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“FACTORS AFFECTING THE DIFFUSION OF NANOTECHNOLOGIES AS A NEW TECHNOLOGICAL PARADIGM ACROSS COUNTRIES. A PATENT ANALYSIS, 1990-2013”

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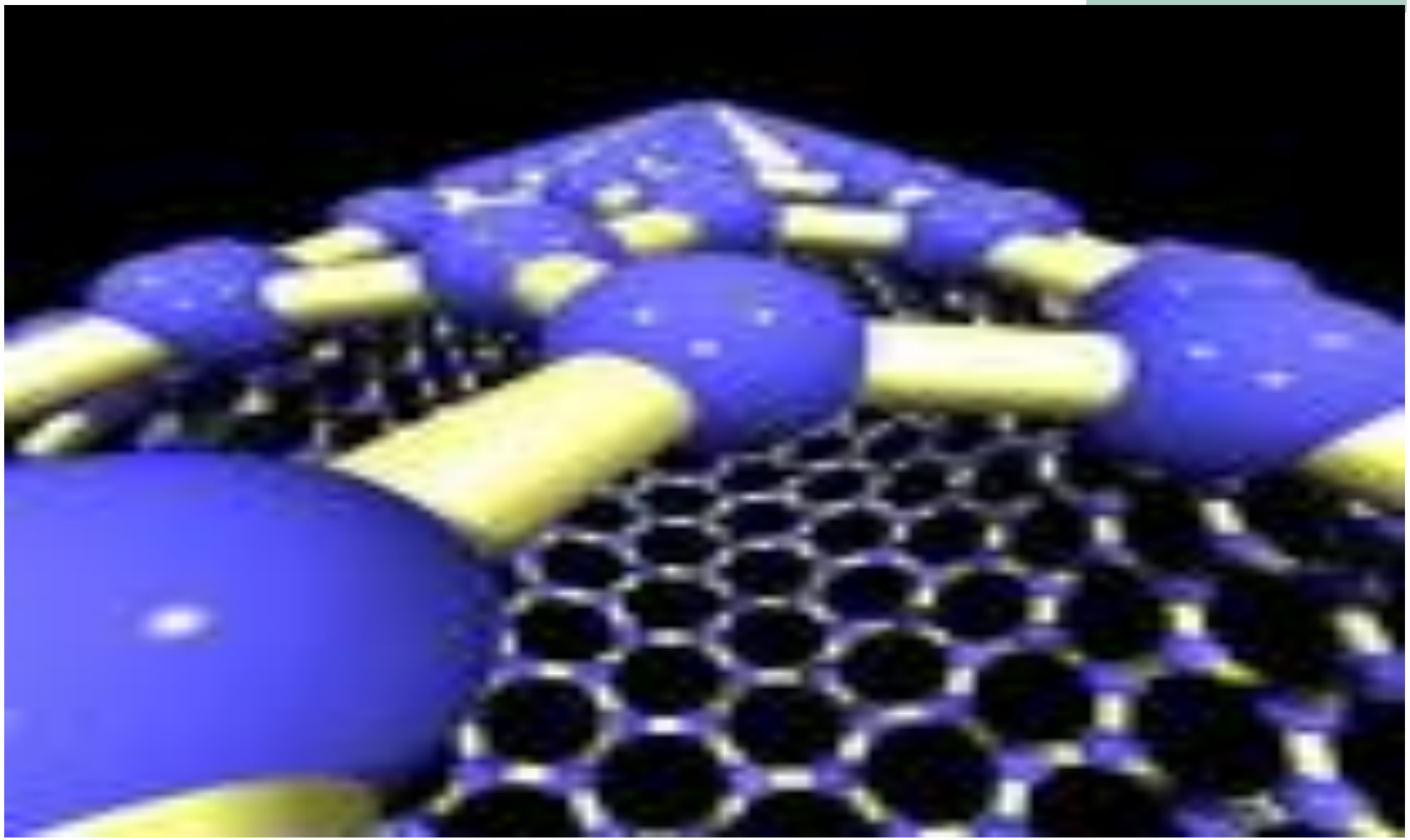
The nanotechnology as a new technological paradigm

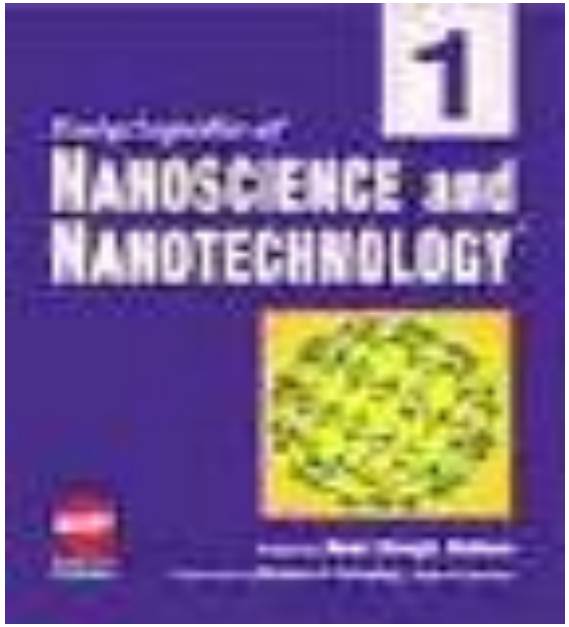


Nanotechnology as an emerging paradigm

Precursors of nano-sciences and nanotechnology :

- Feynman (1959)
- Drexler, 1986
- Curl, Kroto y Smalley

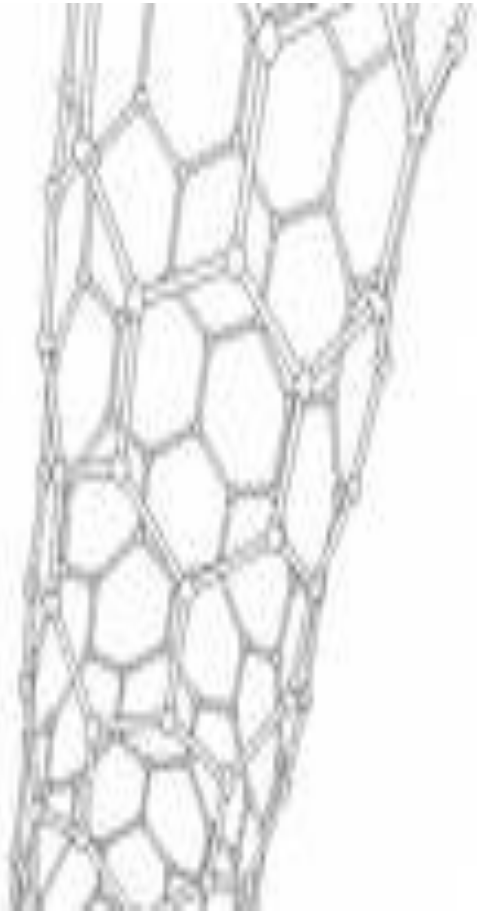
The nanotechnologies emerged as a scientific and technological paradigm and they are predicted to be the next technological revolution



The nanotechnology trascendence

- It involves a scientific and technological revolution based on the knowledge and abilities in order to measure, to manipulate and to organize the matter at the nanoscale of a millionth part of one millimeter
- Confluence of physics, chemistry, biology, scientific and engineering materials fields

(Roco y Bainbridge, 2001).



