Anticipating developments in nanotechnology commercialization

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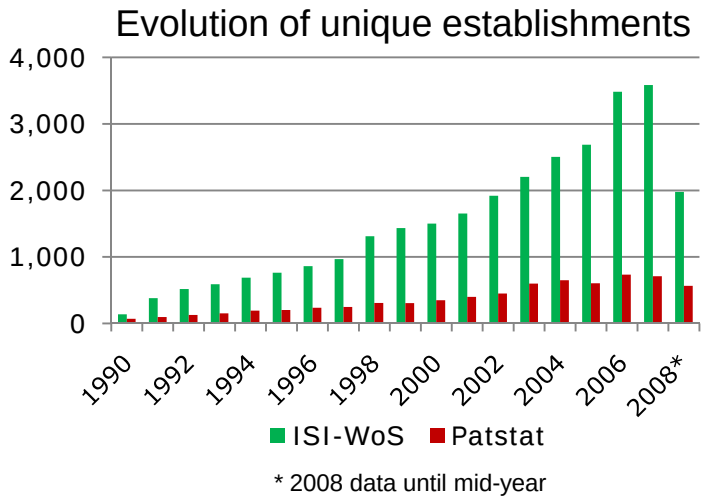
Anticipating nanotechnology commercialization: Some questions which need better answers

- Where is the shift from discovery to application in nanotechnology taking place?
- Who is turning nanoscience knowledge into nanotechnology innovations?
- What type of applications will be developed?
- How do companies address uncertainty in nanotechnology commercialization?
- How can we feed insight about nanotechnology commercialization into the processes of anticipatory governance?

Starting Point:
Base Analysis

CNS-ASU Program in Nanotechnology Research and Innovation at Georgia Tech

- Identified ~**12,000 companies worldwide**, with either publications (10,600 firms) or patents (2,200 firms)



Data Sources

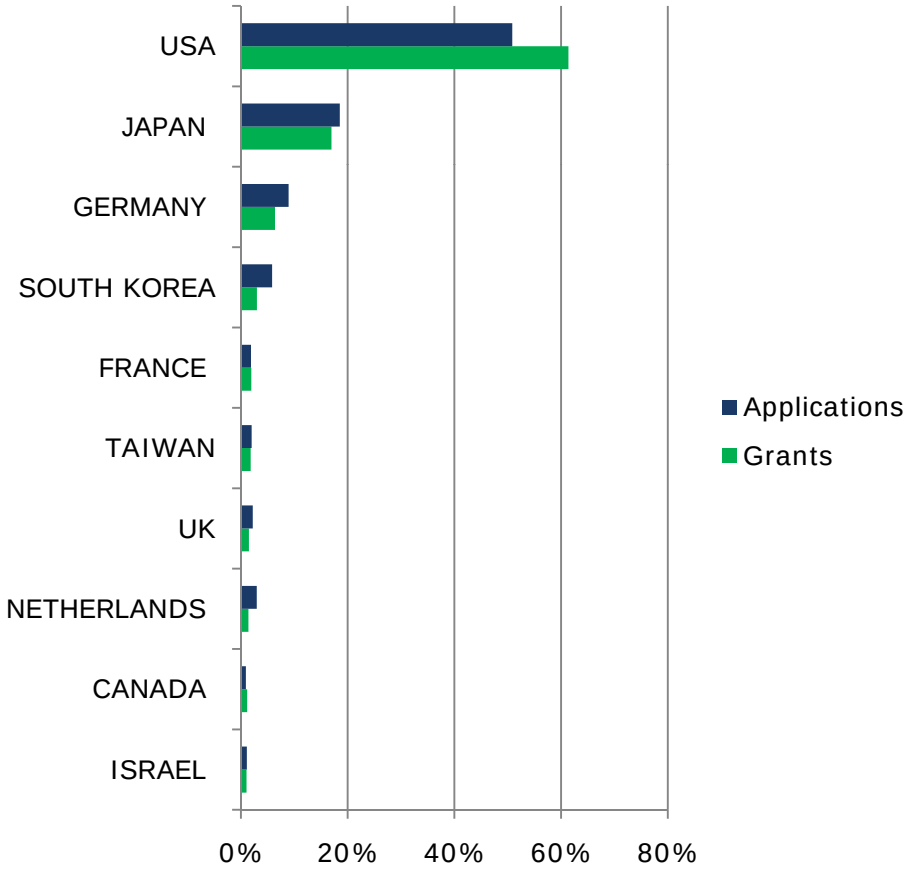
- ISI-WoS (1990-2008)
  - More than 500K publications
- Patstat (1990-July 2008)
  - 71K patent applications
  - 27K patent grants
- Corporate data:
  - Analysis at the establishment level (unique city, country locations)
  - Location data availability:
    - About 100% for publications
    - About 29% for patent app., 52% for patent grants
    - Subject to clean up, missing values

