



# Nanotechnology\* as the next general purpose technology?

- Insights and challenges from a Finnish small country viewpoint

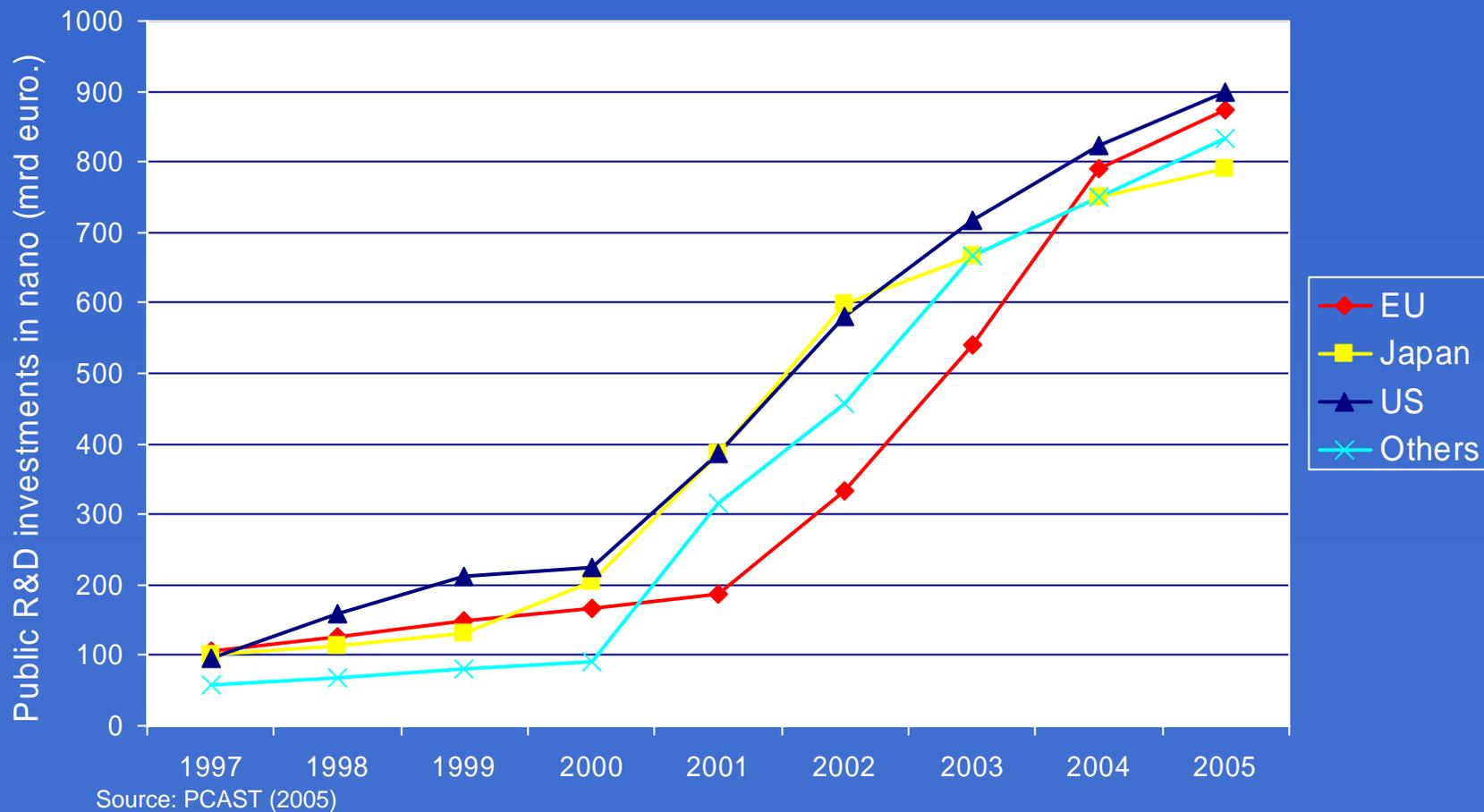
*PRAXIS 25/08 2006*

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\*The abbreviation 'nano' is used throughout

# Public nano R&D investments



# Structure of presentation

1. What is nanotechnology?
2. 'General Purpose Technologies'
  - Theoretical basis, analytical dimensions
  - Could nano become one?
3. Developments in Finland
  - Policies, research and firm communities
  - Publications, patents, application fields
  - Challenges
4. Summing up

# 1. What is nano?

A nanometer is  
one-billionth of  
a meter...