Nanotechnology's interdisciplinary nature

Open broaden opportunities on:

- potential R&D paradigms in nanomaterials,
- mass application nanomanufacturing products,
- molecular medicine and health,
- environment processes and energy,
- biotechnology and agriculture
- electronics, ICT
- national security.

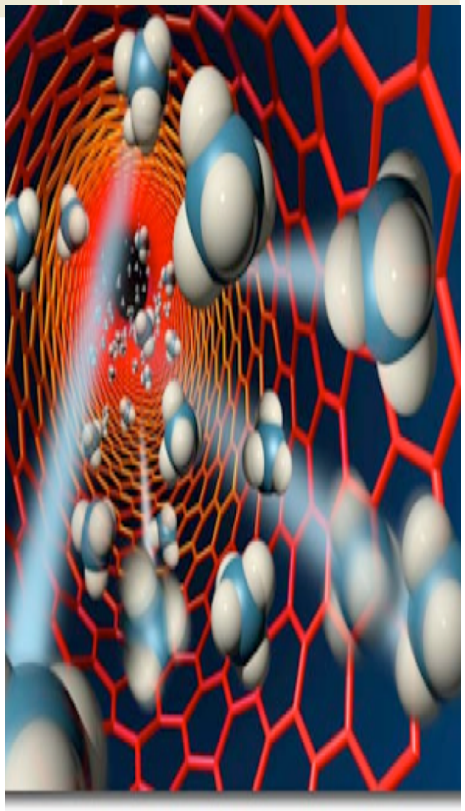
During the last decade, the NNI in the US has developed the nanotechnology through several strategies

Fundamental and application-focused R&D and investment policy;

new modes of advocacy for innovation resource-sharing and cross sector communication;

partnerships with industry and academics units, specially,

new networks focused on high school and undergraduate nanotechnology education



Products with nanoscale component…goals after 10 years

- Worldwide market arose a quarter of trillion dollars. (Rocco, 2011).
- Mayor industry involvement after 2002-2003: …more than 5,400 U.S. companies had patents, and/or products in 2008….
- Unanticipated discoveries and advances in several science and enginering fields, including plasmonics, metamaterisls, spintronics, graphene, cancer detection and treatment, drug delivery, synthetic biology, neuromorphic enginering, and quantum information systems.
- Formation and growing strenght of the international nanotechnology community…"

Aim

- To analyze the factors affecting the diffusion of the new technological paradigm of nanotechnologies (NNP) across countries.

Theoretical background

- **I**nnovation trajectory (Schmooker, 1962)
- **I**nnovation nature (Grilliches 1984; Jaffe y Trajtenberg, 2002)
- **T**echnological knowledge flows (Hall, Jaffe y Trajtenberg, 2001b; Jaffe y Trajtenberg, 2002)
- **I**nnovation value (Criscuolo, Narula and Verspagen, 2001; Gay, Latham & Le Bàs (2008)
- **K**nowledge networks and their spillovers impact

Research questions

- Which is the probability of diffusion of the NNP across the countries?

- Which factors explain the NNP diffusion across countries?

Hypothesis:

The highest probability of the nanotechnology diffusion across countries, is positively related with: number of claims, stock of previous knowledge, greater extension towards technological fields, technological cooperation, size of inventor teams, the mobility of inventors, relationship with the academic sector, the institutional effort in nanotechlogy innovation, the participation of large private firms and the lag time.

Source: USPTO Database Class 977: patents on nanotechnology field

i. Nanostructure and chemical compositions of nanostructure (defined to mean an atomic, molecular, or macromolecular structure);

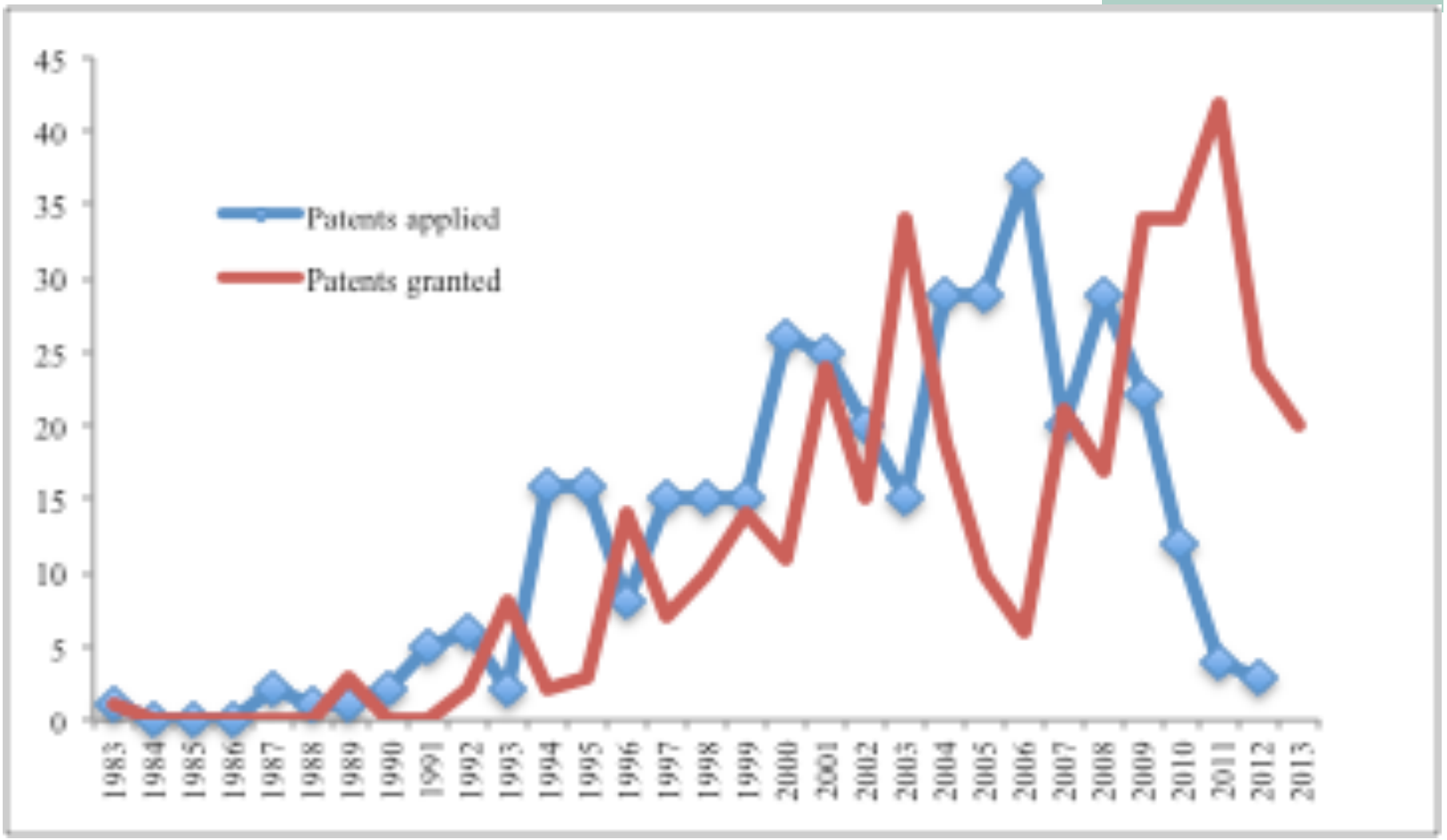
ii. Device that include at least one nanostructure;