For definition of nanotechnology, see Porter, A., Youtie, J., Shapira, P., Schoeneck, D., "Refining Search Terms for Nanotechnology," Journal of Nanoparticle Research, 10(5), 715-728, 2008

“Multi-player” rather than “global”

Applications v. Awards 1990-2008 by country

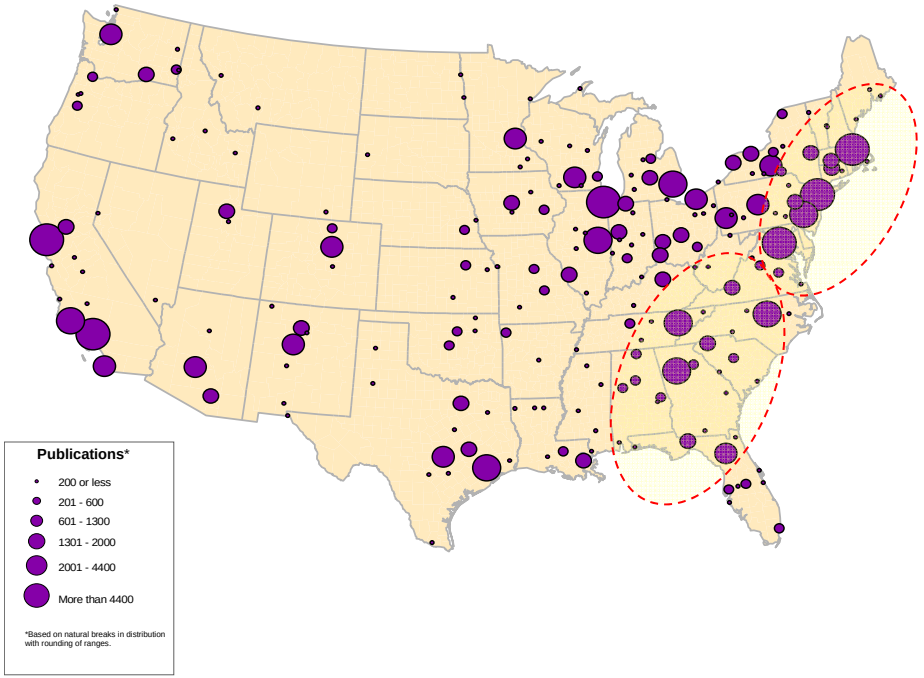
Share of global patents for assignee country