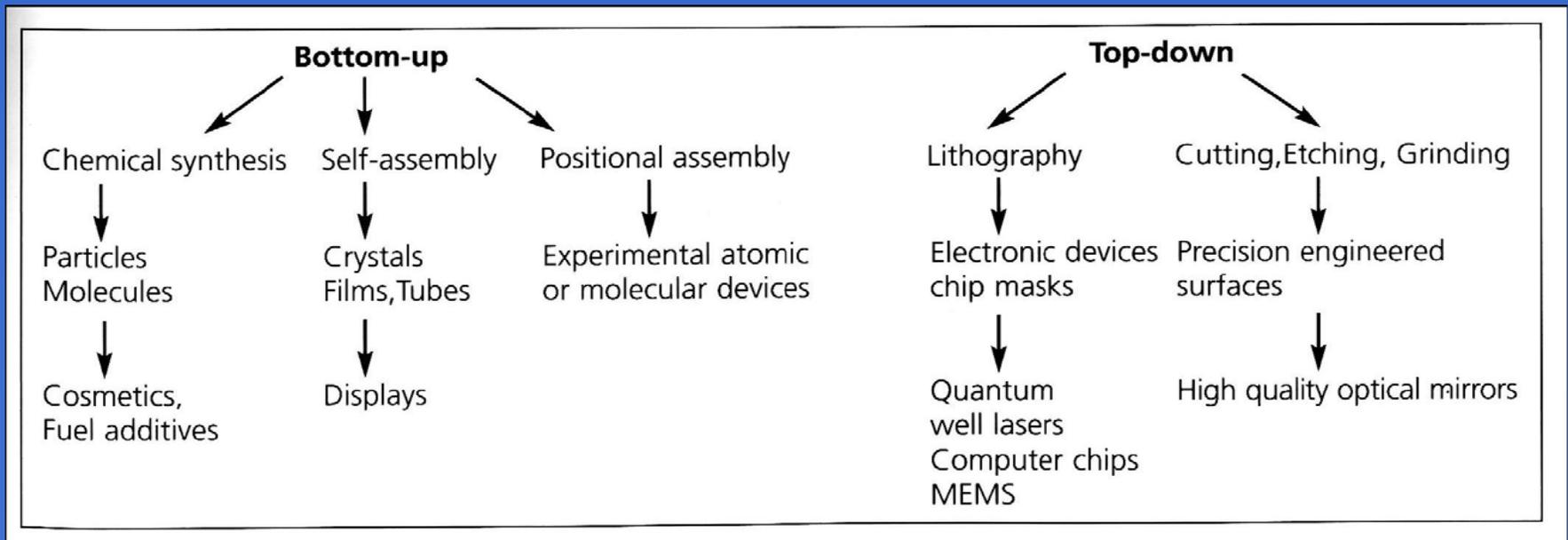


...or like the size  
of a marble to the  
size of Earth

# Brief policy-related definition

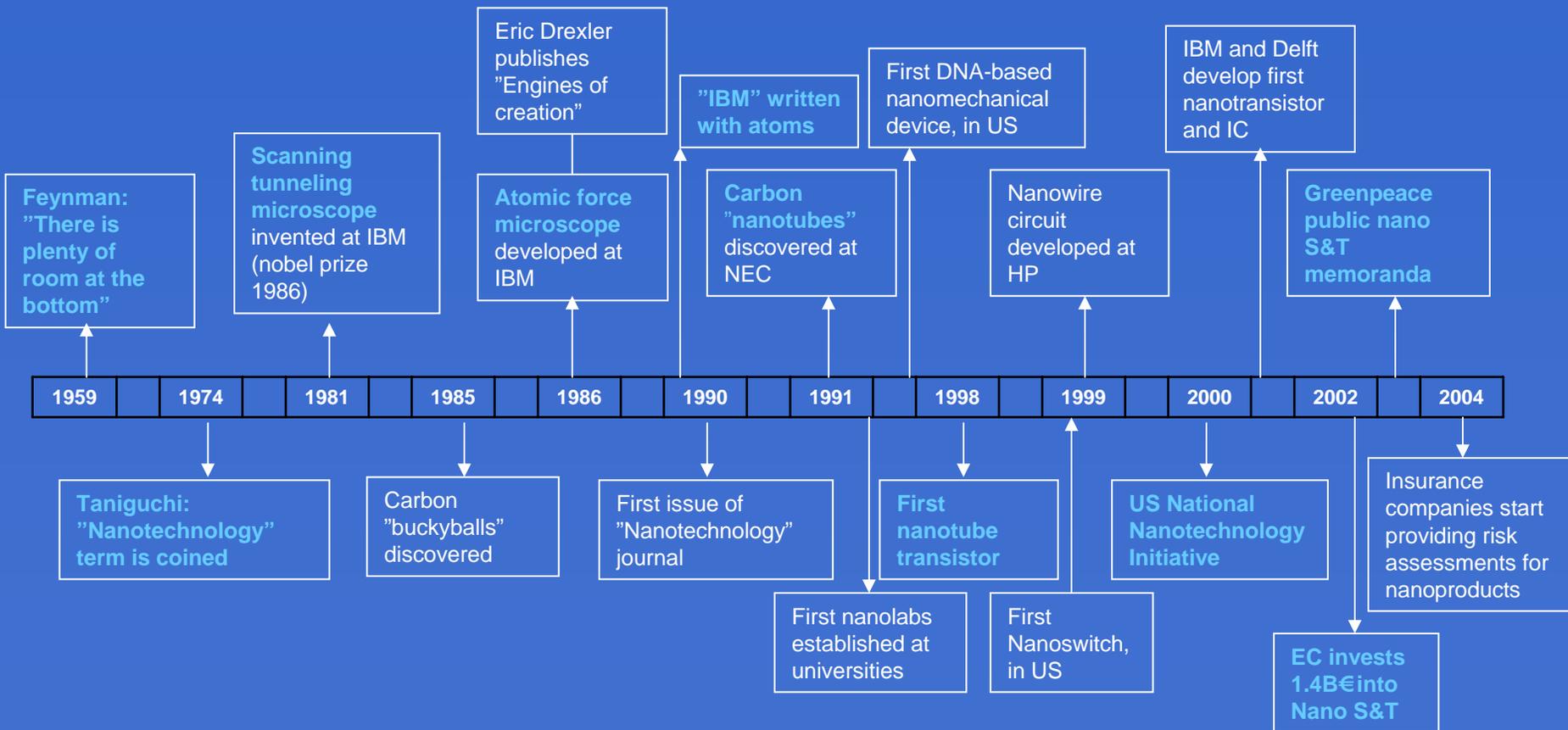
*“Nanotechnology is the **understanding and control** of matter at dimensions of roughly **1 to 100 nanometers**, where **unique phenomena enable novel applications**. Encompassing nanoscale engineering and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale”* (Source: <http://www.nano.gov>)