iii. Mathematical algorithms, e.g., computer software, etc., specifically adapted for modeling configurations or properties of nanostructure;

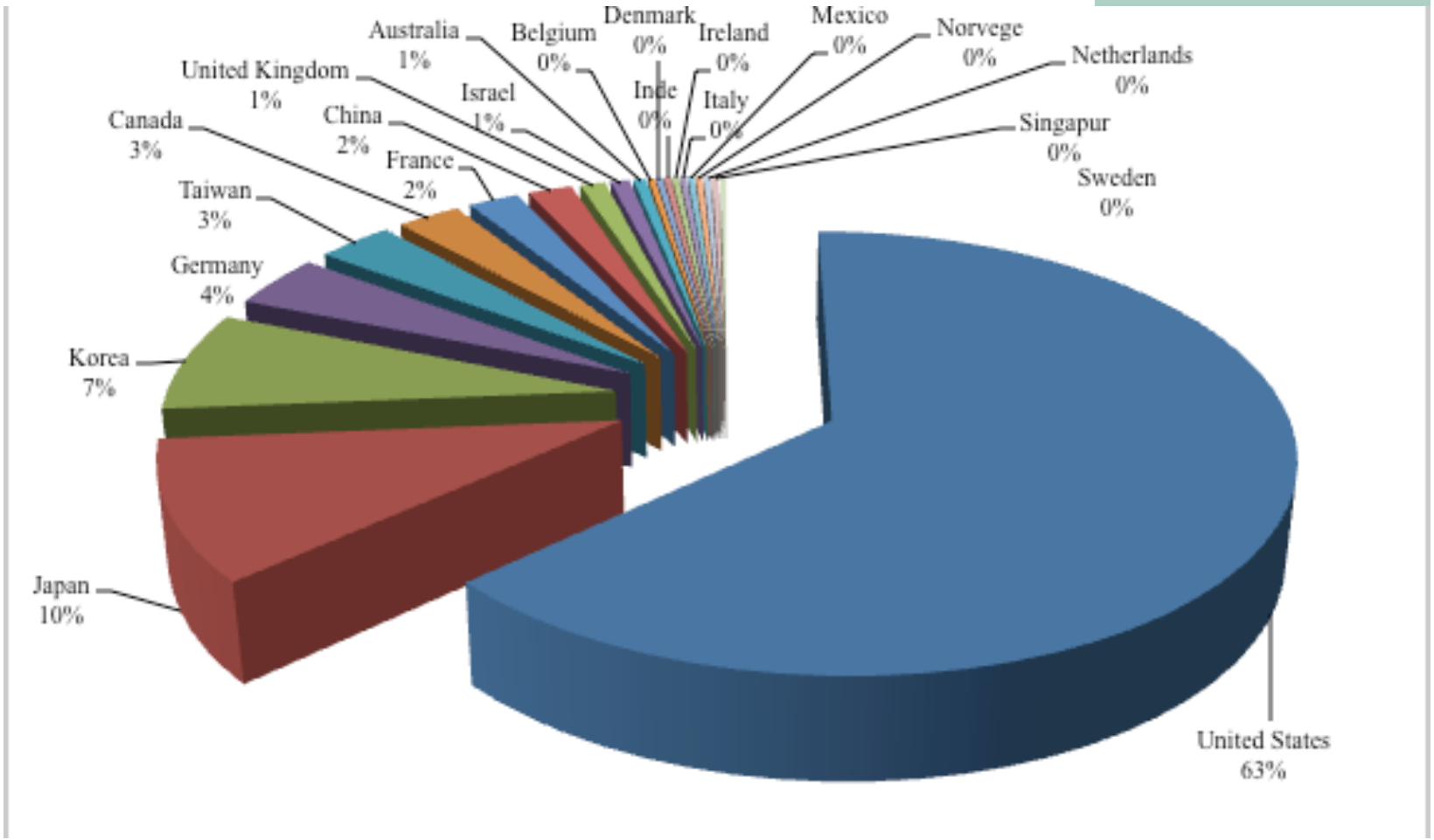
iv. Methods or apparatus for making, detecting, analyzing, or treating nanostructure; and

