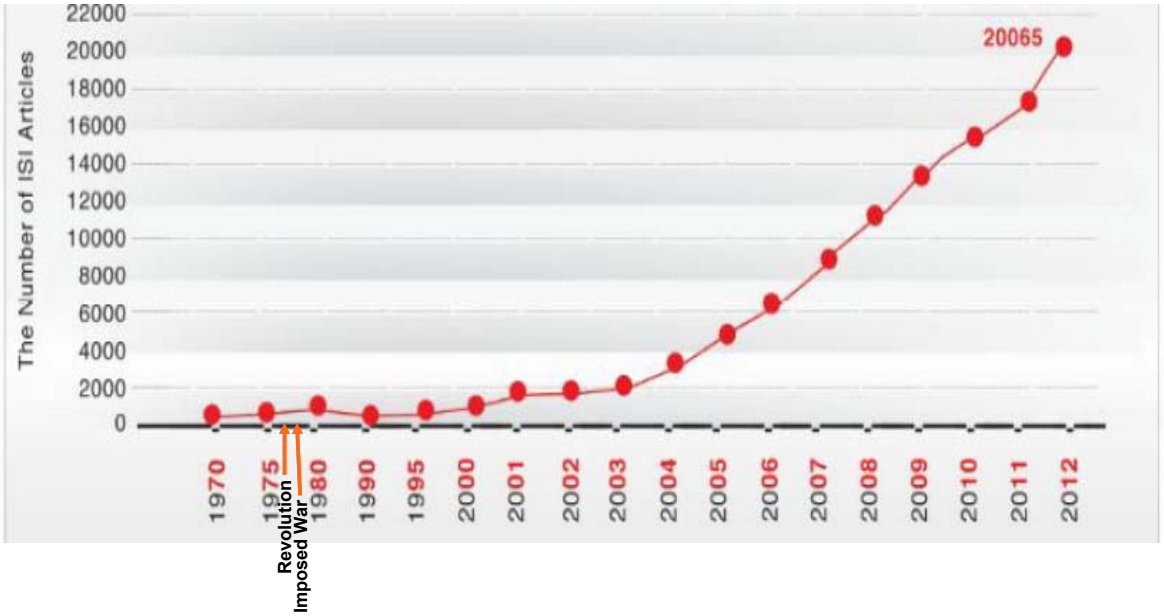
The "Imam Mosque" is one of the finest and the most stunning buildings in the world


Iran's
Science &
Technology
Status
A Brief Representation of
Technological Achievements
THE
ISLAMIC
REPUBLIC OF
IRAN

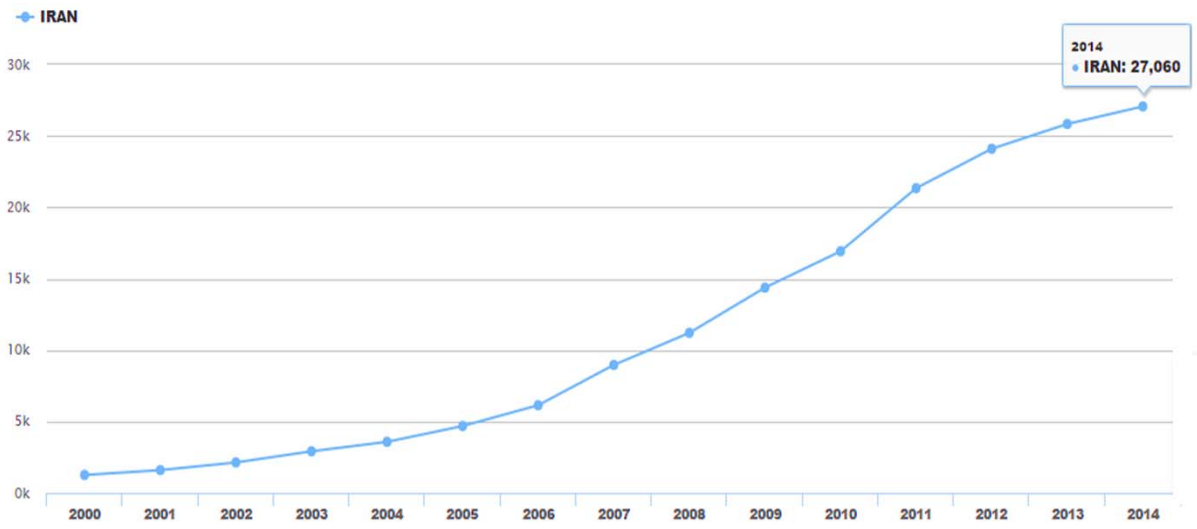
Higher education institutes and center in Iran (2011-12)

1- Governmental Higher Education Sector (Affiliated to MSRT)	
Universities	105
Independent schools	16
Higher education centres	9
Institutes	135
Payam-e-Noor University local study centres and campuses	500
Universities of Applied Science and Technology	169
2- Non-Governmental Education Centres/ Private higher education	
Non-profit institutes	285
Islamic Azad University branches (inside the country and abroad)	406
Total	1625

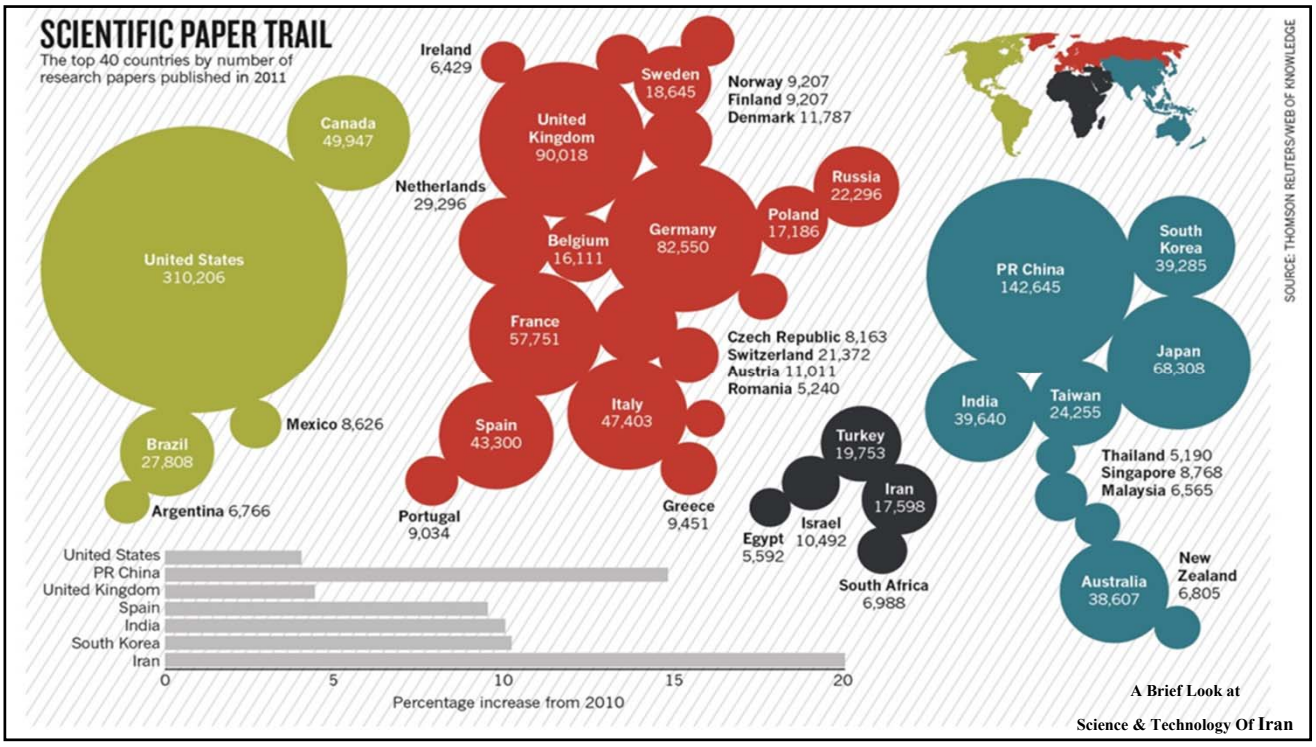
Growth of ISI articles of Iran, 1970-2012