# Bottom-up vs. top-down approaches



Source: The Royal Society (2004), p. 25

# Milestones in nanodevelopments



## 2. 'General purpose technologies (GPT)'

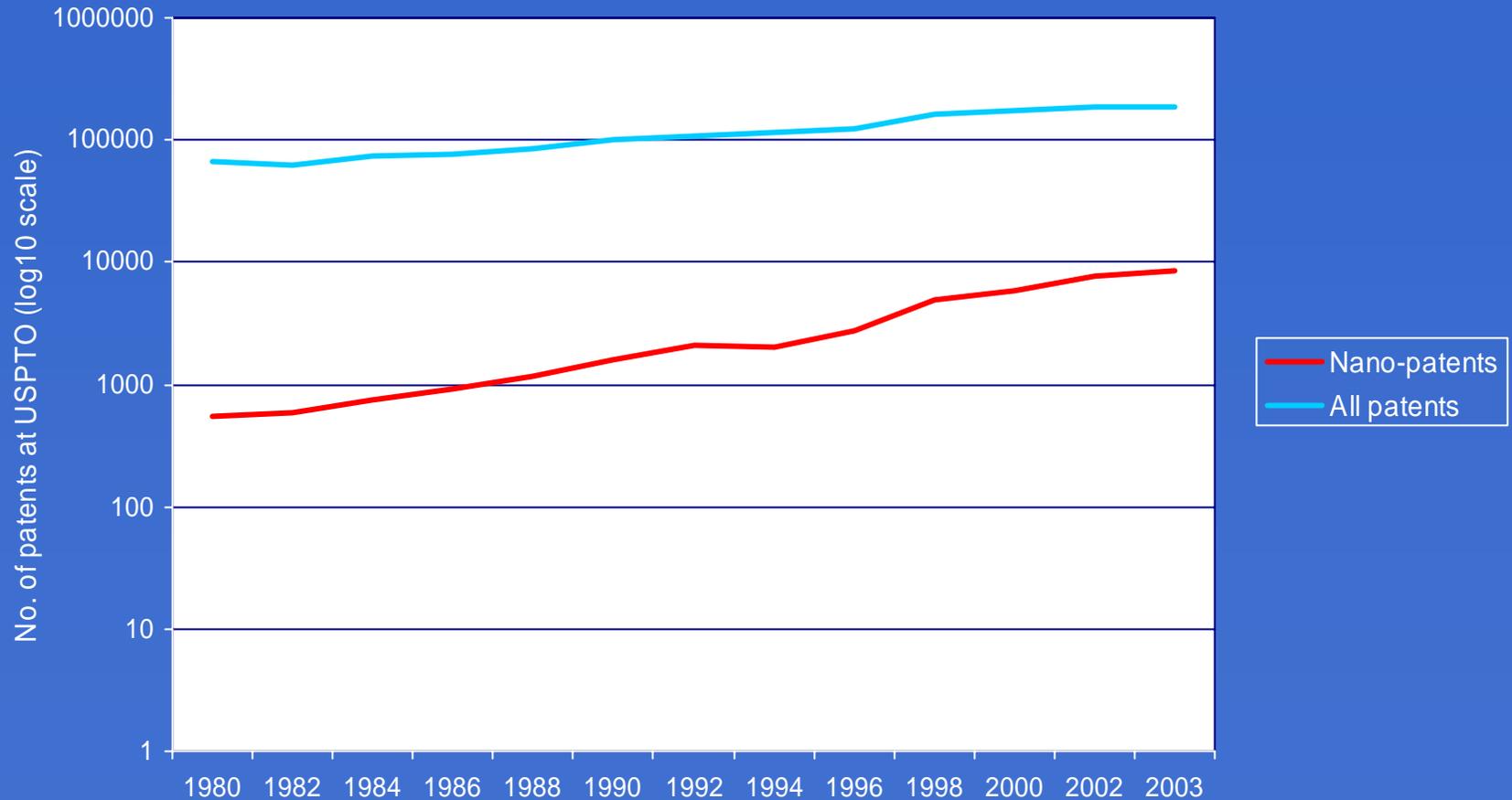
# Theoretical basis

- Schumpeter (1911, 1942): the definition and taxonomy of innovations, "...the gales of creative destruction..."
- Dahmén (1950) "structural tensions"
- Mensch (1979) "statements in technology" and "basic innovations"
- Freeman & Perez (1988), Freeman & Louca (2001) "changes in techno-economic paradigm"
- Helpman (1998) 'General Purpose Technologies and Economic Growth'.
- Lipsey et al. (2005) 'Economic transformations – General Purpose Technologies and Long Term Economic Growth'