v. v)Specified particular uses of nanostructure

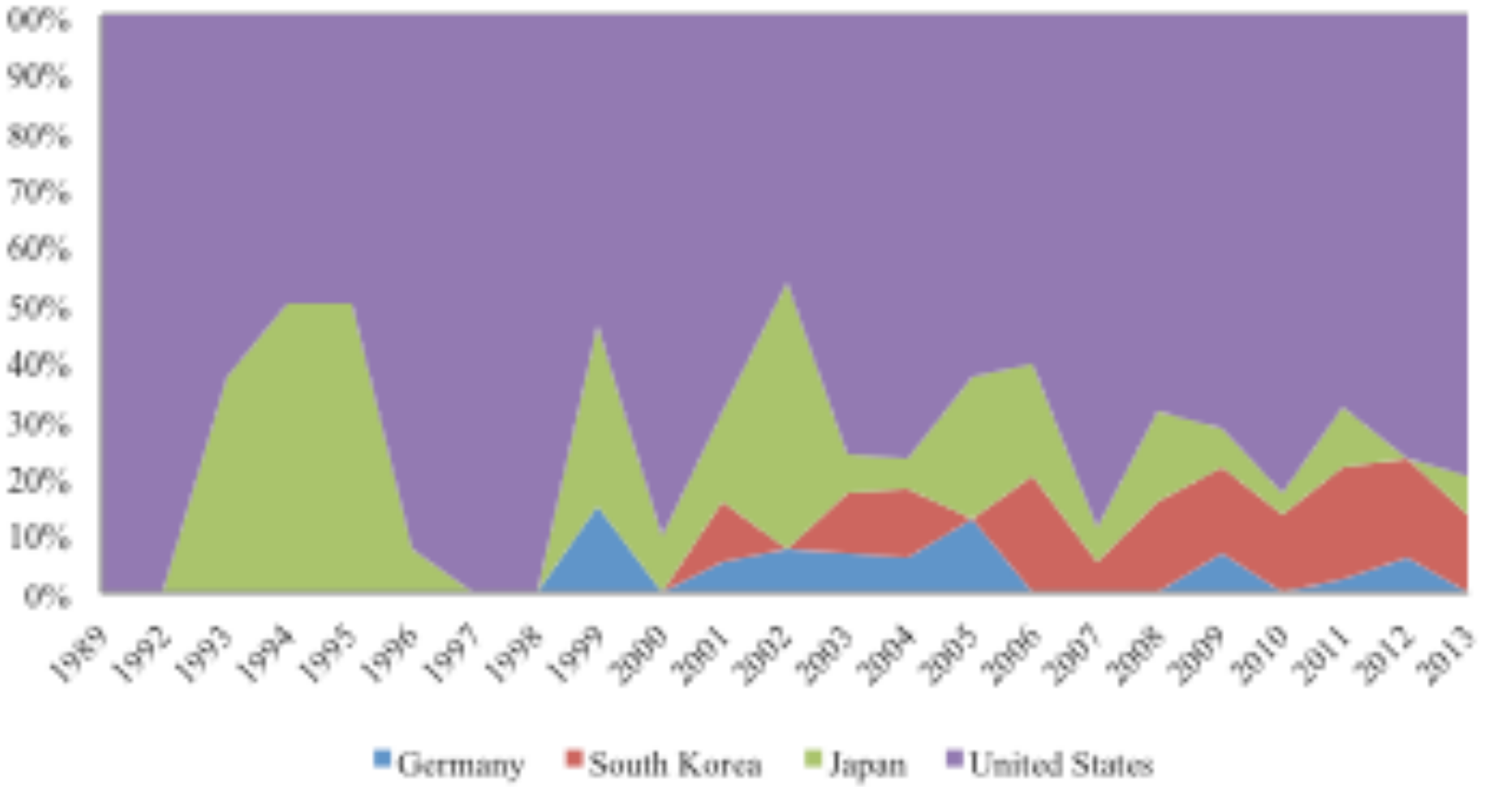
USPTO patents applied and assigned to residents and non residents in nanotechnology field, 1983-2013



Distribution of USPTO patents assigned in nanotechnology by countries (%)

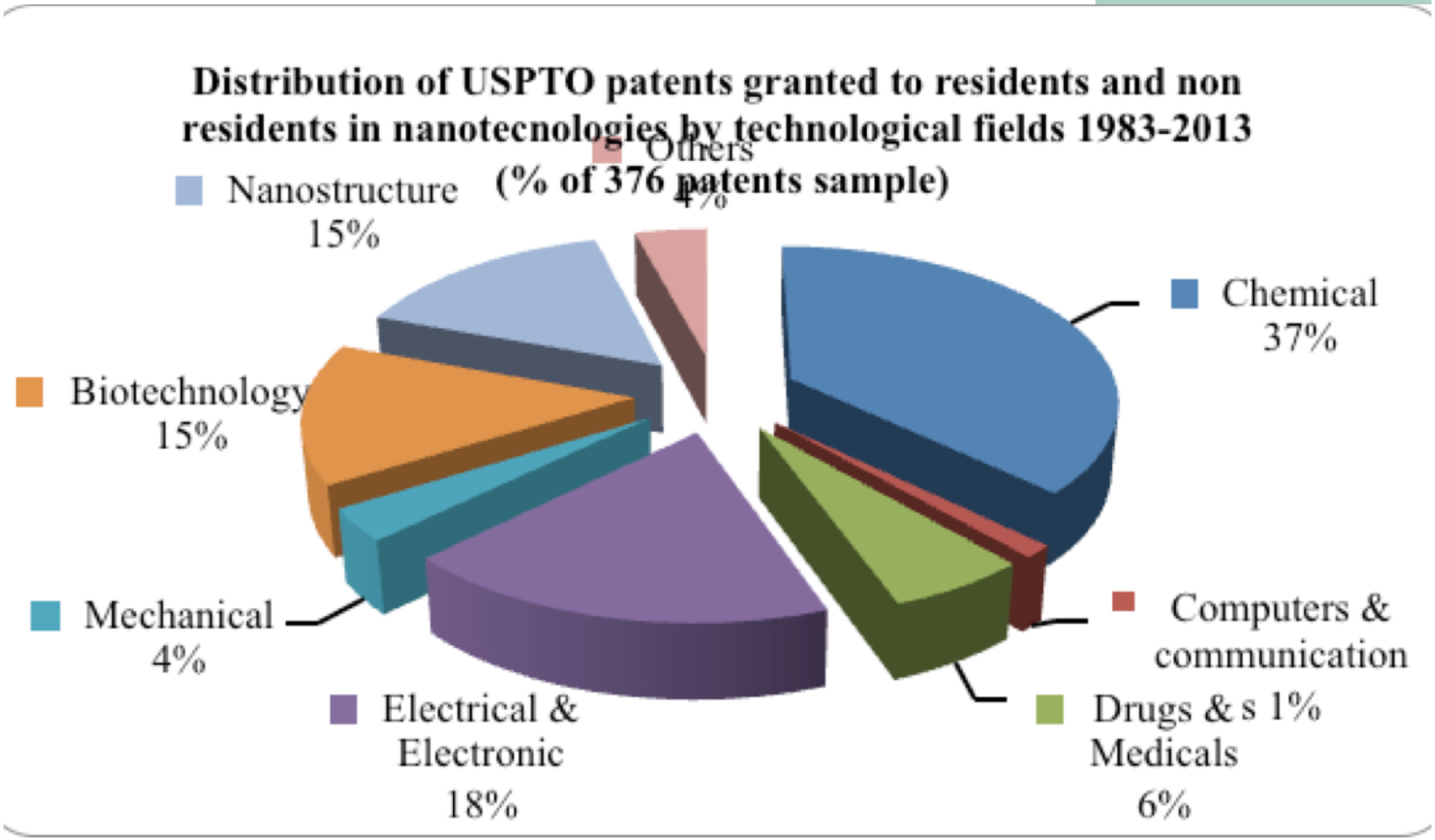


Distribution of USPTO patents assigned in nanotehnology among the main countries (%)