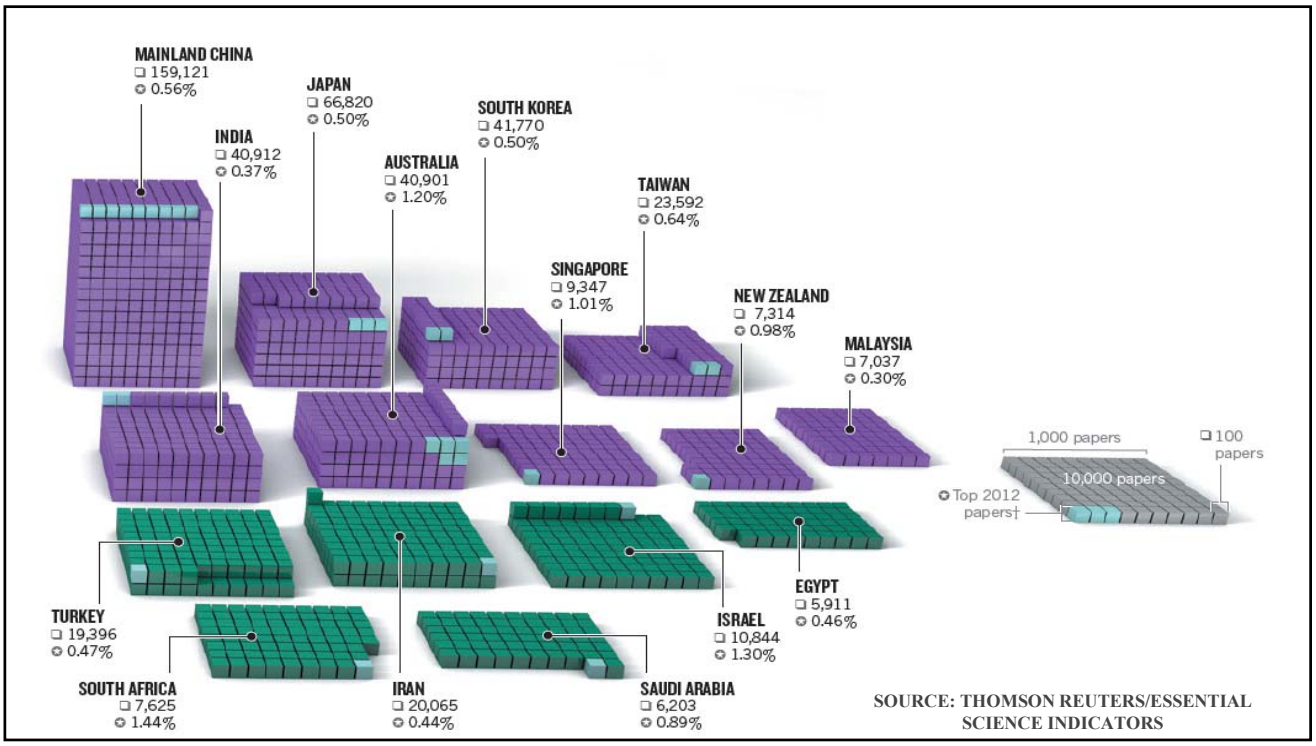


Growth of ISI articles of Iran, 2000-2014

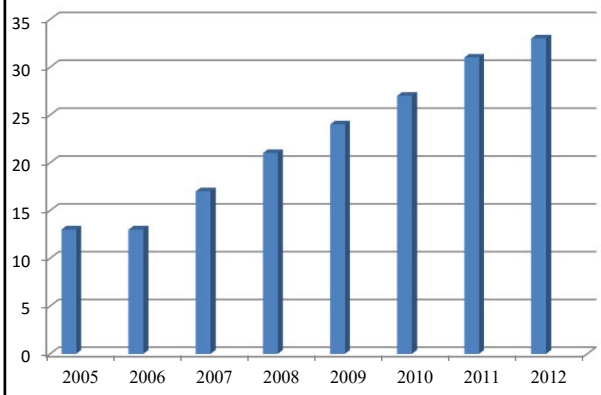


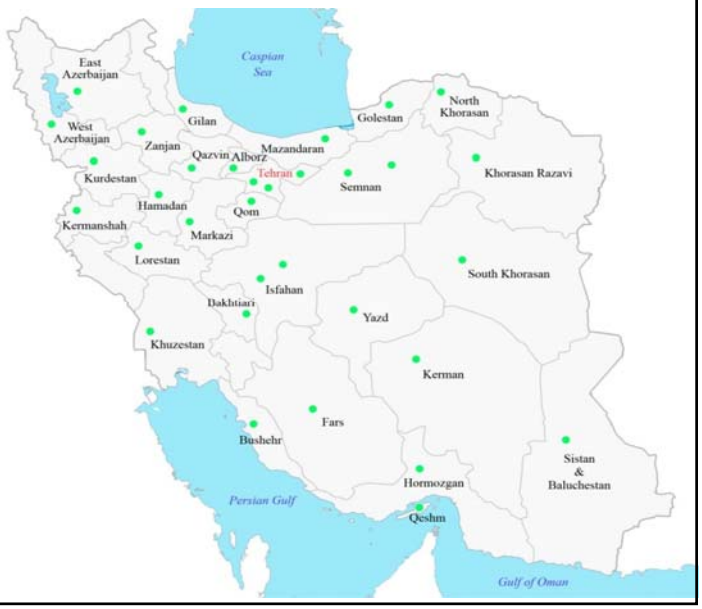
Rank	Country	No. of Research Papers Published in 2011	No. of Research Papers Published in 2012	Rank	Country	No. of Research Papers Published in 2011	No. of Research Papers Published in 2012
1	United States	310206	311975	21	Poland	17186	17602
2	People's Republic of China	142645	159121	22	Belgium	16111	16442
3	United Kingdom	90018	86544	23	Denmark	11787	12376
4	Germany	82550	83216	24	Austria	11011	11132
5	Japan	68308	66820	25	Israel	10492	10844
6	France	57751	57320	26	Portugal	9034	10068
7	Canada	49947	51107	27	Norway	9207	9456
8	Italy	47403	48353	28	Finland	9207	9368
9	Spain	43300	44935	29	Singapore	8768	9347
10	South Korea	39285	41770	30	Greece	9451	9281
11	India	39640	40912	31	Mexico	8626	9034
12	Australia	38607	40901	32	Czech Republic	8163	8400
13	Netherlands	29296	30616	33	South Africa	6988	7625
14	Brazil	27808	29924	34	New Zealand	6805	7314
15	Taiwan	24255	23592	35	Malaysia	6565	7037
16	Russia	22296	22340	36	Argentina	6766	6866
17	Switzerland	21372	21796	37	Ireland	6429	6238
18	**Iran**	**17598**	**20065**	38	Saudi Arabia	N/A	6203
19	Turkey	19753	19396	39	Egypt	5592	5911
20	Sweden	18645	19421	40	Romania	5240	N/A


SCIENTIFIC PAPER TRAIL
The top 40 countries by number of research papers published in 2011
Canada 49,947
United States 310,206
Mexico 8,626
Brazil 27,808
Argentina 6,766
Ireland 6,429
Sweden 18,645
United Kingdom 90,018
Norway 9,207
Finland 9,207
Denmark 11,787
Netherlands 29,296
Russia 22,296
Belgium 16,111
Germany 82,550
Poland 17,186
France 57,751
Czech Republic 8,163
Switzerland 21,372
Austria 11,011
Romania 5,240
Spain 43,300
Italy 47,403
Portugal 9,034
Greece 9,451
Turkey 19,753
Iran 17,598
Egypt 5,592
Israel 10,492
South Africa 6,988
PR China 142,645
South Korea 39,285
Japan 68,308
India 39,640
Taiwan 24,255
Thailand 5,190
Singapore 8,768
Malaysia 6,565
Australia 38,607
New Zealand 6,805
United States
PR China
United Kingdom
Spain
India
South Korea
Iran
0
5
10
15
20
Percentage increase from 2010
SOURCE: THOMSON REUTERS/WEB OF KNOWLEDGE
A Brief Look at
Science & Technology Of Iran

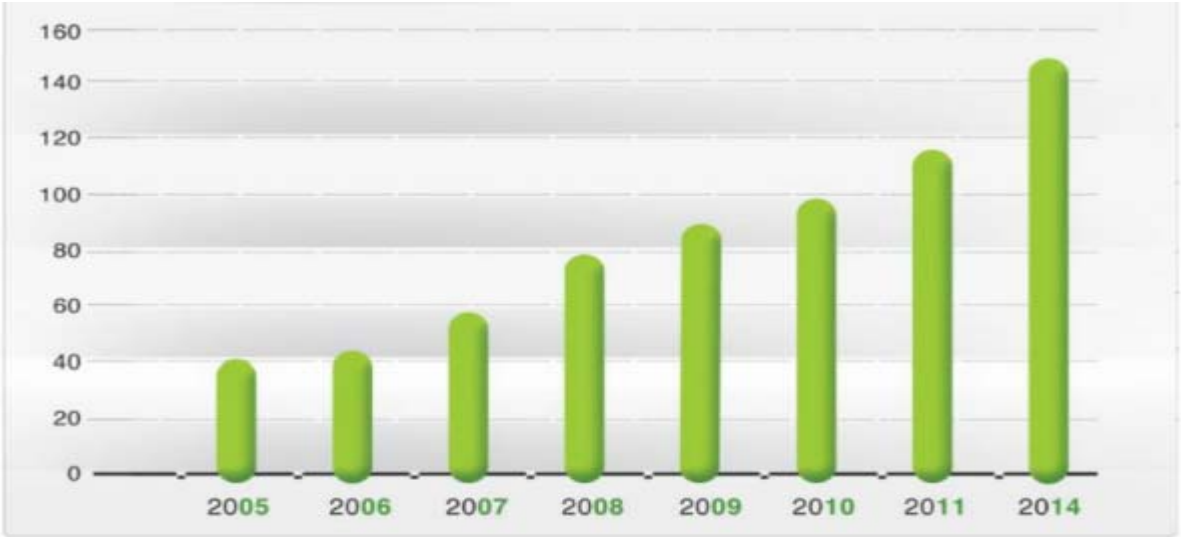

MAINLAND CHINA
159,121
0.56%
JAPAN
66,820
0.50%
INDIA
40,912
0.37%
AUSTRALIA
40,901
1.20%
SOUTH KOREA
41,770
0.50%
TAIWAN
23,592
0.64%
SINGAPORE
9,347
1.01%
NEW ZEALAND
7,314
0.98%
MALAYSIA
7,037
0.30%
1,000 papers
100 papers
10,000 papers
Top 2012 papers†
TURKEY
19,396
0.47%
SOUTH AFRICA
7,625
1.44%
IRAN
20,065
0.44%
SAUDI ARABIA
6,203
0.89%
ISRAEL
10,844
1.30%
EGYPT
5,911
0.46%
SOURCE: THOMSON REUTERS/ESSENTIAL SCIENCE INDICATORS

Growth in the number of S&T Parks during 2005-2014



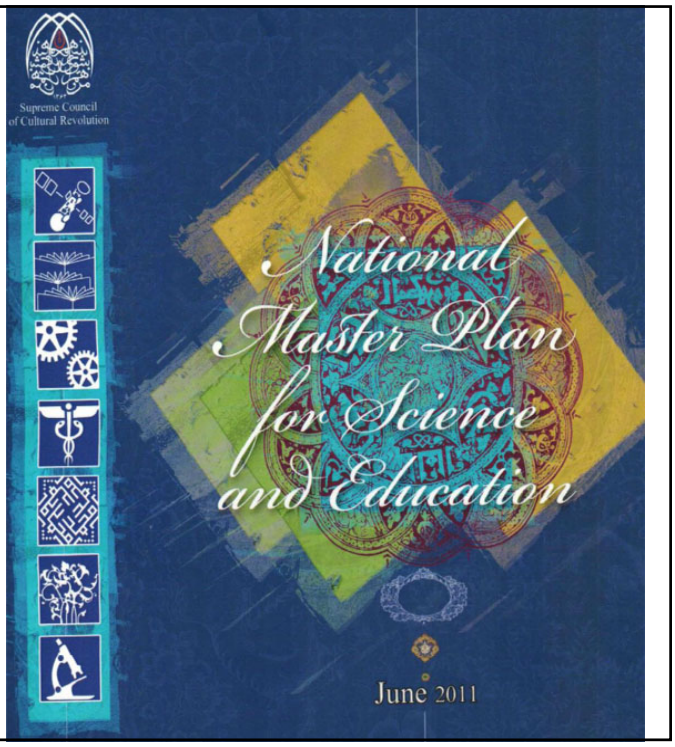


Science and Technology Incubators 2005-2014



National Master Plan for Science and Technology approval in June 2011;

NanoTechnology as a Priority



Iran's ranks in different fields according to the number of published documents (2012)

Technology field	Rank in the World
Biotechnology	14
Agriculture and Biological Sciences	12
Nanotechnology	8
Materials Science	11
Energy Engineering and Power Technology	6
Fuel Technology	4
Renewable Energies, Sustainability and Environment	16

Source: [http://www.scimagojr.com]

Current Biotechnology Position of Iran in the World

Published articles in comparison to other countries of the world [1]	Rank: 14th
General ranking in terms of production in Asia	Among top 5 Countries
Production rate in the Middle East	Rank: 1st
Vaccines production rate in the Middle East	Rank: 1st
Currently producing 28 of the most expensive Biopharmaceuticals	

Biotech progress in Iran

	1995	2011
Number of Published papers in the international Journal	6	570
Ph.D Students in the related science	30	490
Molecular diagnostic kits	0	22
Molecular Genetic lab	0	More than 22
Recombinant medicine	0	14 12 in the pipeline
ElISA based diagnostic	0	9 companies
Stem cell Therapy	0	MS, Heart diseases,…
Private Biotech company	0	42 (16 are biopharmaceutical)