# A definition – necessary but not always sufficient criteria

- *”A GPT is a technology that initially has **much scope for improvement** and eventually comes to be **widely used**, to have **many uses**, and to have **many and strong innovational complementarities**” (Lipsey et al., 1998)*
- Prominent examples: steam power, electricity, ICT

# #1: Large scope for improvement?



- Growth rate of patenting in US exceeds that of all other fields
- Resembling early development of modern biotech after enabling inventions in microscopy
- Might sustain Moore's law...
  - ⇒ #1 criterion is becoming fulfilled pending on **when** and **where** 'bottom-up' approaches to nano-scale engineering become industrially viable

## #2: Widening fields of application?

- A new process technology enabling product innovation, applicable in virtually all manufacturing sectors (contrast with biotech)
  - Evidence of widening use especially towards chemicals, biotech and drug development /delivery and electronics
- ⇒ #2 criterion is becoming fulfilled pending on standardization, regulatory issues and ethical concerns

# #3: Widening purposes of use?

- Has most/all characteristics of a multipurpose technology almost by definition (compare to process control/ICT)
  - Cross-pollination with both ICT and modern biotechnology
- ⇒ #3 criterion is becoming fulfilled pending on social and political endorsement, regulations, health concerns and ethical issues

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**"If you increase the magnification another million times you can see the safety regulations."**

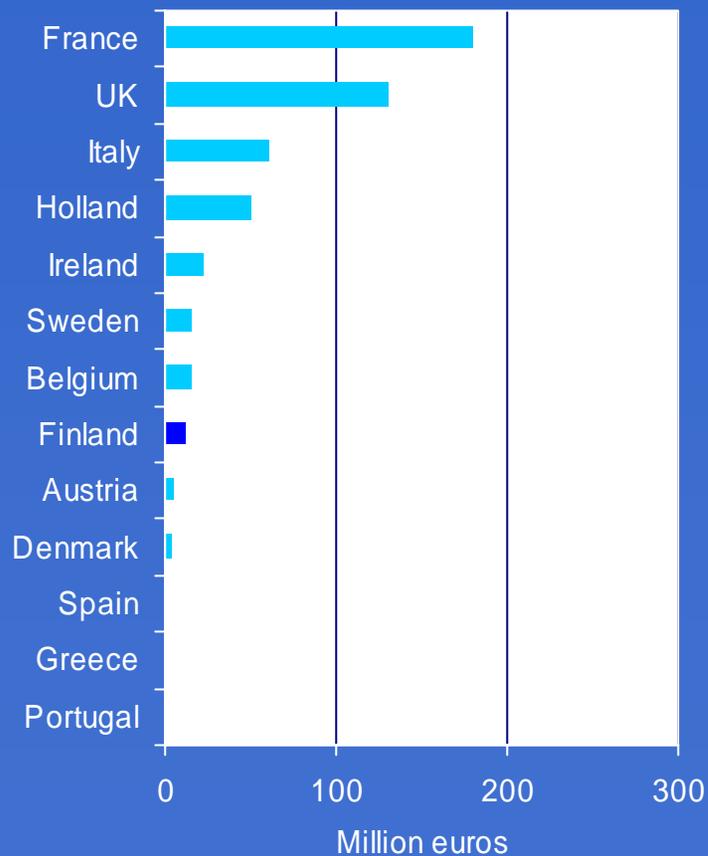
# #4: Complementary innovations?