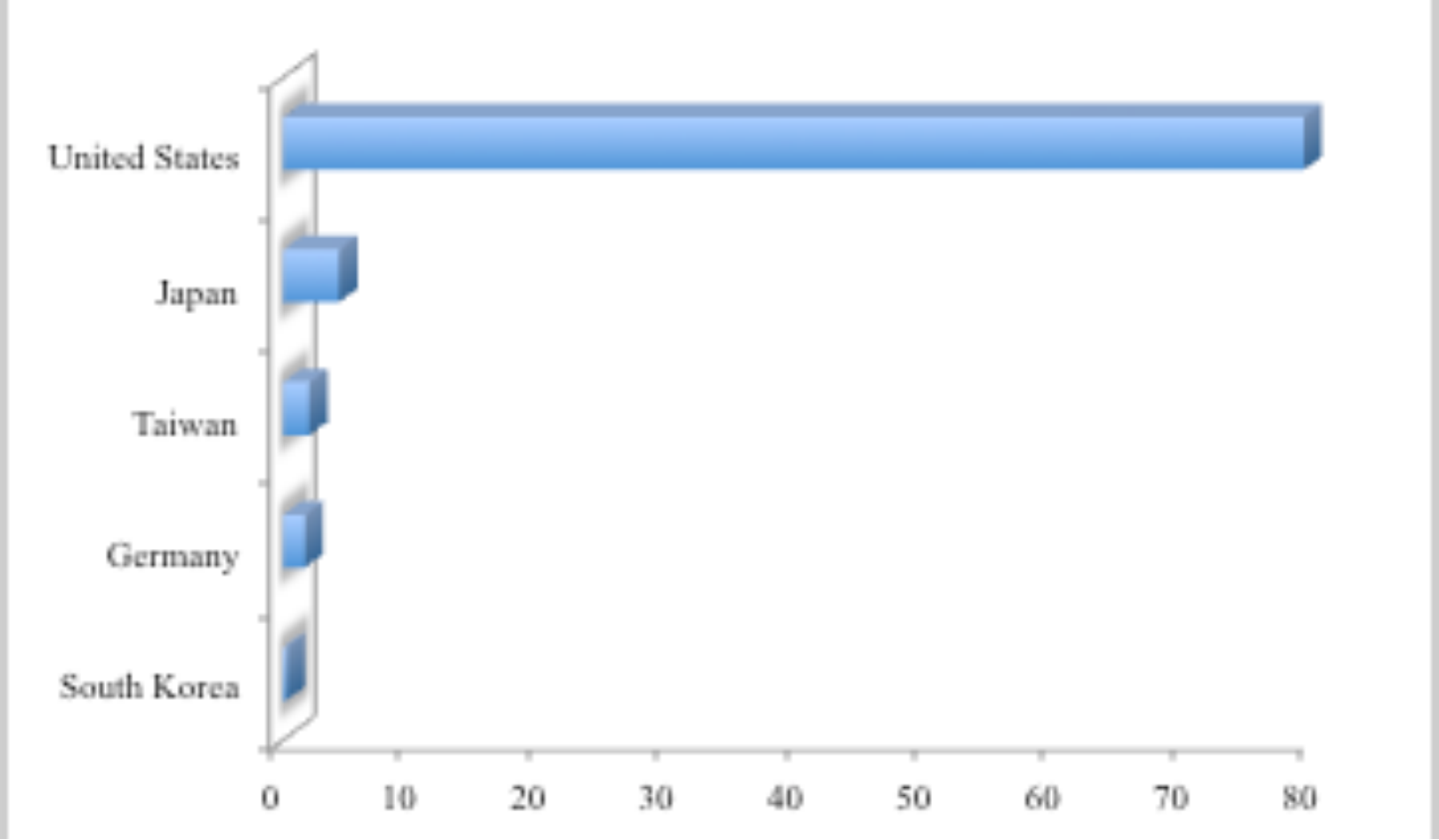


Distribution of USPTO nanotechnology patents by technological fields, 1983-2013

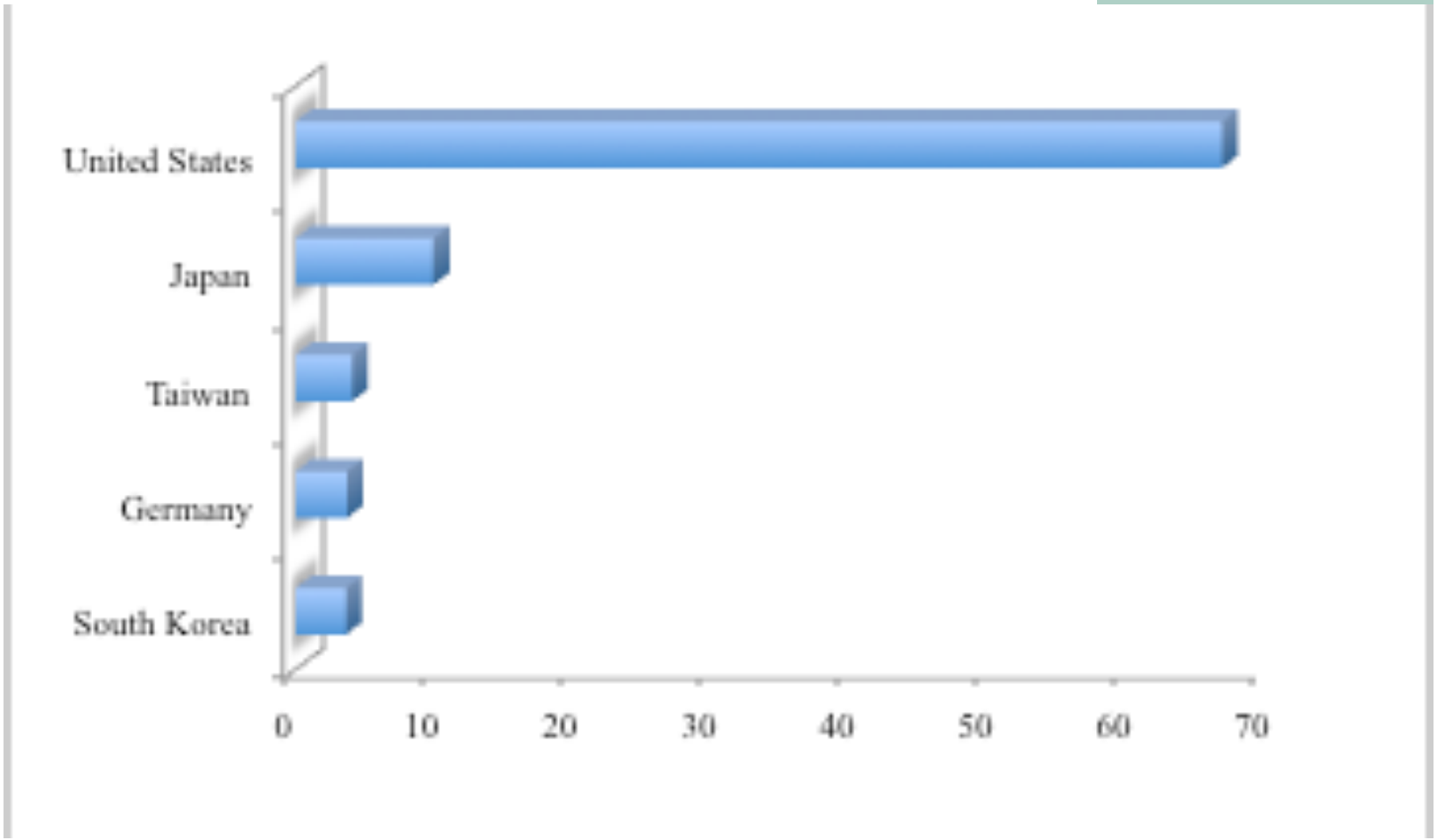