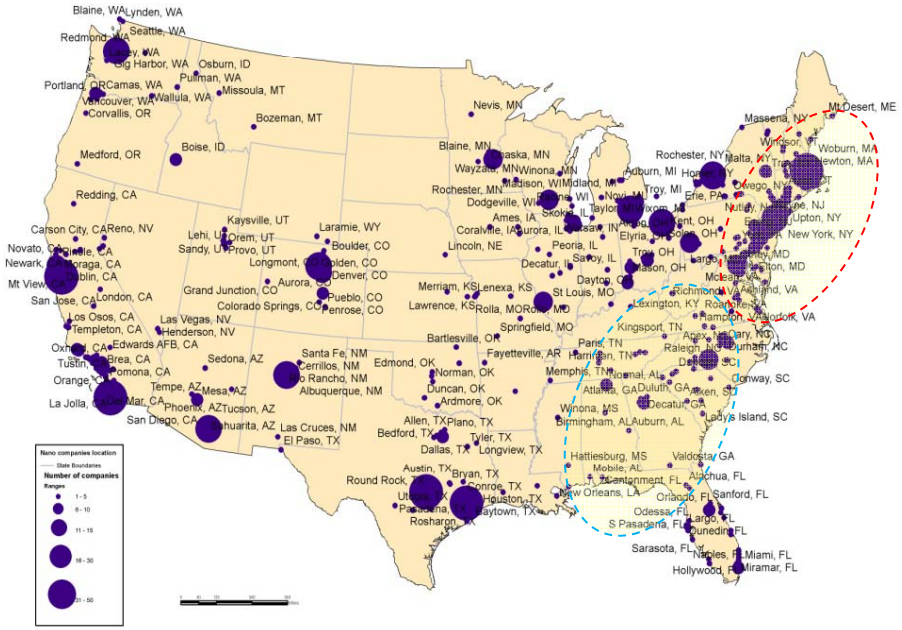
- US: leading-edge of nano commercialization – 5,200 firms (1,300 with patents)
- China: 2nd in publications, 12th in patents, 7th in firms
- Top foreign assignees in USPTO: Japan (16%), Germany (4%), South Korea (3%), Taiwan (2%)
- Growth of non-US assignees in USPTO patents
  - patent grants for non-US assignees (33%) have lower share than US assignees (67%)
  - patent applications (after 2001), slightly higher share for non-US assignees (36%)

Source: Analysis of Georgia Tech global nanotechnology patent databases. For details and definition of nanotechnology, see Porter et al., 2008

Locations of Research Not Necessarily the Same as Commercialization



Nano Publications
1990-2006



Nano Corporate Entry
as of 2009

Source: Analysis of Georgia Tech global nanotechnology publications and patent databases. For details and definition of nanotechnology, see Porter et al., 2008

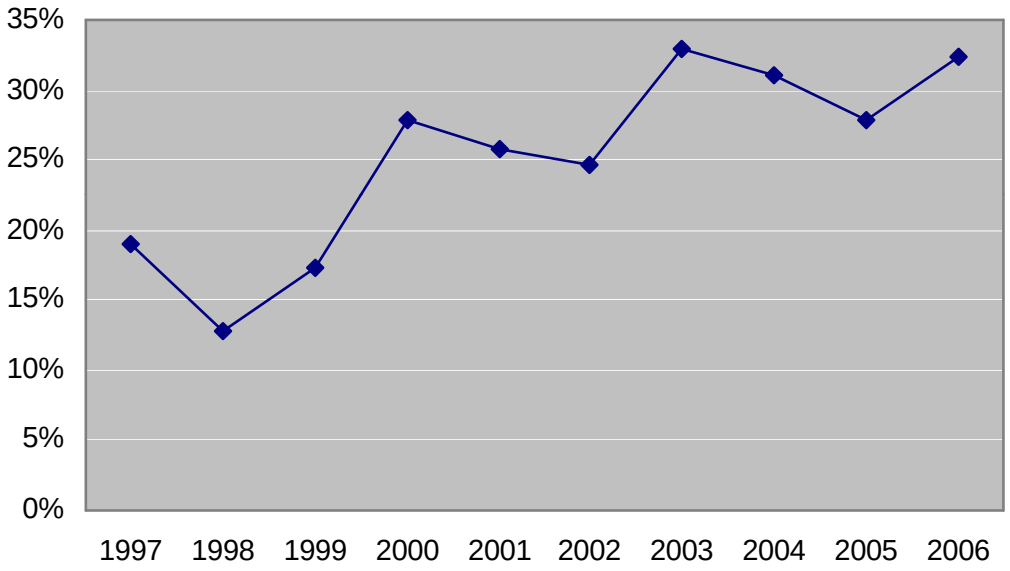
Nanotechnology Patenting Strategies: US Multi-Nationals Increasingly Invent at Home