8/8/2015

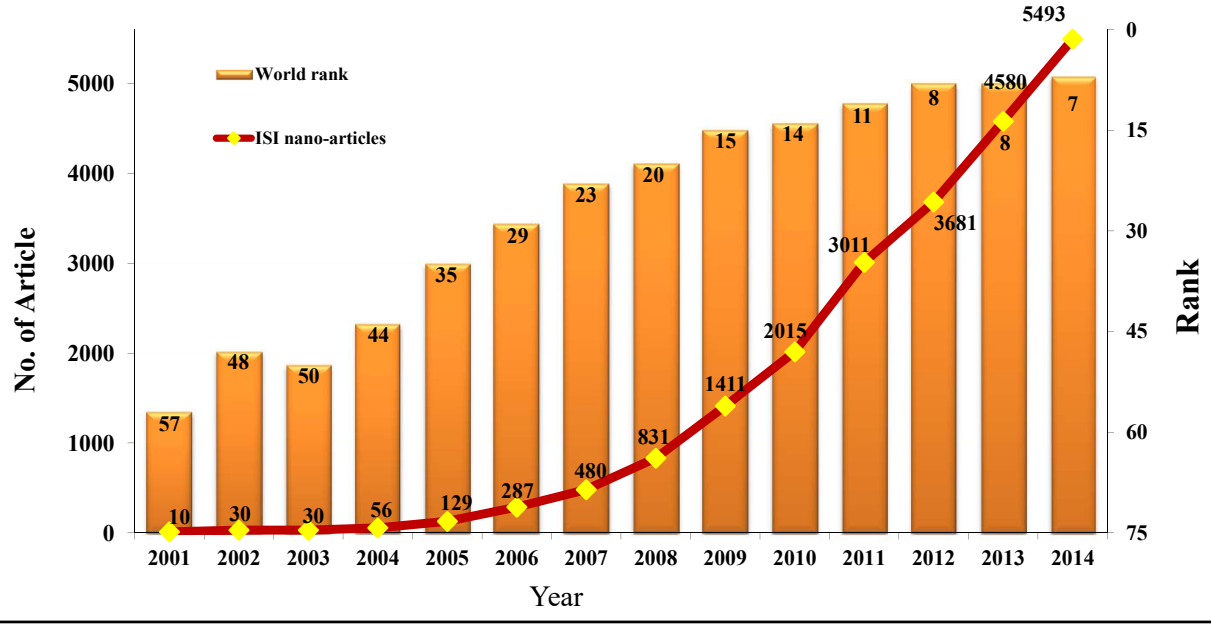
26

Biotech progress in Iran

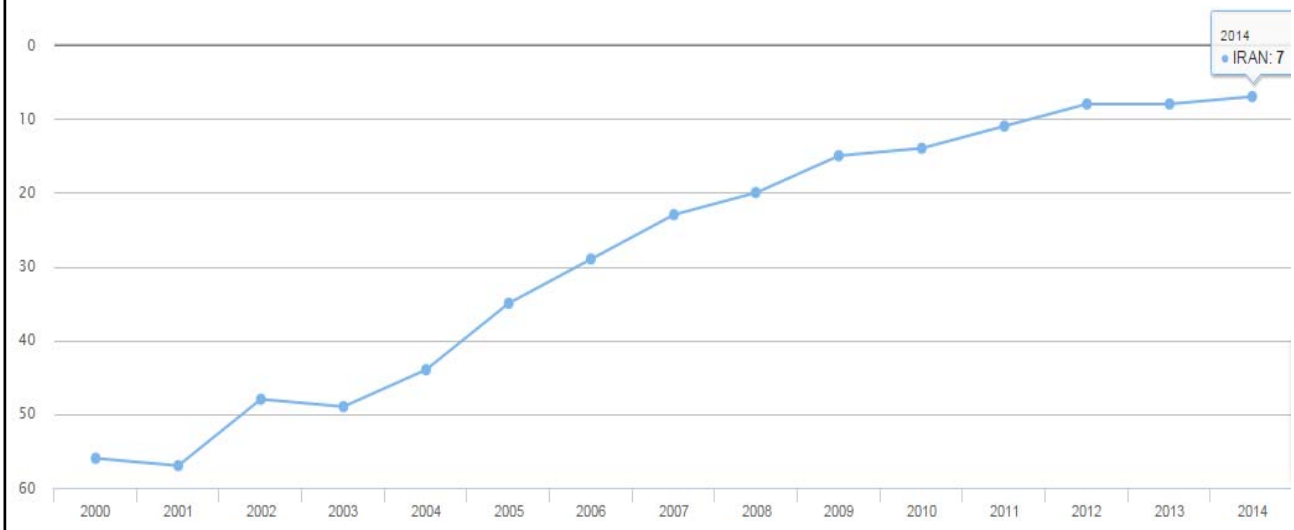
	World	China	India	Iran
Recombinant Bio pharmaceutics EPO (alpha and beta) IFN beta 1a (Cinnovex, Recigen) IFN alpha IFN gama G-CSF Peg IFN alpha HGH Peg-GCSF T-PA G-MCSF FSH PTH HB Vaccine Streptokinase	**143**	**15**	**13**	**14**
Pipeline **Majority mAb**		**6**	**5**	**12**

27

Iran`s Rank in Nano ISI Articles (2001-2014)



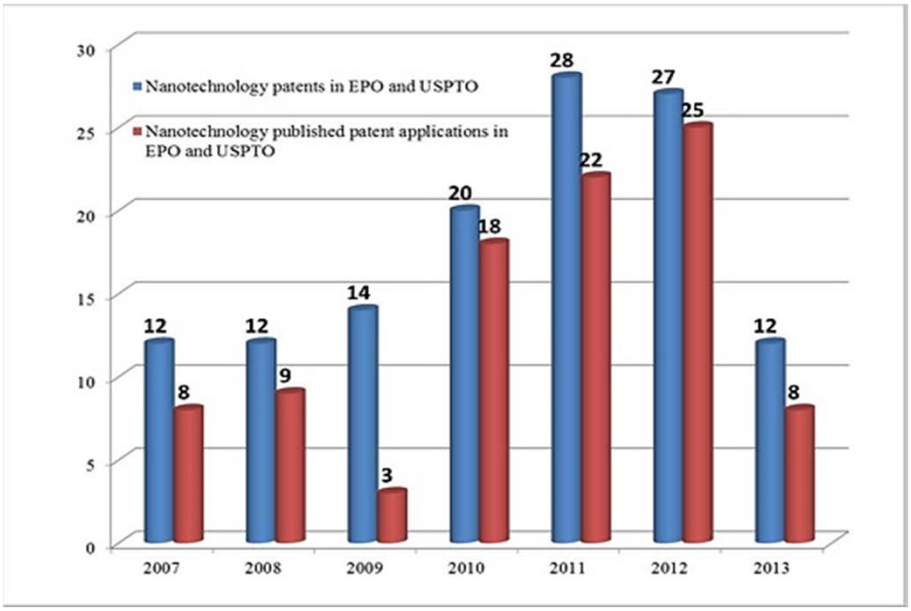
Iran`s Rank in Nano ISI Articles (2000-2014)



Top 30 Countries by Published Nano Articles in 2014

Rank	Country	Number	Share (%)	Rank	Country	Number	Share (%)
1	China	41147	32.11	16	Singapore	2299	1.79
2	USA	22260	17.37	17	Brazil	2062	1.61
3	India	9329	7.28	18	Poland	1928	1.5
4	South Korea	8237	6.43	19	Saudi Arabia	1763	1.38
5	Germany	7845	6.12	20	Switzerland	1706	1.33
6	Japan	7252	5.66	21	Turkey	1578	1.23
7	Iran	5493	4.29	22	Sweden	1542	1.2
8	France	5211	4.07	23	Malaysia	1480	1.15
9	UK	4349	3.39	24	Netherlands	1465	1.14
10	Spain	3890	3.04	25	Belgium	1211	0.95
11	Italy	3733	2.91	26	Egypt	1110	0.87
12	Russia	3508	2.74	27	Mexico	1038	0.81
13	Taiwan	3397	2.65	28	Czech Republic	914	0.71
14	Australia	3052	2.38	29	Portugal	910	0.71
15	Canada	2912	2.27	30	Finland	858	0.67

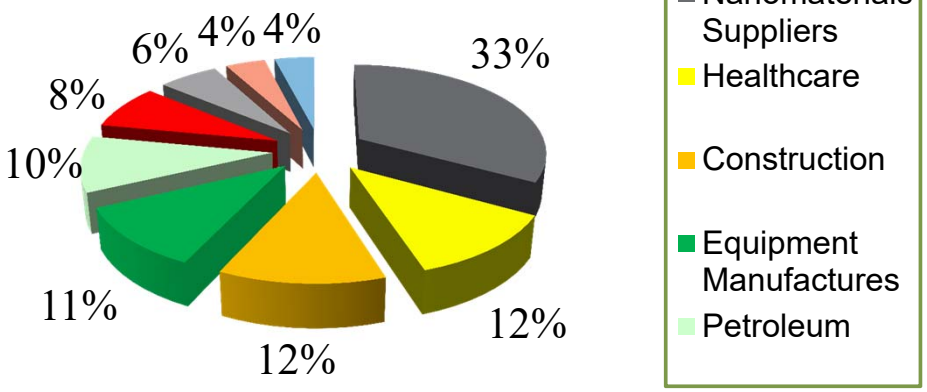
Iranian Registered NanoTechnology Patents in EPO and USPTO



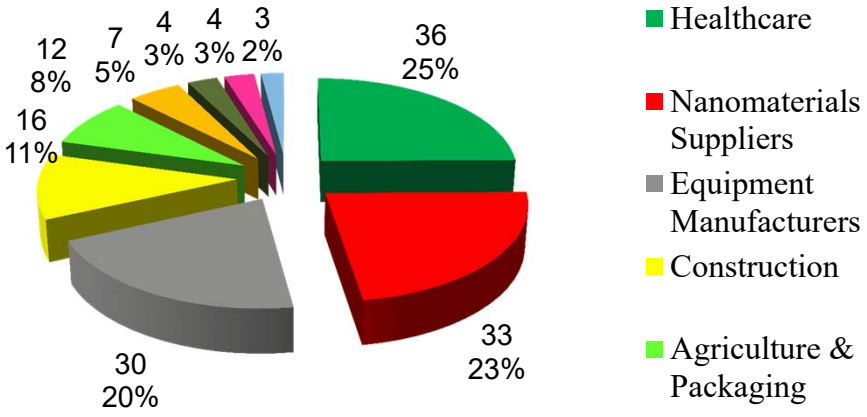
Contribution of Iran's Nano articles compared to total ISI articles in countries with more than 500 ISI articles in 2012

Rank	Country	Total country records	% of all country records
1	Singapore	9941	19.97
2	Iran	21651	16.86
3	China	175746	16.1
4	South Korea	46029	14.92
5	India	43849	13.86
6	Saudi Arabia	6664	13.78
7	Ukraine	4797	12.67
8	Malaysia	7592	12.18
9	Taiwan	25851	11.93
10	Romania	6410	11.58
11	Russia	25810	11.12
12	Egypt	6532	10.07
13	Japan	71800	9.33
14	Germany	89581	7.78
15	France	62210	7.73