(according to Jaffe y Trajtenberg, 2002 Classification)



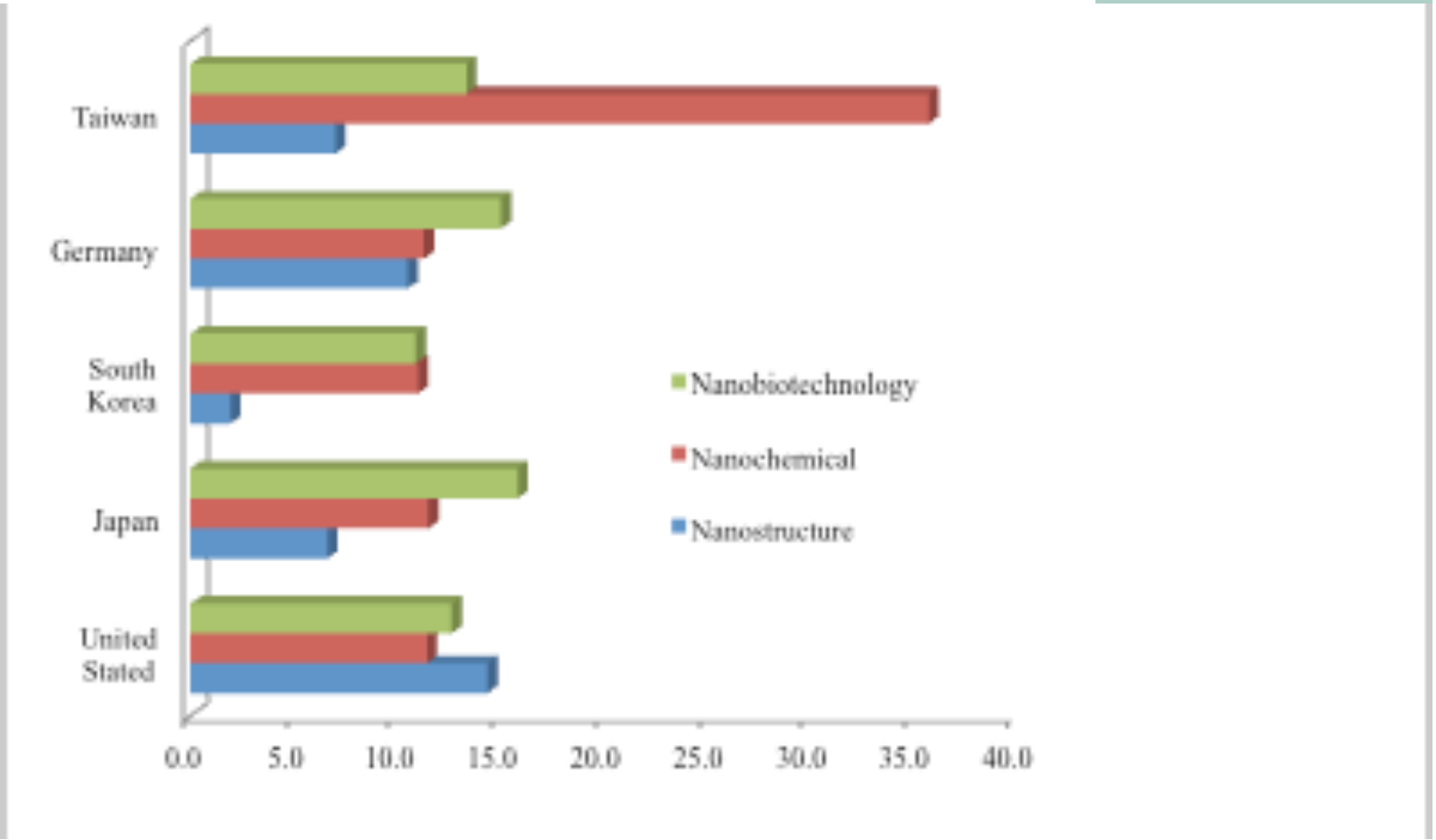
Backward patent citation made by USPTO assigned in nanotechnology patents by countries, 1983-2013 (%)