- 25 largest US Multi-National Enterprises (MNEs) active in patenting in nanotechnology
  - (13% of all USPTO, EPO, WIPO Patents)
- Non-US share declining
  - 1997-2001 = 1187 patents; 17% co-invented abroad; 10% totally invented abroad
  - 2002-2006 = 2555 patents; 13% co-invented abroad; 8% totally invented abroad
- US home advantages still evident.
- Significant for non-US patenting:
  - host country scientific strength, firm experience and technological capabilities, and technological diversity in patenting.
- Not significant for non-US patenting:
  - Market size and GDP/capita

Source: Andrea Fernandez-Ribas and Philip Shapira, Technological diversity, scientific excellence and the location of inventive activities abroad: the case of nanotechnology, *Journal of Technology Transfer* (2009) 34:286–303

International Nano Patent Strategies: Small Businesses are Increasingly Emerging

Proportion of U.S. SMEs* with WIPO PCT filings (relative to U.S. Large)



* SBA standard definition, less than 500 employees

Authors: Andrea Fernández-Ribas with research assistance from Ronak Kamdar. Support obtained through CNS-ASU and the Kauffman Foundation and Georgia Research Alliance.

- Analysis of WIPO PTC nano-related applications 1997-2006 of 300+ US owned SMEs
- Increased geo-graphic breadth of patent protection; regional/ international (co-) invention patterns observed
- **Next Question**: What drives the growth of US SME international patenting?

Opportunities for SMEs and Large companies are in contrasting applications

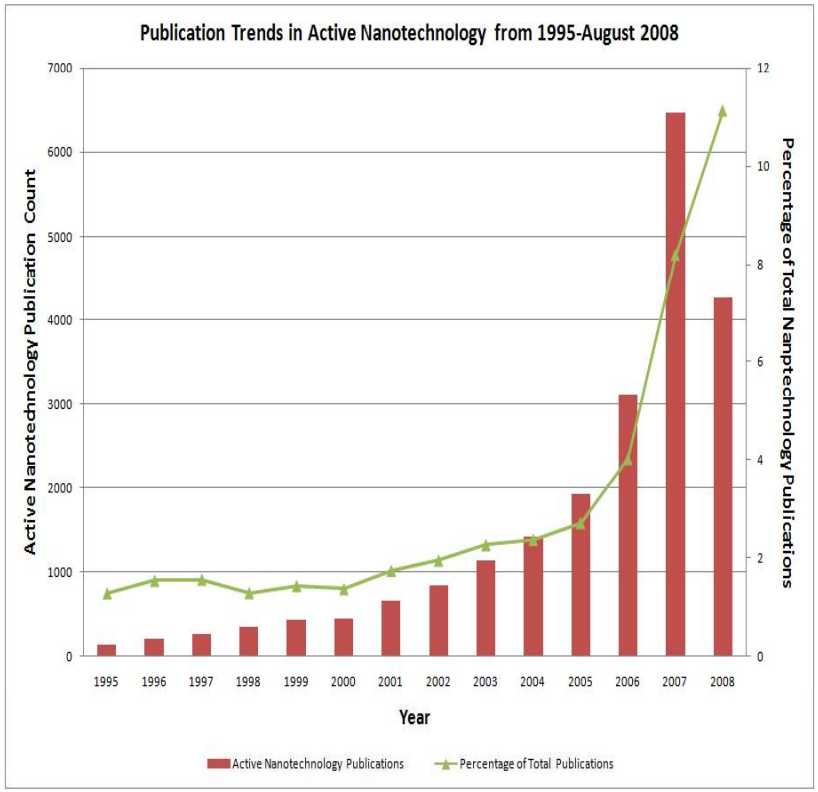
Use of nanotechnology (classes of technologies—IPC codes)**	Firm size*	
	SME	Large
Nano-raw material (e.g. carbon nanotubes, proteins)	21%	10%
Nano-intermediate (e.g. semiconductors, films)	76%	88%
Nano-products (e.g. solar cells, cosmetics, drugs)	11%	6%

* United States, Fortune 1000 vs. Non-Fortune 1000; all nano-patents since 1990.