- 'Top-down' versus 'bottom-up' approaches to nanoscale engineering?
  - Fixed investments of incumbents?
  - Organizational adaptation, perception of users?
- ⇒ #4 criterion too early to assess...again pending on **when** and **where** breakthroughs occur

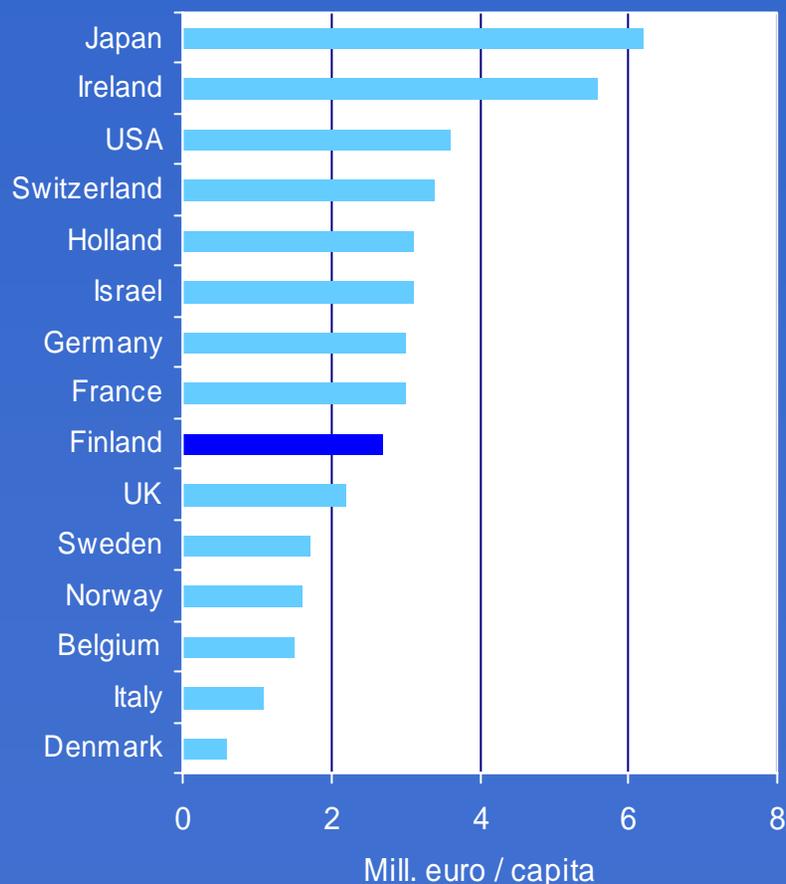
...3/4 criteria becomming  
fulfilled...although big issues lie  
ahead...