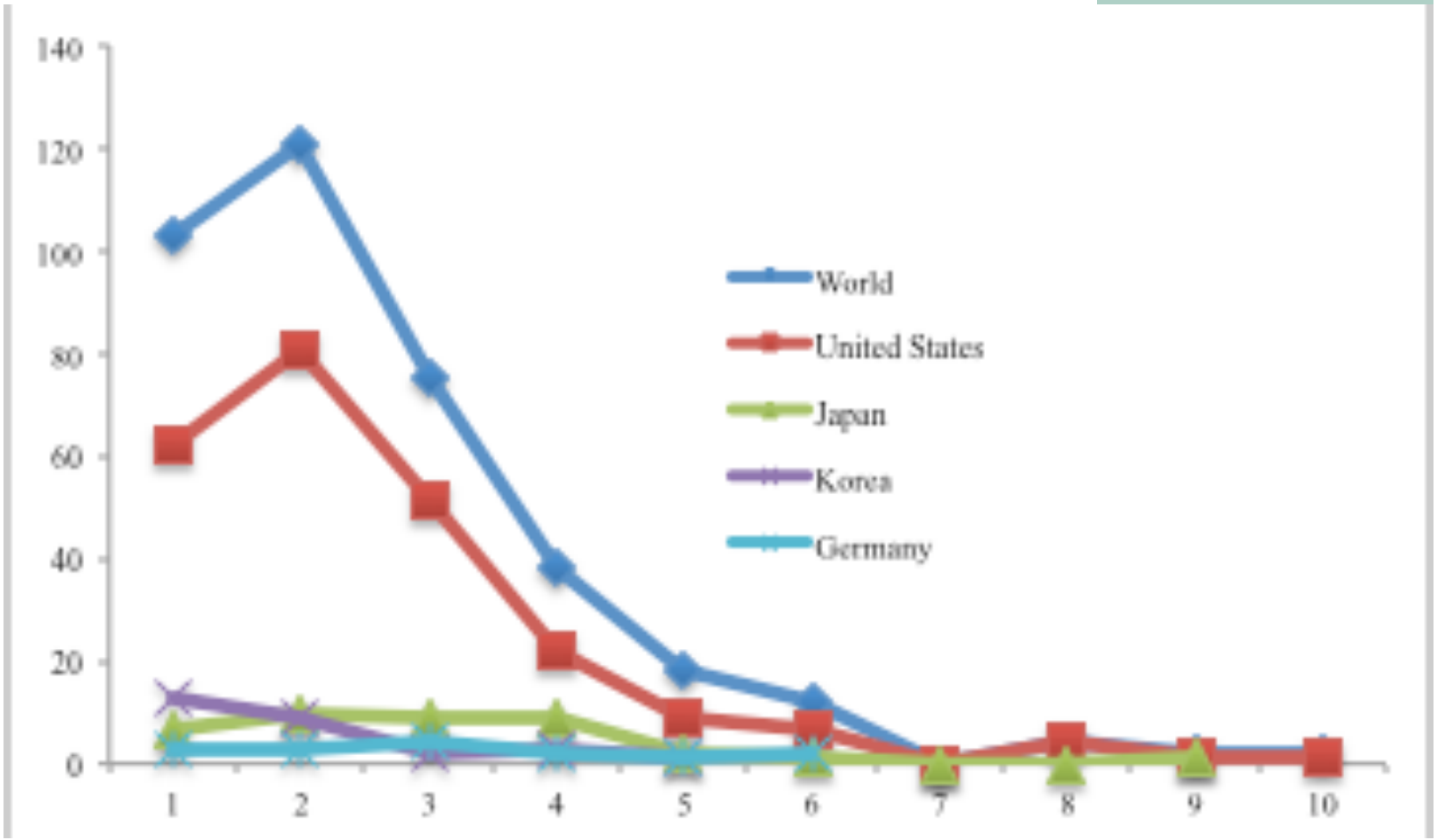
Forward patent citation made to USPTO patents assigned in nanotechnology by countries, 1983-2013 (%)



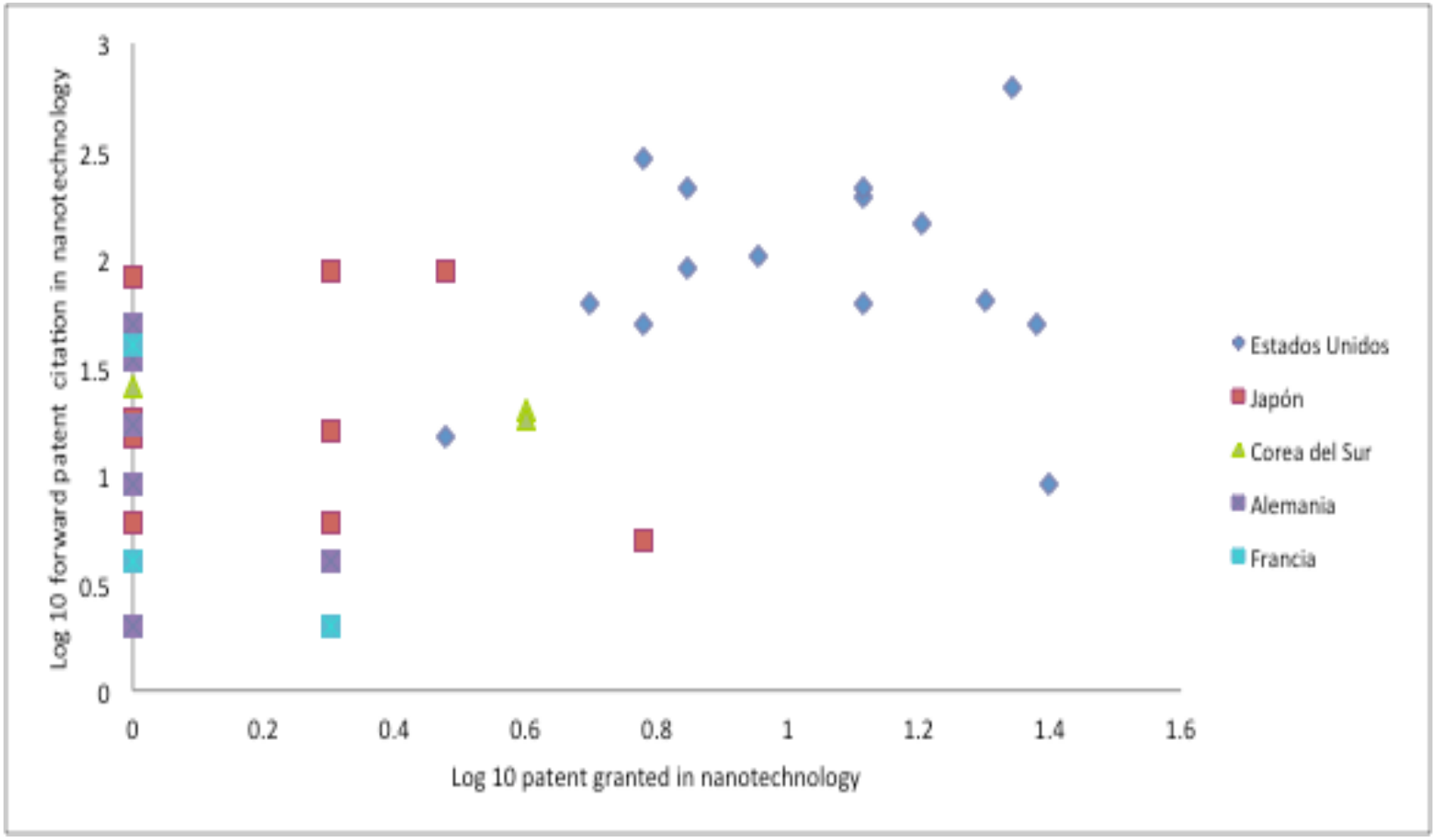
Forward patent citation made to USPTO assigned in nanotecnology patents by countries and technological classes, 1983-2013