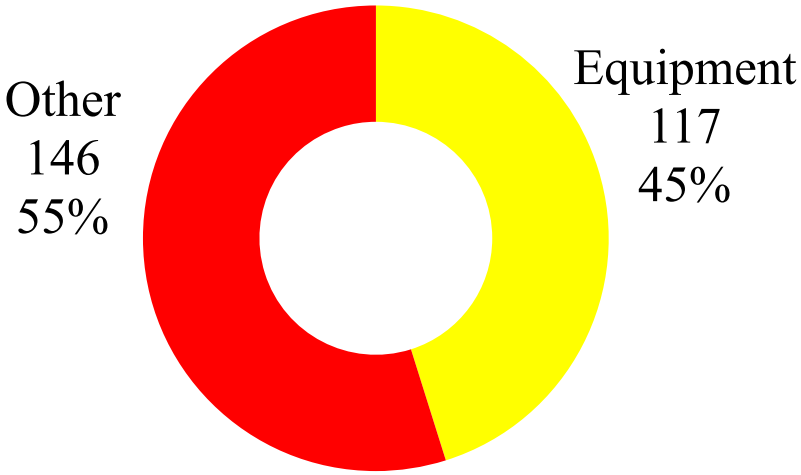
Start-up Companies: 106



Manufacturing Companies: 145

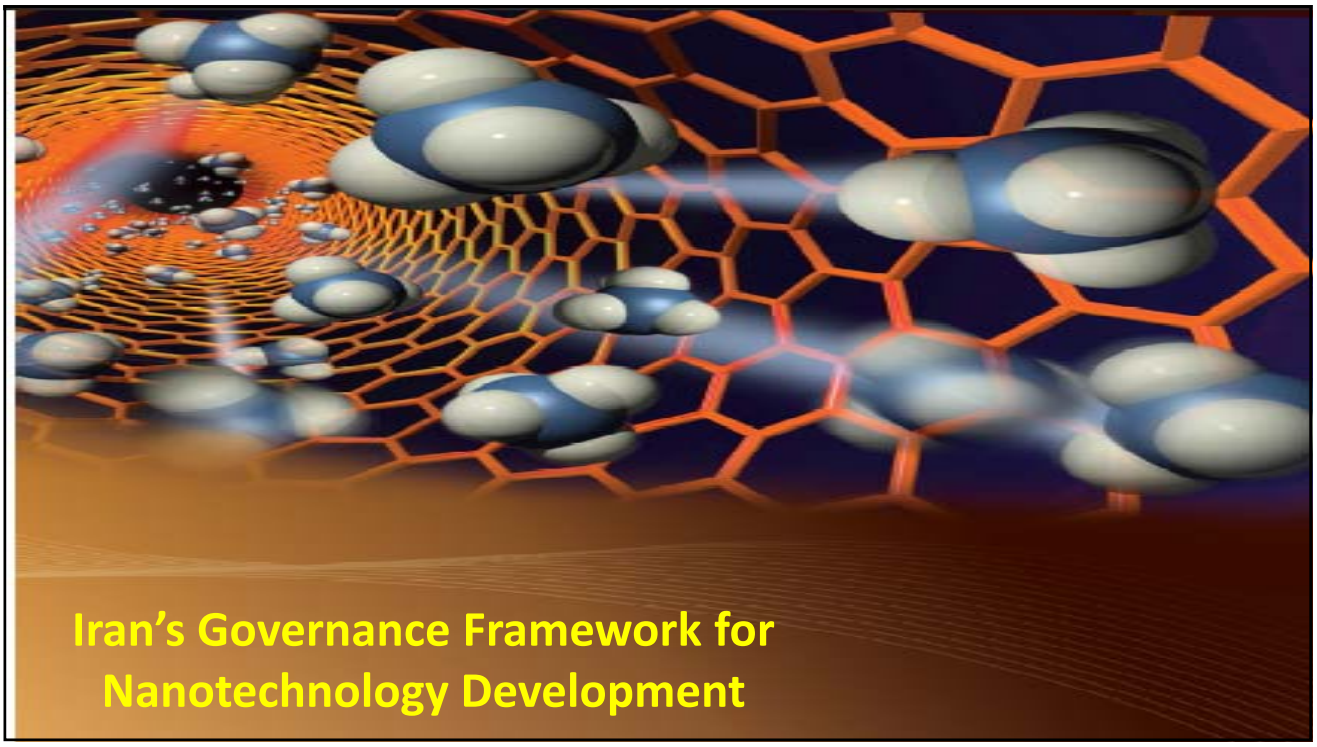


Nano Products: 263

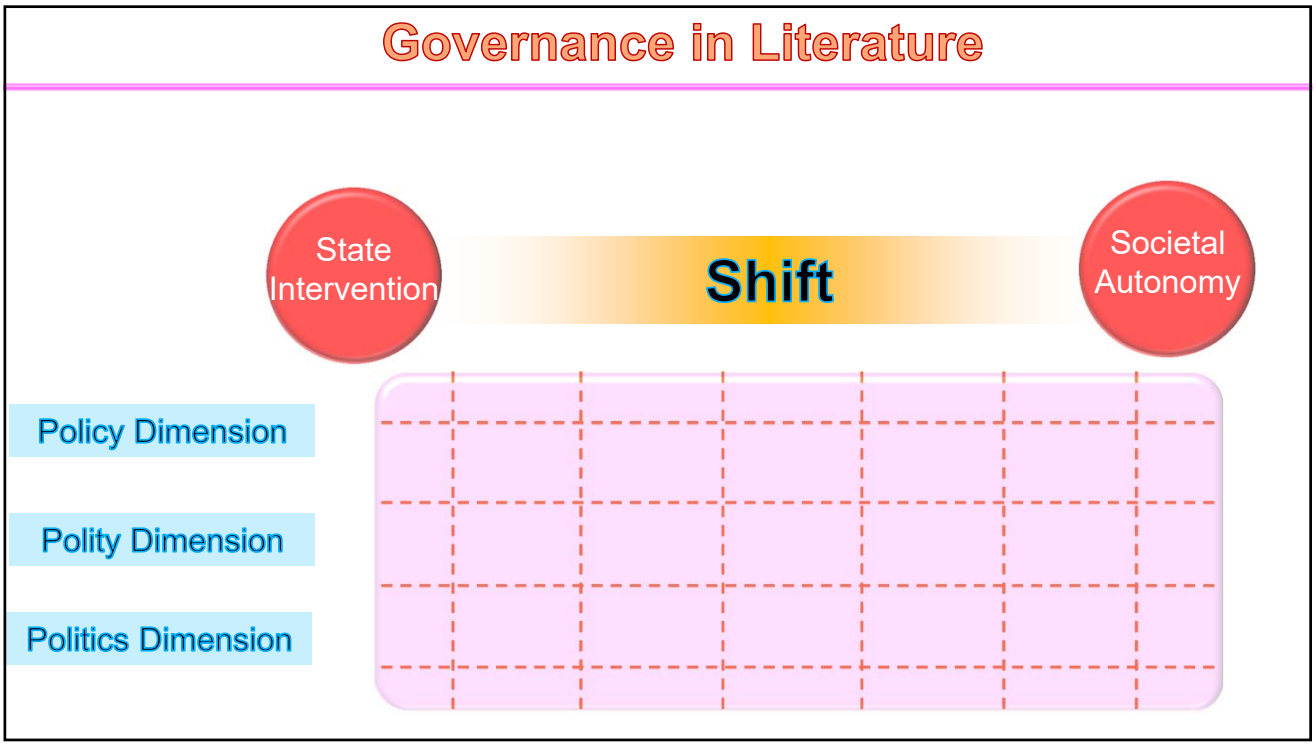


Iran Nanotechnology Statistics (2013)

Items	Total No.
Researchers / Scientists	20393 Scientists
	2614 Faculty members
Universities Running PhD Programs	15
Universities Running MS Programs	34
Universities and Research Institutes Involved	103
No. of Post Graduates (last Update 06/30/2013)	8237
PhD Projects	1312 Finished projects
	1369 Ongoing projects
MS Projects	8125 Finished projects
	4398 ongoing projects
Published Books	126 National books
	32 International books
ISI Publications (2000-2013)	16006
International Patents	119
Nanotech Laboratories	57
Start-up Companies	104

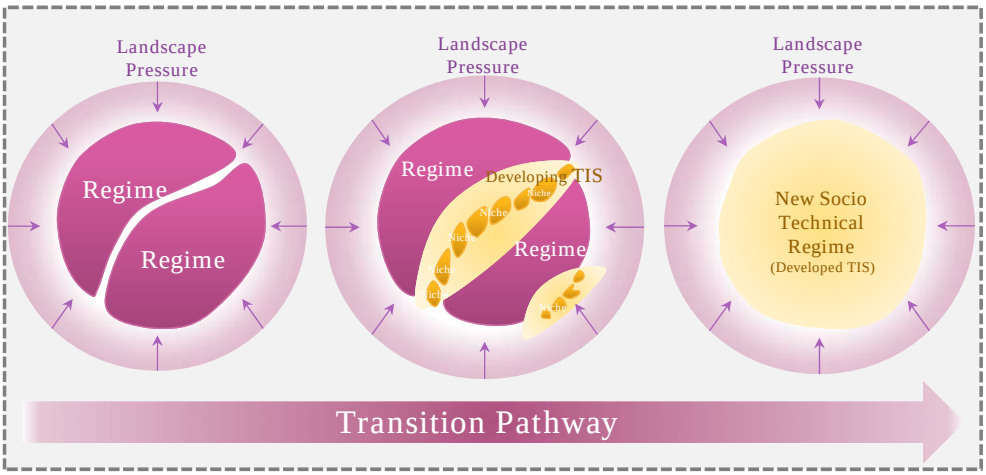


Governance in Literature

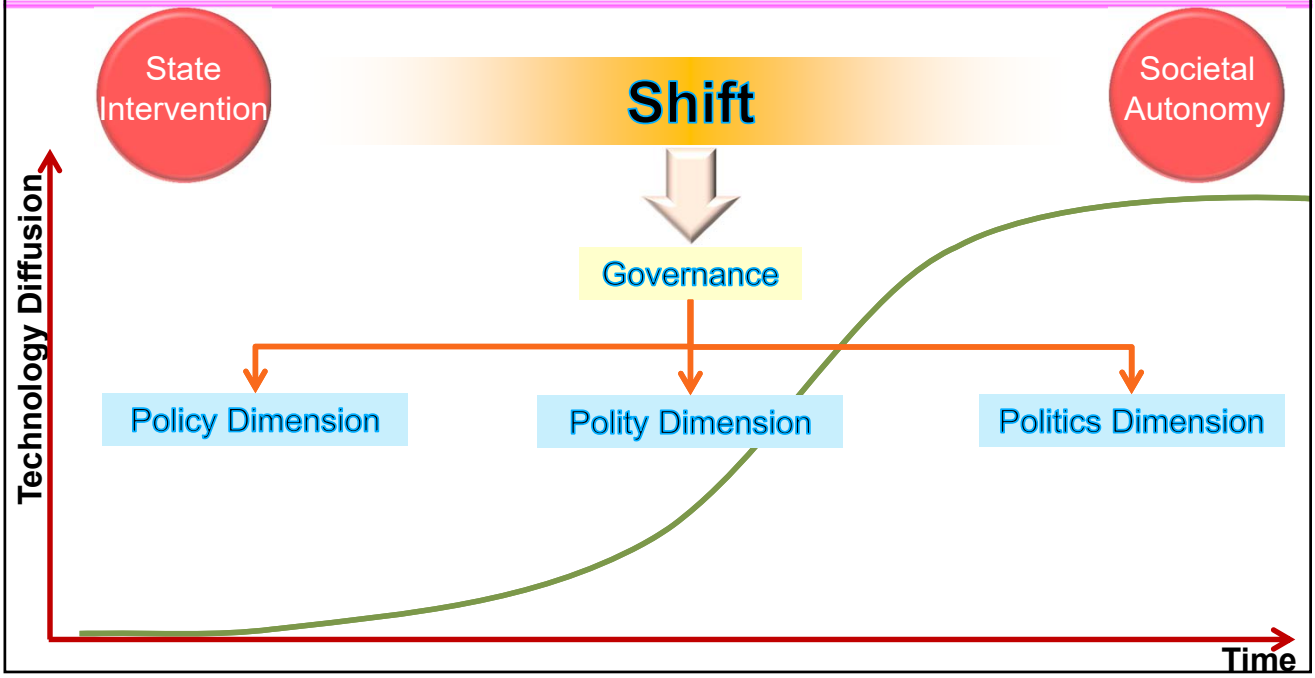


Technological Transition Literature (Moallemi *et.al.* 2012)

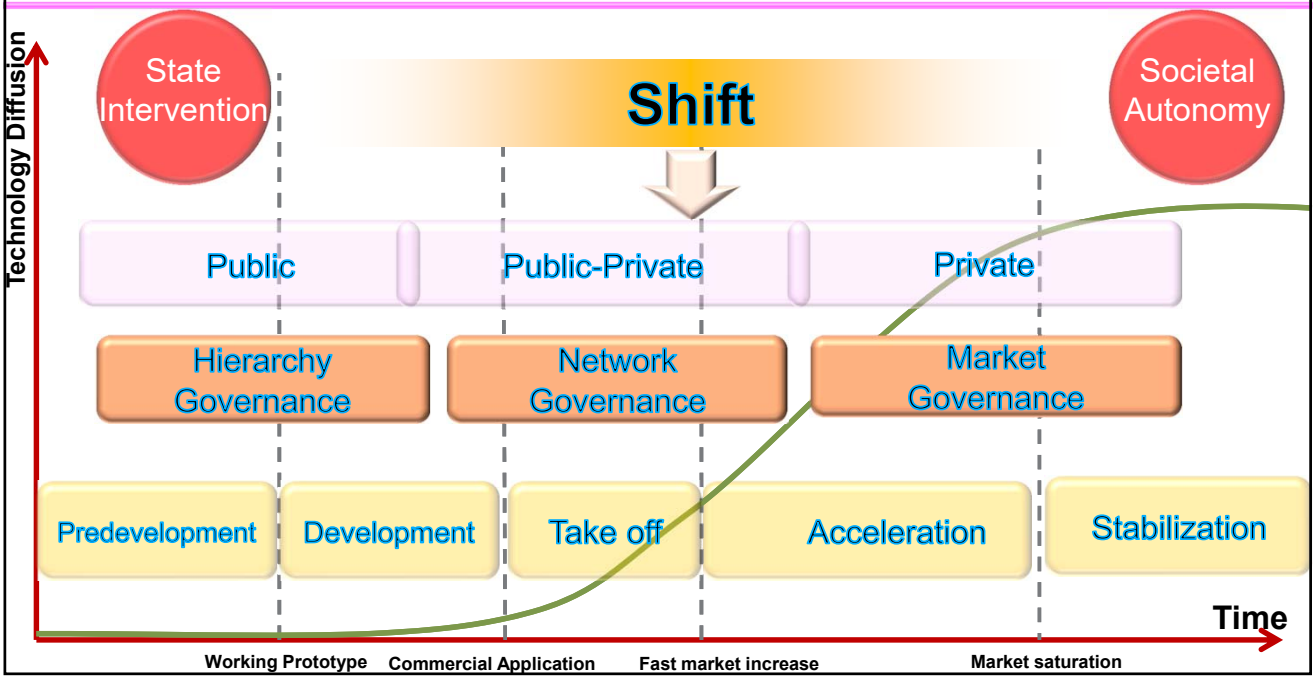
Creation, Diffusion and Stabilization of emerging technologies can be described by "Technological Innovation System" and "Technological Transition" literature



Technological Transition Governance

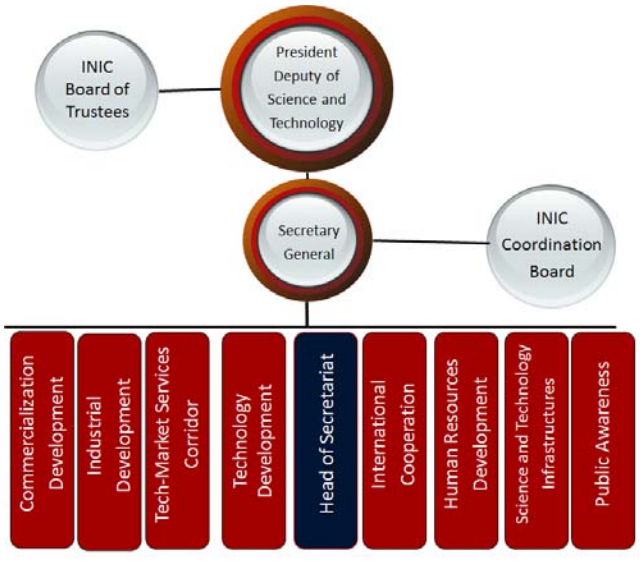


Technological Transition Governance (Polity Dimension)