# 3. Developments in Finland

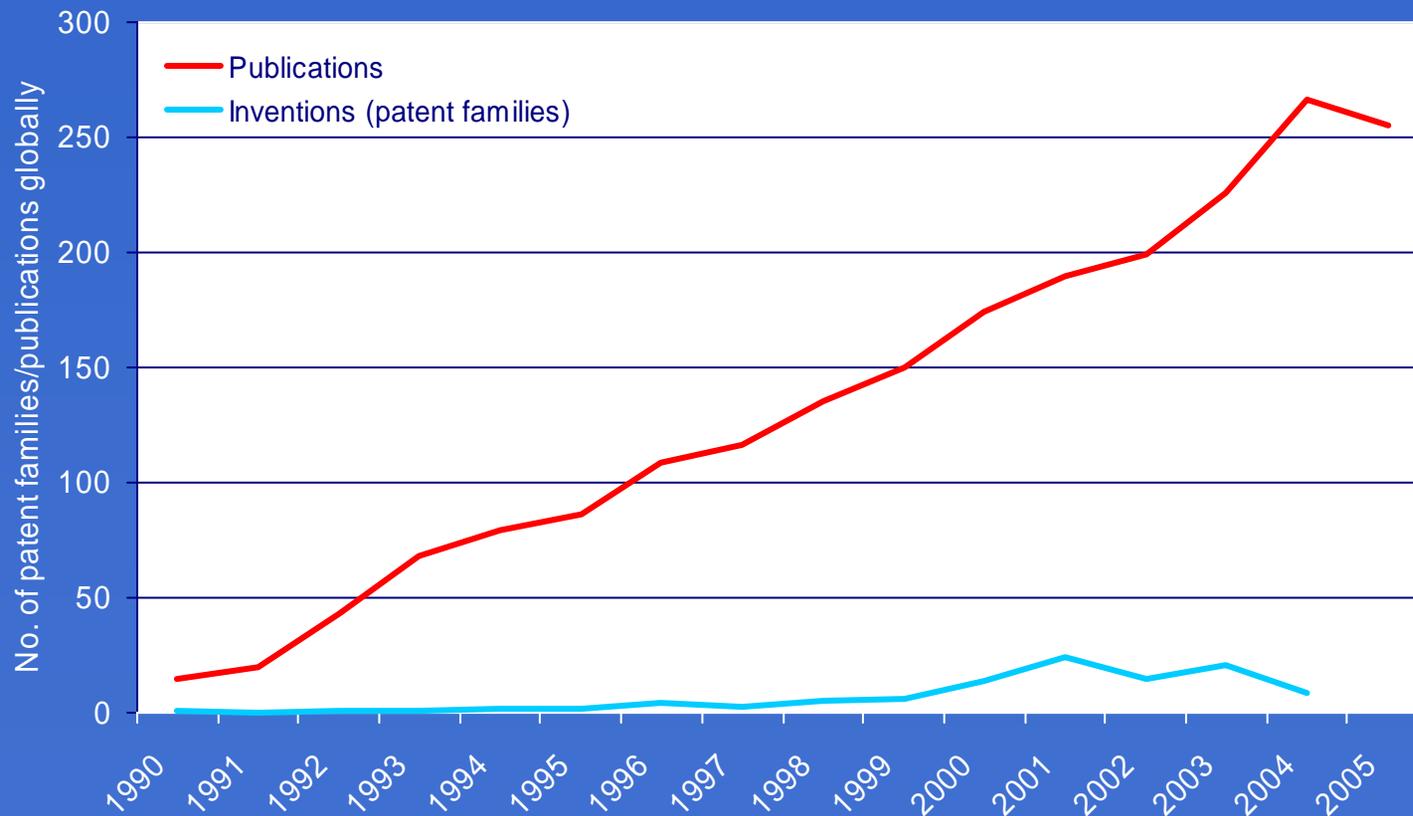
# Comparative public nano R&D investments



Source: EU (2004)