Lagtime diffusion of nanotechnology USPTO patents



Relationship between nanotech patents growth rate and FwPatCit growth rate across countries, 1983-2013



Model of probability of diffusion of the nanotechnologies across countries

Having as a base a Poisson-type model, we plot the following probability equation of the NNTP diffusion:

$$DifNan_i = E[y_i|x_i] = exp(x_i,\beta)$$

The group X of xi, is composed of the following variables:

	Variable proxy	It is expected:
Cl	Number of claims	The higher the number of claims the higher of spread new knowledge (Tong and Frame; 1992, Lanjouw and Schankerman; 2000 and 2004).
$\dot{A}$	Stock of previous knowledge. We use as a proxy variable the number of backward patent citation (BwPCit)	The higher the number of BwPCit, the higher the probability that a patent will be cited by a successive patent (Duguet and Macgarvie; 2005, Gay and Le Bas; 2005),
GTI*	Generality Technological Index, indicates the number of technological classes where an invention is assigned.	The probability of a high forward patent citation FwPC will be greater, therefore more diffusion, if the patent belongs to a wide range of technological fields (Trajtenberg, et al.; 1997; (Jaffe and Trajtenberg; 1999, Maurseth; 2005).
CoopTec	Technological cooperation. The co-patent assignee is used as a proxy variable and it is expressed as a dummy variable.	The shared property of a patent presumes a previous cooperation agreement where efforts in ID are also shared. The higher the cooperation among firms, institutions & individuals the higher the knowledge diffusion of NNP.

….the group X of xi, is composed of the following variables:

SizeRT	Size of research teams. It refers to the number of inventors involved in the generation of the patent.	The larger the team the higher the number of ideas that can be generated.
MobIn	Inventor's mobility. This is a dummy variable where 0 means that there is only a presence of inventors of the same nationality of the patent and 1 indicates the presence of foreign inventors.	The mobility of the inventors favors the spillover of codified and tacit knowledge.
Pat-BibSC	The relationship of technological sector with the scientific sector. We use the number of scientific articles cited (SC) by patent as a proxy variable of academic knowledge used by patents to build the new invention.	There is a higher probability of FwPCit when the relationship of technological sector with the scientific sector is higher.
GovEff	Institutional effort in the generation of nanotechnology inventions. We use the number of patent assignee of universities and research institutes as a proxy variable. A patent is the result of the R&D effort.	By considering the huge R&D expenditure needed to develop nanotech, the higher institutional innovation the higher probabilities to diffuse the NNP.
FirmsINV	Firm's participation in the patents. We used patents whose firms are the holders.	The participation of the firms in the generation of patents suggests a greater probability that these will scale at the industrial level and will be installed as innovations and therefore its diffusion
lagFwCit	Lag time in which the FwPCit is made. It is a proxy variable of the speed of the diffusion of knowledge.	As patents have largest FwPCit their diffusion is faster, thus the NNP. On the opposite, the lowest FwPCit their diffusion is slower (Le Bas, et al.; 2004).

Three diffusion degree in the technological scope

- ***disper*: low diffusion**. Patent is concentrated at last in its own technological field and the GTI goes from 0 to ≤0.33.
- ***medisp*: medium diffusion**. Patent is applied and assigned in more than one technological field and the GTI goes from 0.34≤ to ≤0.66
- ***altdisp*: high diffusion**. Patent is applied and assigned in almost or all the six technological fields and the GTI go from 0.67≤IGT≤1

Outcomes of Binomial model of factors affecting the diffusion in nanotechnology across countries, 1983-2013

Variables	Binomial negative (Coeficients)	P>z	Elasticity	P>z
Constant	0.45518	0.0000		
Cl	0.00296	0.0160	0.00608	0.0150
MobIn	0.22874	0.0080	0.51303	0.0130
Goveff	-0.23875	0.0040	-0.46630	0.0020
Medisp	0.39987	0.0000	0.83310	0.0000
Disper	0.49287	0.0000	1.25712	0.0000

Outcomes of NNP diffusion model in the United States, 1983-2013

Variables	Binomial Negative (Coefficients)	P>z	Elasticity	P>z
Constant	0.4624	0.0000		
Cl	0.0032	0.0350	0.0067	0.0330
MobIn	0.2652	0.0030	0.6161	0.0060
Goveff	-0.2713	0.0040	-0.5350	0.0020
Medisp	0.3950	0.0000	0.8244	0.0000
Disper	0.4436	0.0000	1.1166	0.0020

Conclusions

- Nowadays the nanotechnologies stand up as an emergent paradigm.
- NNP characterized by an important scientific knowledge flows input.
- NNP diffusion is essential to become a dominant paradigm.
- Patents database are an important tool To study the variables whose could affect the diffusion of the NNP across countries,.

Conclusions

- The claims, the international mobility of researchers and the general technological index degree have a positive effect on the diffusion of the NNP.
- Impact of the government/institutions efforts is not yet significant. It suggest that the government/institutions must assume a key role in the spread of this new paradigm that will impact not only the technological scope but it will be influent in the changes of life society.

Conclusions

- Leadership of United States
- Lower level other industrialized countries (Japan, South Korea, Germany and Taiwan)
- This group of industrialized countries have made almost de 90% of the backward citation and the forward citation, standing in the technological border.