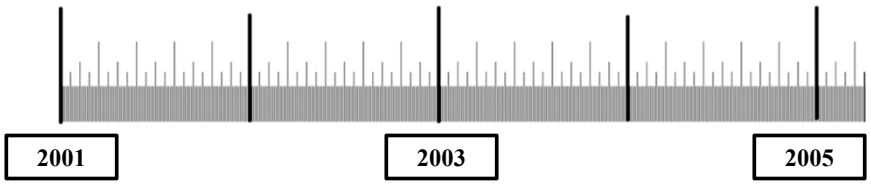


Iran Nanotechnology Initiative Council (Politics Dimension)

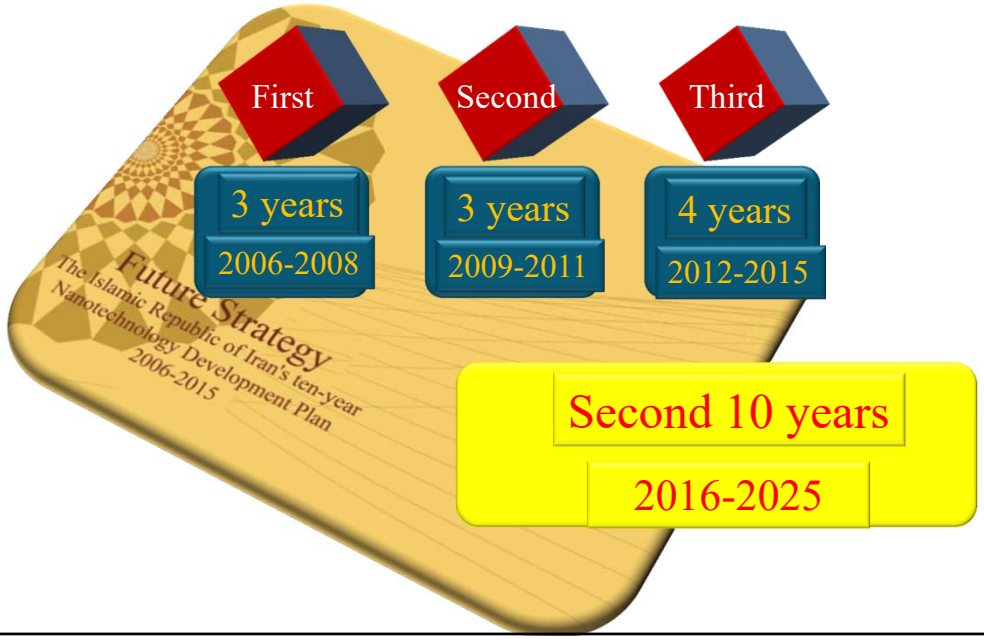
- Policy Making;
- Legitimation& Public Awareness;
- Supporting Nanotechnology Development;
- Evaluation of Activities and Achievements



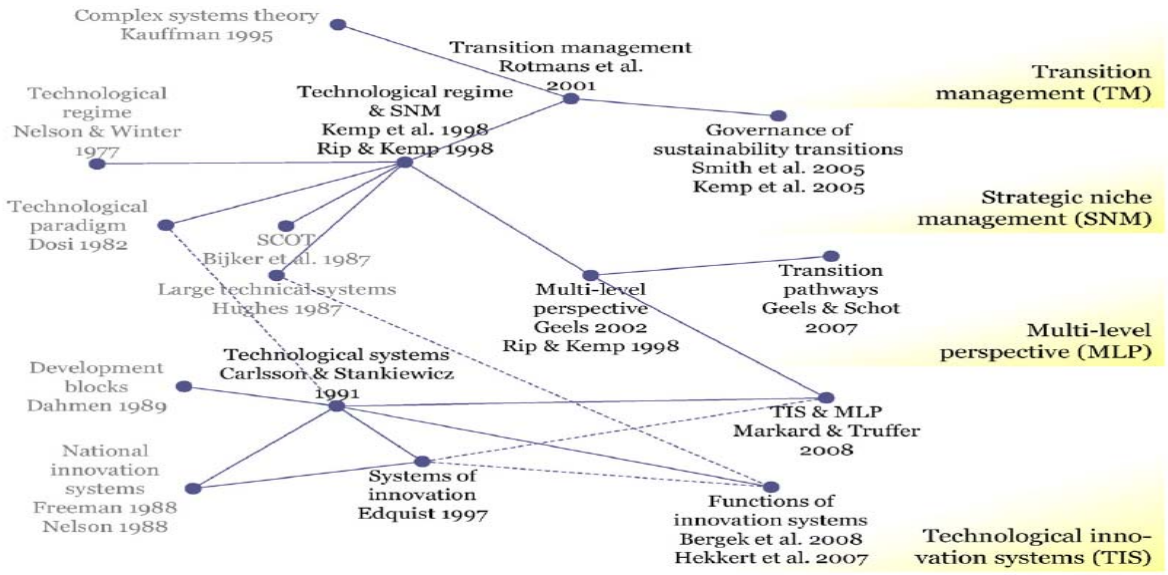
Background History of INIC

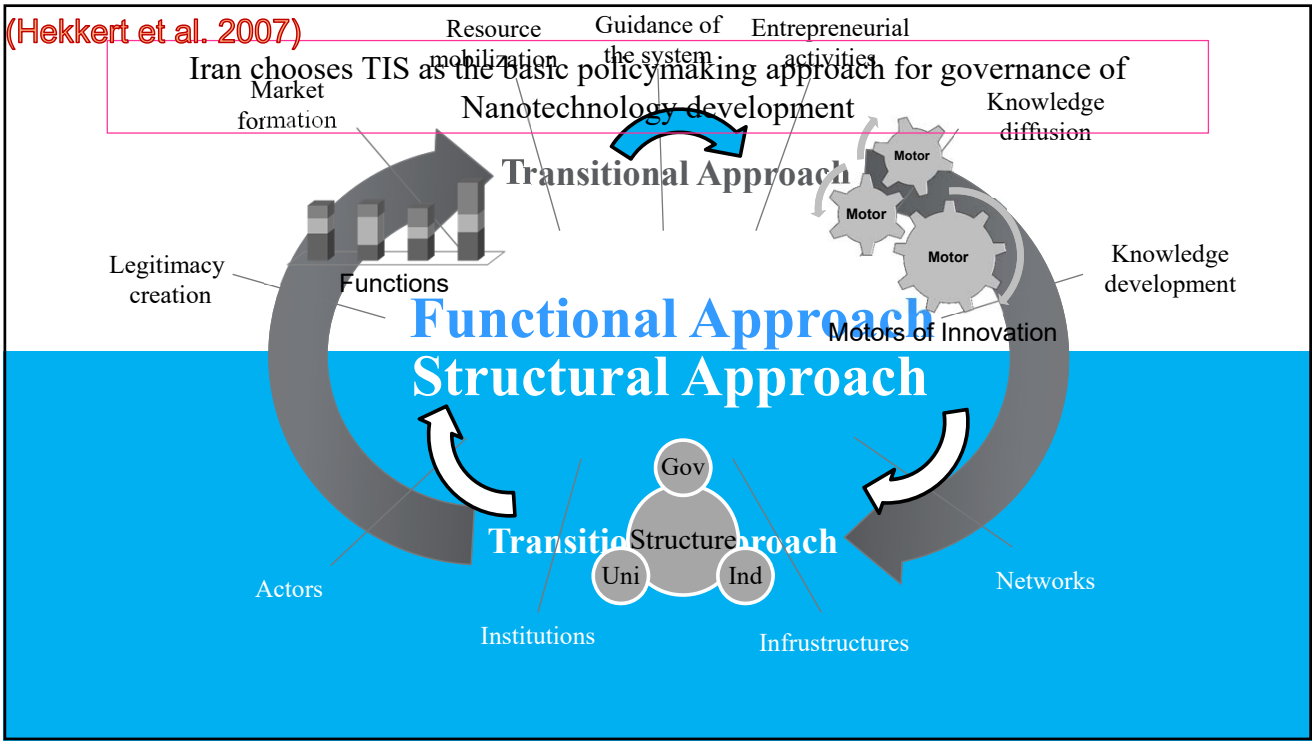


Time Frames of the Future Strategy

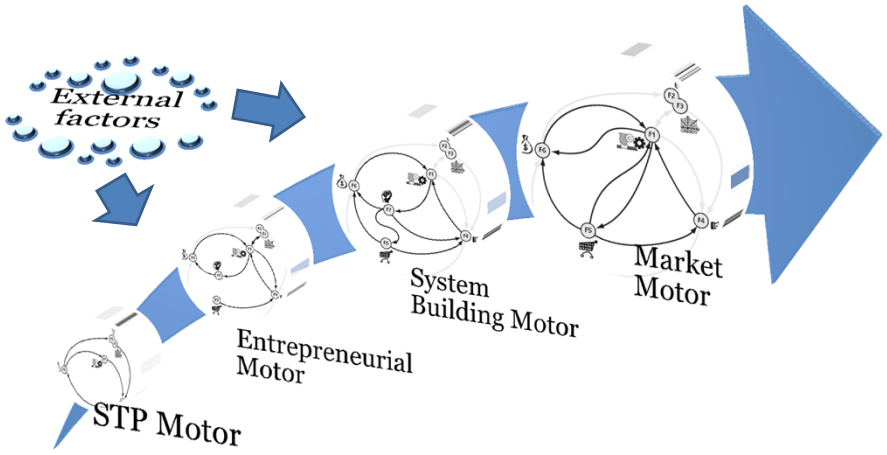


Basic Frameworks for Technological Transition Policymaking (Policy Dimension)