** Technologies classified according to definition in Alencar et al. (2007), multi-classification possible. Covers 57% of all nano-patent records

Source: Analysis of Georgia Tech global nanotechnology patent databases. For details and definition of nanotechnology, see Porter et al., 2008

Is there a shift to “active nanostructures?”



- Shift? Yes, after 2006
  - 21,000+ articles from WOS/SCI from 1995 to 2008
- Product implications
  - Remote Actuated (e.g., Magnetic, electrical, light and wireless tagged nanotechnologies)
  - Environmentally Responsive (e.g., actuators, drug delivery)
  - Miniaturized (e.g., molecular electronics)
  - Hybrid (e.g., uncommon material combinations, biotic-abiotic, organic-inorganic in chips)
  - Transforming (e.g., self-healing materials)

Source: Vrishali Subramanian, Jan Youtie, Alan L. Porter, and Philip Shapira (2009). Is there a shift to "active nanostructures?" *Journal of Nanoparticle Research*, 2009 http://dx.doi.org/10.1007/s11051-009-9729-4.

Pilot Cases

Contrasts in Positioning of "Nano"

Company	Segment	Strategy	R&D/Linkages	Marketing
3M Co.	Industrial materials	Multi-segment Multi-product	Global R&D Multi-university links	Nano" = USP
Nantero, Inc.	Industrial materials	Single-segment	Central R&D Multi-university	"Nano" = USP
SurModics, Inc.	Medical markets	Single-segment Multi-product	Central R&D University link	Nano" = USP
Merck & Co., Inc.	Medical markets	Products yet to appear? Invest SMEs	Global R&D Multi-university links	No "nano" labeled products
International Cosmeceuticals, Inc.	Consumer products	Single-segment Intermediate user	No R&D University link	"Nano" downplayed

Source: multiple data sources online, as of 2008 otherwise indicated (e.g. Reference USA, BusinessWeek, Yahoo Finance)

Nanotechnology commercialization summary

"Knowns" and "Unknowns"

"Knowns" (or better "knowns")

- Corporate entry into nanotechnology through research publications and patenting
- Geographical concentration of corporate entrants in nanotechnology
- First generation consumer-oriented products
- Linkages with public research and universities
- Nano varies as a marketing brand / certification

"Unknowns" (or mostly "unknowns")

- Corporate strategy (in the face of uncertainty)
- Influence of contrasting regulatory environments
- Fit in the global supply chain v. inventive activity
- International boundaries, consumer values and demand
- Employment and labor market implications
- Implications for anticipatory governance

2010-2015 Plan

CNS-ASU @ Georgia Tech

Nanotechnology Research and Innovation Systems Assessment Group

- Objective: Develop real-time strategic intelligence about nanotechnology commercialization in the US and globally
- Methods:
  - Global corporate entry database (pubs, patents, other sources)
    - c. 12K corp organizations & 19K corp establishments – and growing
  - Literature-based discovery (corporate pubs, linkages, patents, announcements)
  - **New corporate nanotechnology panel (five years)**
    - **250 US + 250 international (LEs & SMEs)**
    - Georgia Tech lead, with international collaboration (Europe, Asia, other locations
- Research thrusts:
  - Corporate strategy:
    - Development of MNE and SME's activities in nano. Emergence of "next generation" nano products and applications.
    - Nanotechnology decision-making under uncertainty
    - Research and innovation strategies (university linkages, patenting, R&D location, open innovation)
  - National developments & regional clustering ("nanodistricts)
  - Emergence of global nano R&D, production and use pathways
  - Labor market implications
  - Policy implications

Further information

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