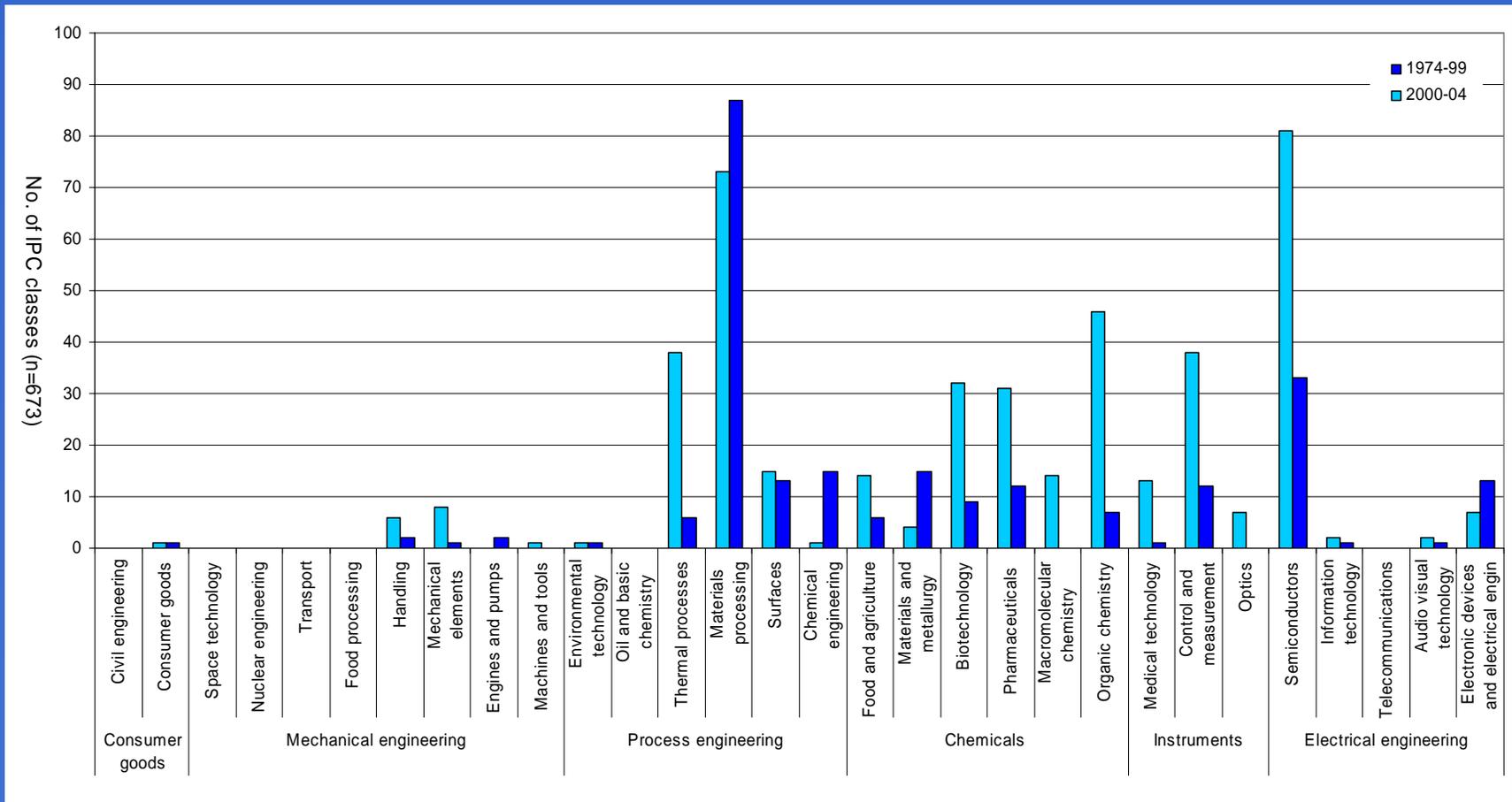


# Finnish nano publications and inventions



Source: Derwent World Patent Index, Scisearch

# Emerging Finnish application fields for nano



Source: Derwent World Patent Index,  
IPC classification based on Mancusi (2003)

# 4. Summing up

## General issues

- It is probably that nano – in some incarnation - will become a GPT
- Complementary innovations are lacking – competence-destroying vs. –enhancing?
- Nano is still scientist-driven (exogenous) –genuinly new challenges for technology transfer?
  - Interdisciplinarity?
  - Role of "gatekeepers"!
  - Unsettled demand?
  - Timing?
- Industrial dynamics and organisation unsettled and pending on **how** and **where** nano will achieve breakthroughs

# The case of Finland

- Stands out in terms of relative R&D investments and publications
- Some new entrants in close vicinity to technical universities, incumbents variably less active
- Nano largely driven by scientists also in Finland
- Narrow commercial spearheads in materials processing and biopharma, ICT surprisingly absent by S&T indicators
  - Nano-traditional industries?
  - Nano-ICT?
  - Nano-bio?
  - Nano-bio-ICT?

**Thank you!**