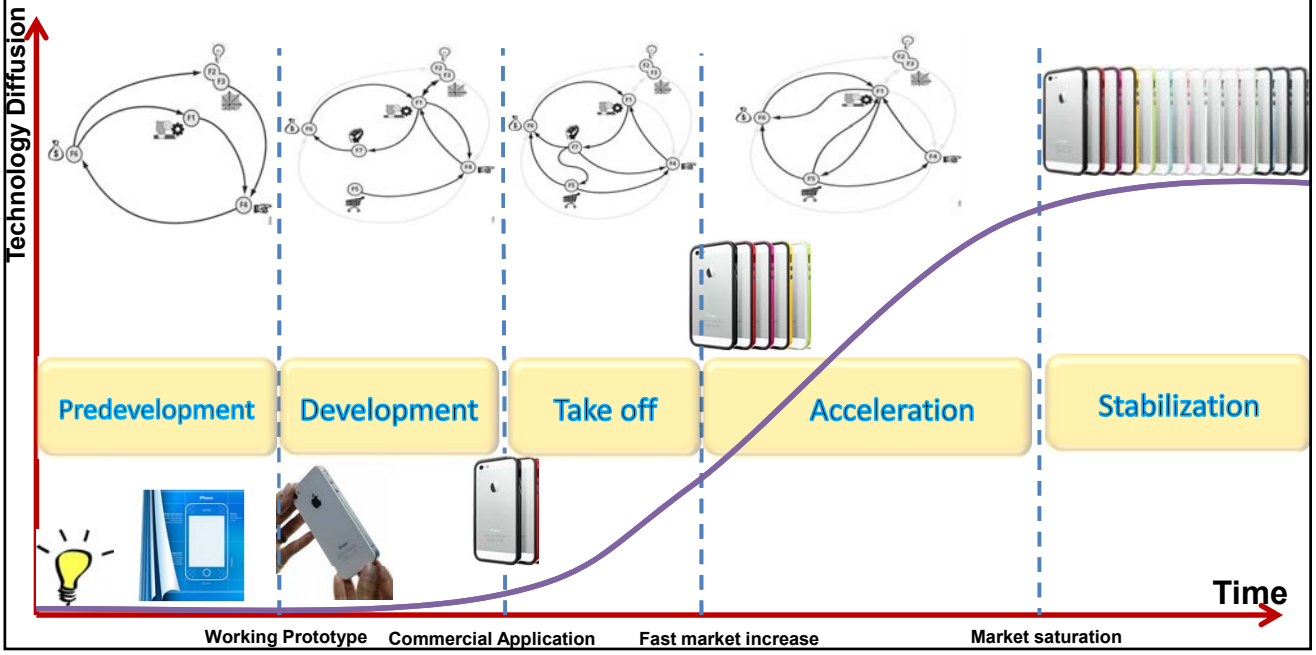




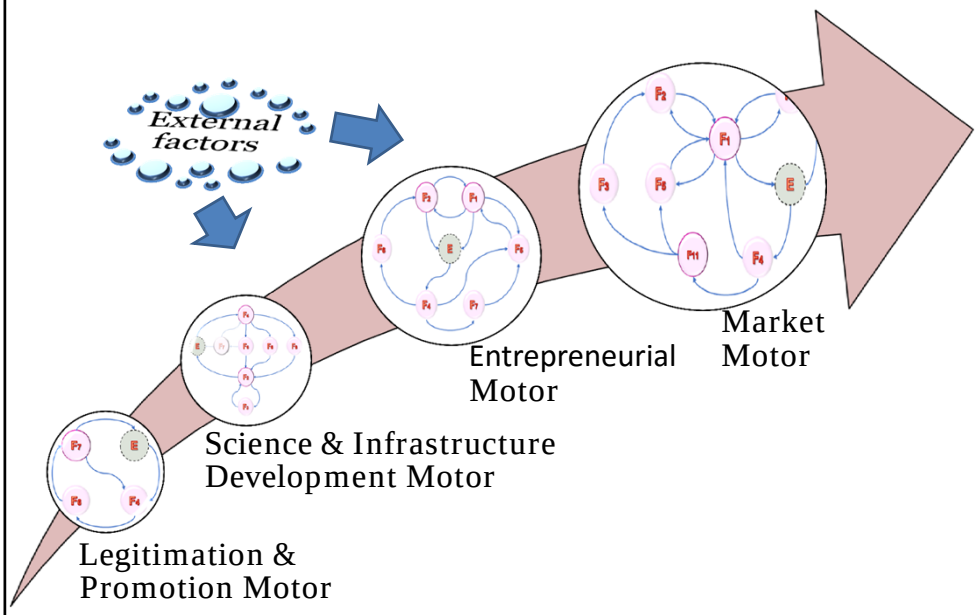
TIS Dynamics (Suurs 2009)



TIS Phases of Development

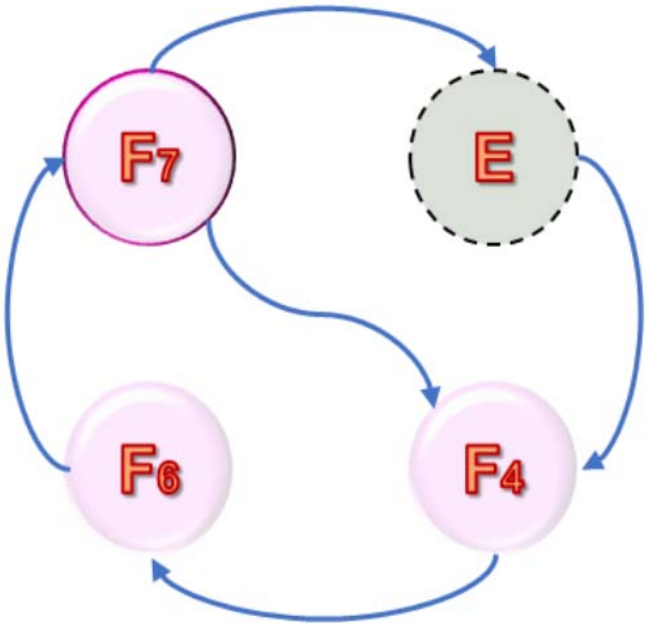


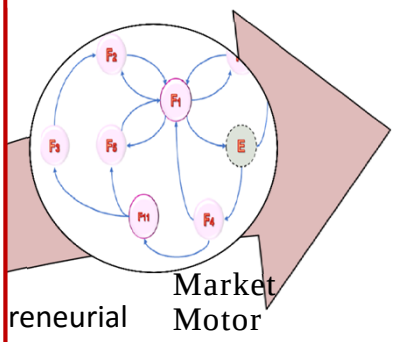
Nanotechnology Innovation System's Dynamics in Iran



F1	Entrepreneurial activities
F2	Knowledge development
F3	Knowledge diffusion
F4	Guidance of system
F5	Market formation
F6	Resource mobilization
F7	Legitimation
F8	Structure formation
F9	Human resource
F10	Technology transfer
F11	International interaction

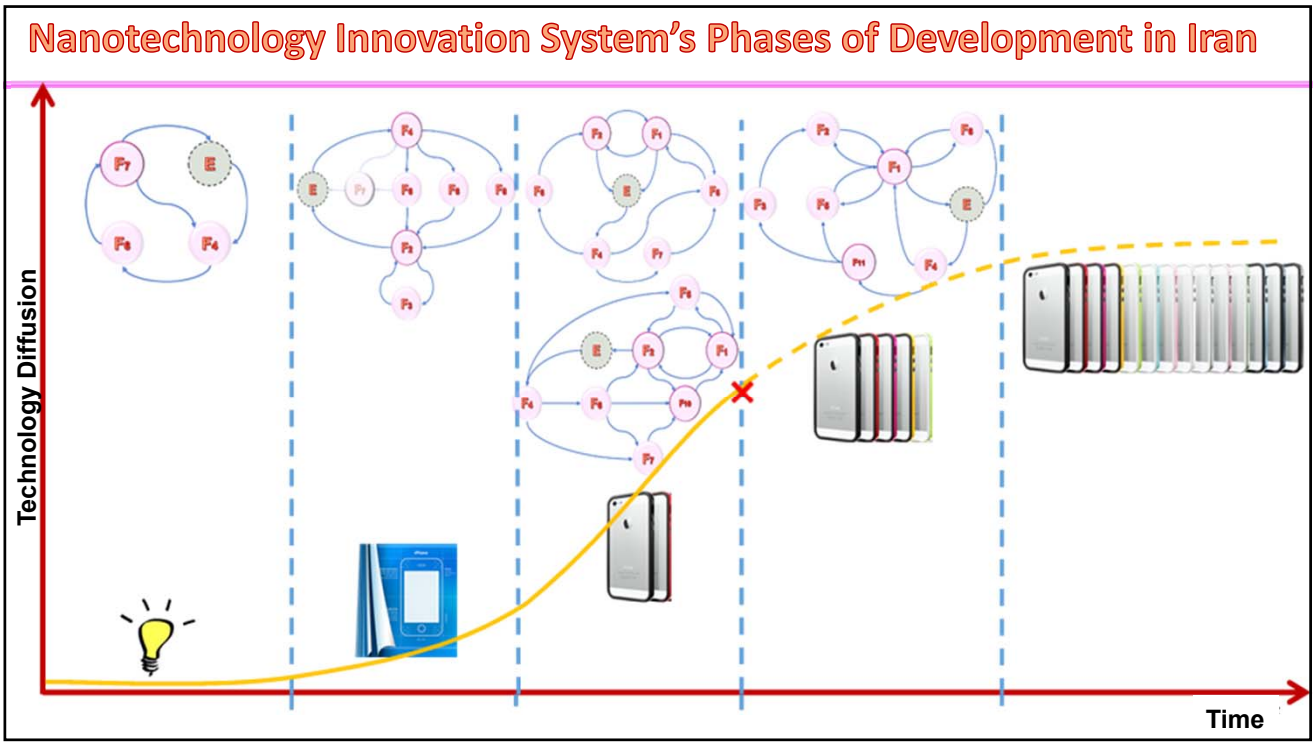
Iran Nanotechnology Innovation System's Dynamics (INIS)



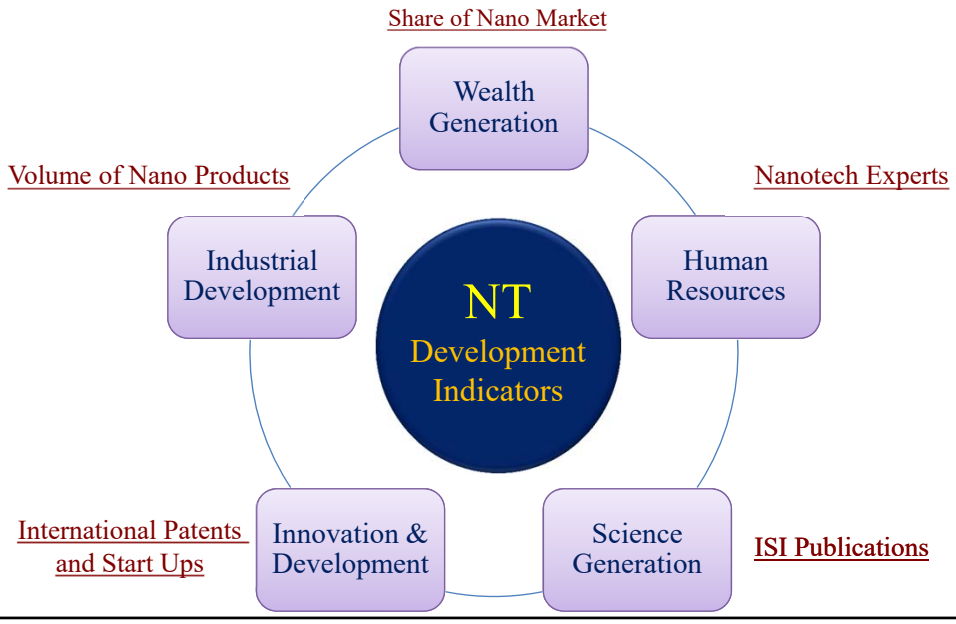


F1	Entrepreneurial activities	F7	Legitimation
F2	Knowledge development	F8	Structure formation
F3	Knowledge diffusion	F9	Human resource
F4	Guidance of system	F10	Technology transfer
F5	Market formation	F11	Technology diplomacy
F6	Resource mobilization	E	Expectation

Nanotechnology Innovation System's Phases of Development in Iran



Nanotechnology Phases of Development Indicators

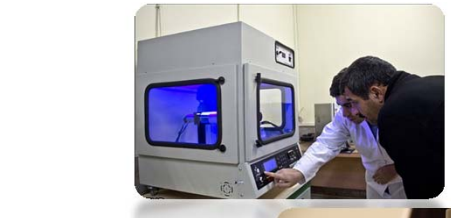


Student Nanotech Educational Exhibitions

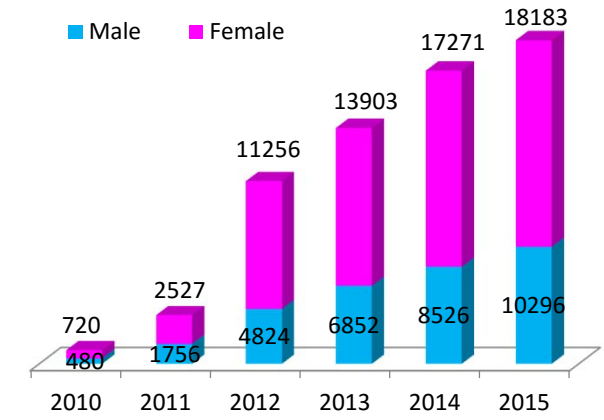
About 413,000 high school students have been trained in Nanotechnology by NANOCLUB activities (2008-2014)

Educational Nano Labs

- Establishing Educational Nano-Labs for High School Students
- **49** Established Laboratories

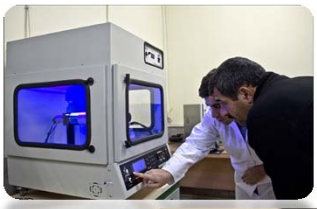


NANO - OLYMPIAD



Educational Nano Labs

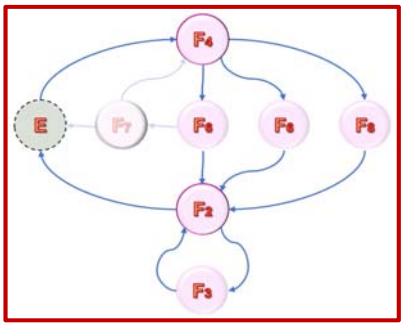
- Establishing Educational Nano-Labs for High School Students
- **49** Established Laboratories



Industrialists Knowledge Promotion

- Industrial Reports
- Industrial Shows
- Industrial Magazines
- Tech-based Meetings
- Website: www.nanoindustry.ir

Muhammad ibn Zakariyā Rāzī,
854-932 CE
Discoverer of Alcohol



Science & Infrastructure Development Motor

Ibn Sīnā
980-1037 CE
The Canon of Medicine, a standard medical text at many medieval universities

No. of ISI Articles (End of April 2015)

Rank	Country	Nano-articles	Share (%)
1	China	14643	35.32
2	USA	6560	15.82
3	India	3223	7.77
4	South Korea	2580	6.22
5	Germany	2304	5.56
6	Iran	2062	4.97
7	Japan	1998	4.82
8	France	1581	3.81
9	UK	1332	3.21
10	Spain	1206	2.91
11	Italy	1176	2.84
12	Russia	1107	2.67
13	Australia	1075	2.59
14	Taiwan	916	2.21
15	Canada	911	2.2

H-Index of Nano-articles (Update:Feb. 2015)

Rank	Country	2013	Country	2014
1	USA	76	USA	31
2	China	65	China	29
3	Germany	43	Germany	20
4	South Korea	43	Singapore	19
5	Singapore	42	UK	19
6	UK	40	Iran	18
7	Japan	38	South Korea	17
8	Australia	36	Japan	16
9	France	32	Australia	15
10	Spain	31	france	15
11	Switzerland	31	Netherlands	15
12	Canada	30	Switzerland	15
13	India	30	India	14
14	Italy	30	Saudi Arabia	14
15	Netherlands	30	Spain	14
16	Taiwan	28	Canada	13
17	Sweden	26	Italy	13
18	Saudi Arabia	25	Sweden	12
19	Iran	24	Taiwan	12
20	Israel	23	Denmark	11
21	Denmark	22	Austria	10
22	Finland	22	Belgium	10
23	Russia	22	Finland	10
24	Belgium	21	Poland	10
25	Ireland	21	Russia	10

Horizontal Approach

- 41 Universities Engaged in M.Sc. Programs,
- 22Universities Running Ph.D. Programs
- PhD: More than 3000
- MSc: More than 13100
- More than 90 Universities and Research Institutes
- More than 24000 Experts
- More than 2200 Faculty Members

Published Books:

- International: 32
- National: 126

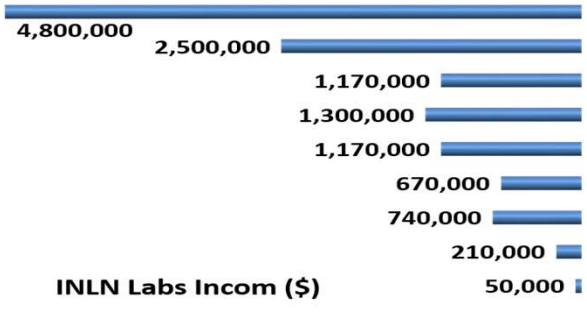
Vertical Approach Priorities

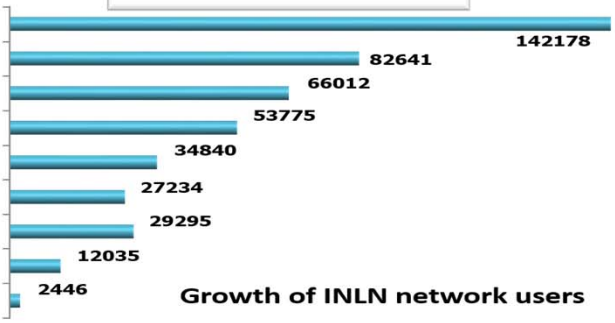
- Energy
  - Oil, Gas & Petrochemicals
  - Solar Cells
- Health
  - DDS (Drug Delivery System)
  - Diagnostic Kits
- Water and Environment
- Construction

IRAN Nanotechnology Laboratory Network (INLN)

1082 *equipment from*

68 *research centers throughout IRAN*

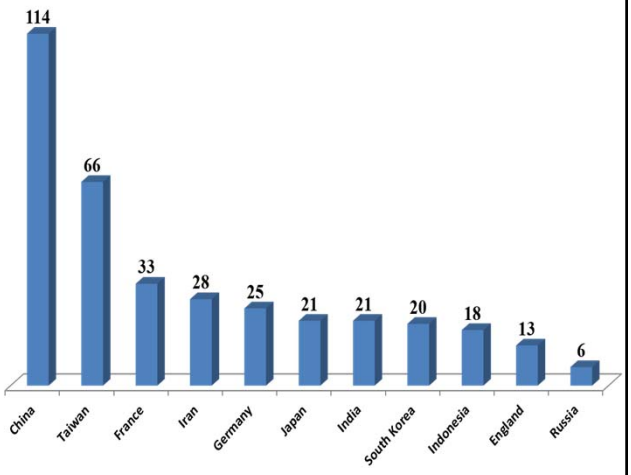


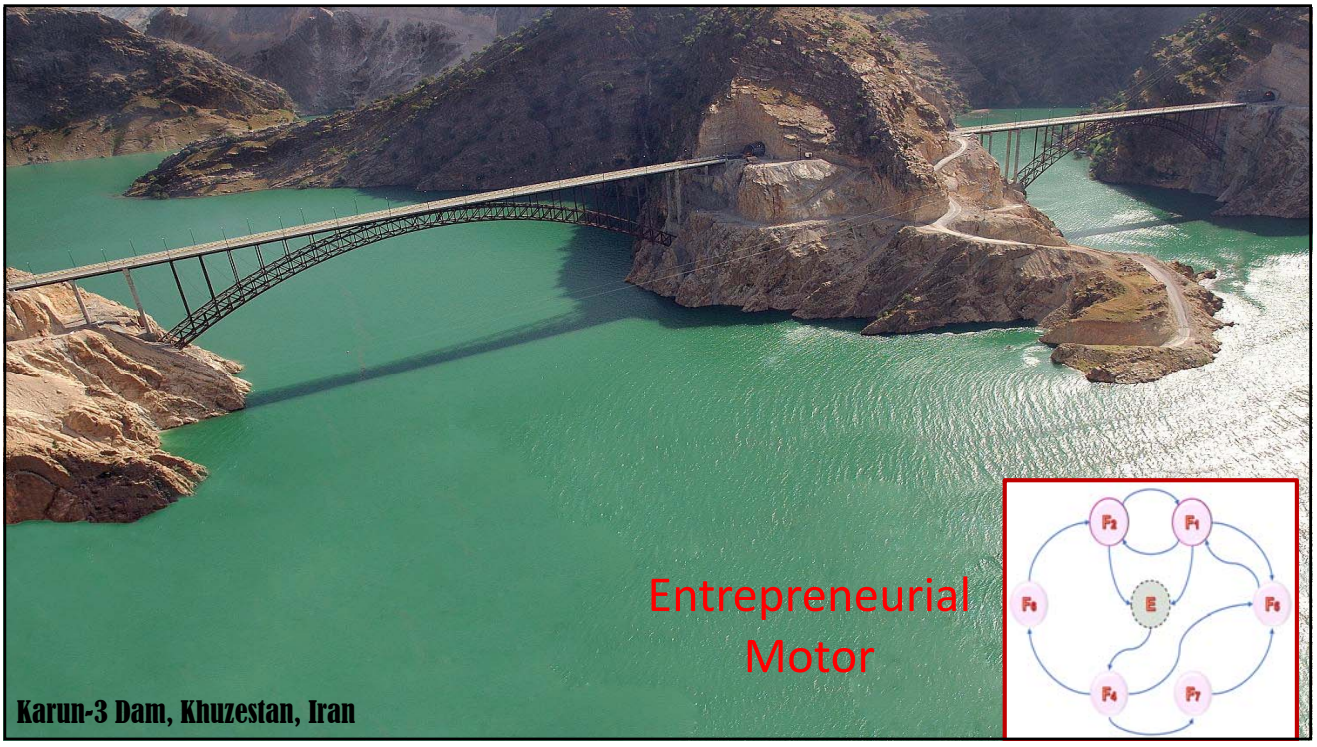


Iran Nanotechnology Standardization Committee (ISIRI/TC229)

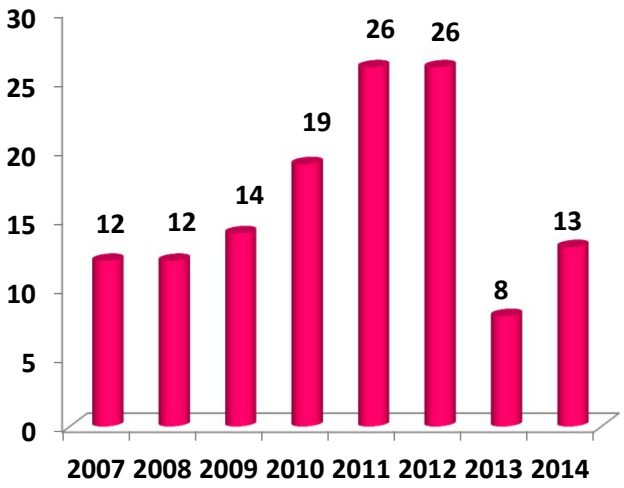
- Established in 2006
- P-member of the ISO/TC229
- Published 31 national Nanostandards and 7 standards currently under development.
- Published 3 international standards in ISO/TC229.
- Established Nanostandardization Committees at the Ministry of Health and Ministry of Agriculture.
- Established Nano-Safety Network.

National Standards (2014)

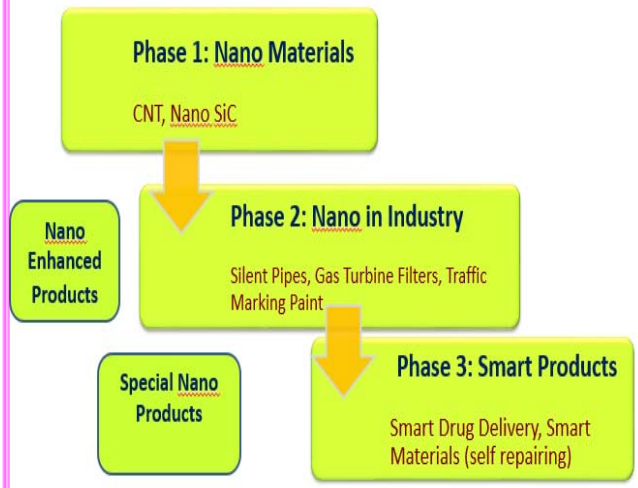




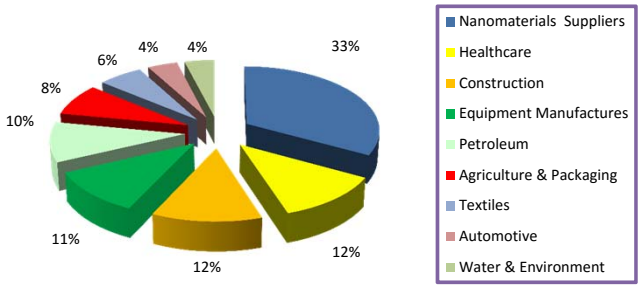
International Patents



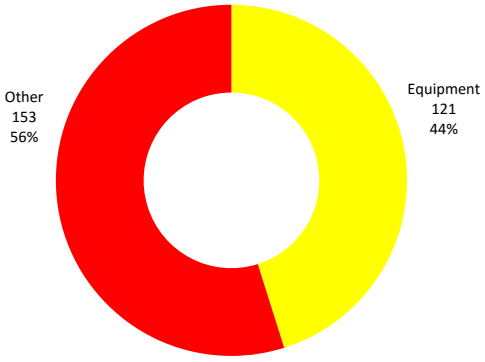
Nano Tech Development



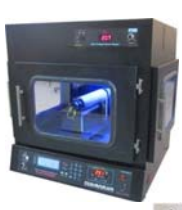
Start-up Companies: 109



Nano Products: 274



Some of Iran's NanoProducts




TE

CVD

PLD system

فناوران نانومقیاس

NANOMETRIC ADVANCED MATERIALS
شرکت نانومتری پژوه

Some of Iran's NanoProducts

Plasma Nano Colloid Maker

Pulse Electrical Explosion (PEE)


Vacuum Melt Spinner


Animal SPECT Imaging

Freeze dryer

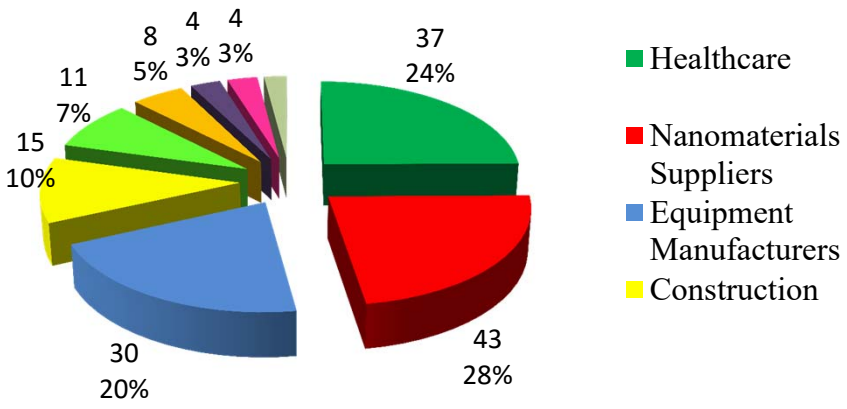
KPF VACUUM TECHNOLOGY

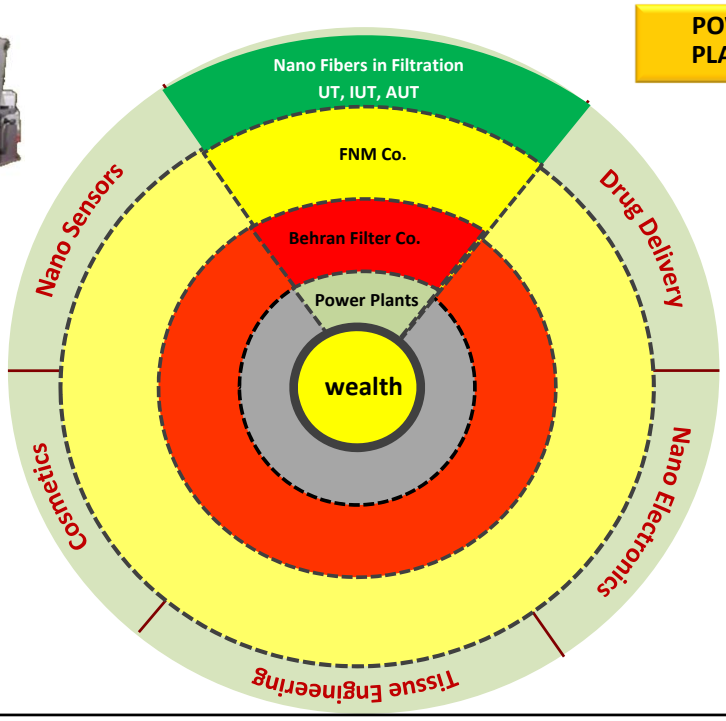
Adeeco

NANOMETRIC ADVANCED MATERIALS
شرکت نانومتری پژوه

Tech-Market Services Corridor

Manufacturing Companies: 152





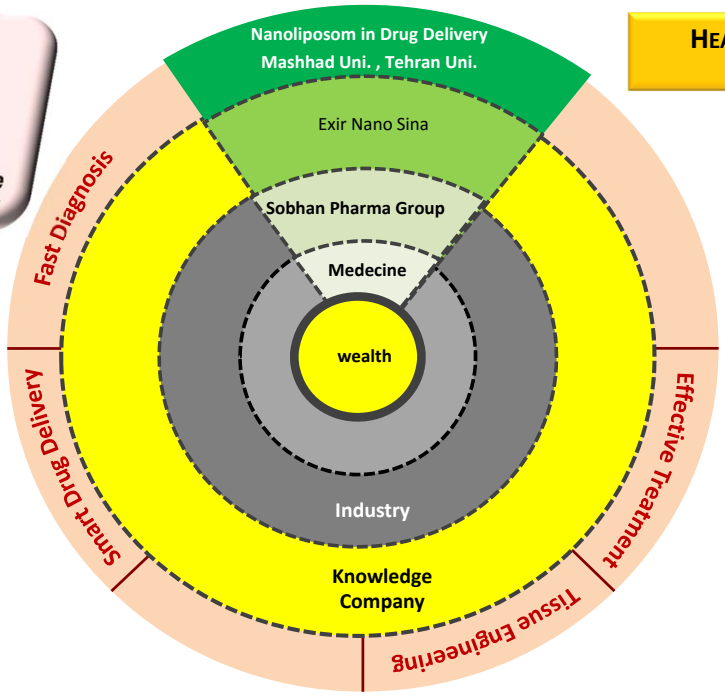
Production of Air Filters by Behran Filters Co.

Benefits:

- Increasing of filter's lifetime (up to 200%)
- Filtration efficiency improvement (Grade 7 to Grade 9)
- Improvement in Protection of Turbines (saves up to 300k USD)

Development Model:

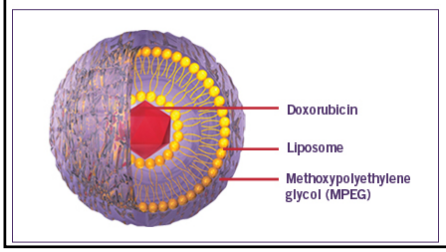
1. Equipment and Machinery development by FNM CO.
2. Production Line by Behran Filters Co.



"SinaDoxosome" Liposomal Doxorubicin for Cancer Chemotherapy

Benefits:

- Tumor targeting
- Less side effects
- Lower price compared to competitors'



Development Model:

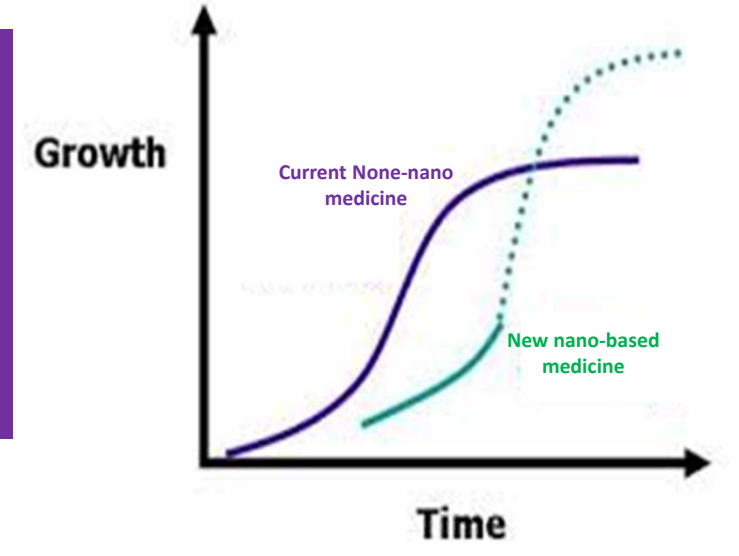
- Formulated and developed by Exir Nano Sina Co.
- Mass Production by Sobhan Pharma Group

"SinaDoxosome" Liposomal Doxorubicin for Cancer Chemotherapy

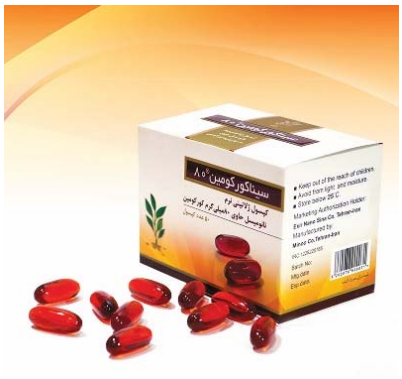
None-nano based medicine price: 40$ per vial

Nano-based imported medicine price: 700$ per vial

Nano-based medicine produced in Iran price: 80$ per vial



SinaCurcumin (Curcumin 80 mg as Nanomicelle)

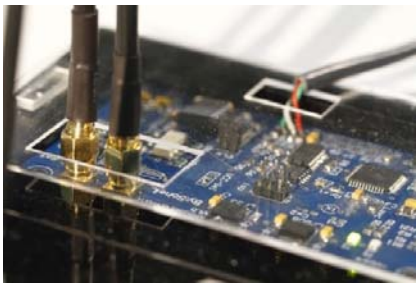


Curcumin is the principal curcuminiod of the popular Indian spice turmeric, a member of the ginger family. The oral absorption of curcumin is poor

Application:
joint diseases, intestine inflammation diseases, fatty liver, cataract, some skin diseases, lipid adjustment, reduction of cholesterol, thinning of the blood, Alzheimer's, and controlling convulsion and Parkinson's.

Curcumin capsule can be effective in cancer prevention too due to its anti-proliferation properties.

Cancer Diagnostic Kit



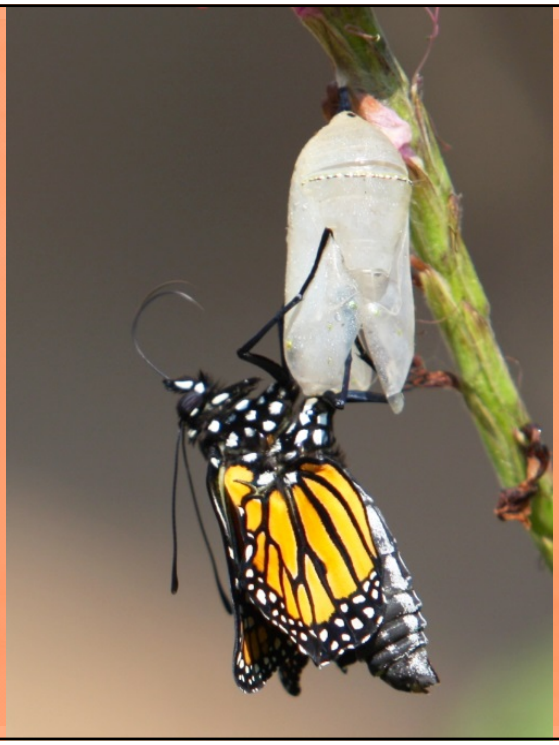
Features
- Based on CNT & SiNW- ECIS
- Detecting changes of dielectric properties of cell based on vertical CNT array
- Monitoring of vital functions of cells such as Seed, Spread, Proliferation, Spread
- Detecting healthy cells from cancer cells
- Detecting the effects of anti-cancer drugs on cellular metabolism

Advantages
- Deposition of cell on it in a shorter time in comparison with common kids
- Increasing the accuracy and quality of signals according to direct interaction between the tips of nanotubes and nanowires
- Possibility of functionalization of nanostructures with various nano-markers

Conclusion

- Diffusion of Mission-Oriented technological fields has a pivotal role in the economic growth of developing countries.
- Developing countries must set endogenous governance models for developing emerging technologies due to their exclusive societal (social, economical, political and cultural) characteristics.
- Iran is ready to share its experiences in S&T policymaking through collaborations.

A man found a cocoon of a butterfly. One day a small opening appeared. He sat and watched the butterfly for several hours as it struggled to force its body through that little hole. Then it seemed to stop making any progress. It appeared as if it had gotten as far as it could, and it could go no further. So the man decided to help the butterfly.
He took a pair of scissors and snipped off the remaining bit of the cocoon. The butterfly then emerged easily. But it had a swollen body and small, shriveled wings. The man continued to watch the butterfly because he expected that, at any moment, the wings would enlarge and expand to be able to support the body, which would contract in time.
Neither happened! In fact, the butterfly spent the rest of its life crawling around with a swollen bod



Product	Year Registered	Doses imported	International price $/dose	Saved in Currency $millio
IFN alpha	1383	200,000	5	1
G-CSF	1385	250,000	40	10
EPO alpha	1385	800,000	10	8
IFN beta 1a CinnoVex	1385	400,000	200	80
PegIFN alpha	1386	10,000	270	2.7
IFN beta 1a ReciGen	1387	650,000	80	52
Epo beta	1387	300,000	25	7.5
HGH	1387	827,000		12
IFN gamma	1387	10,000	120	1.2
Total				174.4
8/8/2015				80

New Recombinant protein in the Pipeline in the next two years

Product	Year Registered	Doses imported	International price $	Saved in Currency $millions
IFN beta 1b	1388	600,000	50	30
PTH	1388	10,000	700	7
Rituximab	1388	10,000	2000	20
HBS Vaccine	1388	8,000,000	0.5	4
Streptokinase	1388			3
FSH	1388	200,000	18	3.6
VII	1388	200,000	280	30
Enbrel	1389	40,000	240	9.6
Total revenue for products in the pipeline in next two years				105
Total revenue for products in the market				179.2
				290

81

Export of biotech Products

Product	Year Registered	$ million per year	Country of Export
IFN alpha	1385	1	Pakistan
IFN beta CinnoVex	1387	0.3	Pakistan
EPO alpha	1385	0.5	Pakistan
IFN beta 1a CinnoVex	1388	3	Syria
	1388	14	Ukraine and Russia
Other biotech products such as Mab for blood group and molecular biology products	1385	1.5	To 5 countries
Total		20.3	

82