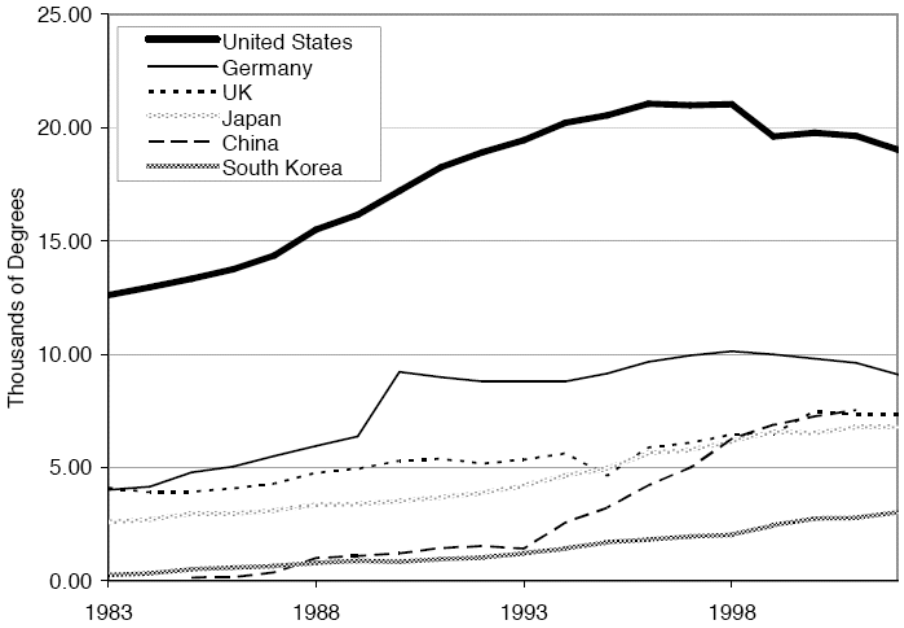
National Research Council Panel on Benchmarking the Research Competitiveness of the U.S. in Mechanical Engineering

Ward O. Winer

Georgia Institute of Technology

Study Context

- Globalization and international competitiveness
- Changing S&E culture
- Technical innovation



Doctoral degrees in Engineering and Natural Sciences 1982 - 2002

Statement of Task

1. What is the current position of U.S. mechanical engineering research relative to that of other regions or countries?

2. What key factors influence US performance in mechanical engineering?

3. On the basis of current trends in the United States and abroad, what will be the relative U.S. position in the near term and in the longer term?

Supported by NSF

Study Process

- Ad hoc panel of 11
- The group met one time in person, and otherwise met via teleconference.
- Final report issued November 2007.

The Panel

Ward O. Winer (NAE), Chair, Georgia Institute of Technology
Cristina H. Amon (NAE), University of Toronto
L. Catherine Brinson, Northwestern University
Earl H. Dowell (NAE), Duke University
John R. Howell (NAE), The University of Texas
Marshall G. Jones (NAE), GE Corporate Research and Development
Chang-Jin "CJ" Kim, University of California, Los Angeles
Kemper E. Lewis , University of Buffalo
Van C. Mow (NAE, IOM), Columbia University
J. Tinsley Oden (NAE), The University of Texas
Masayoshi Tomizuka, University of California, Berkeley

Tina Masciangioli, NRC Staff Officer

Areas of Mechanical Engineering Used in the Study

Acoustics and Dynamics
Bioengineering
Computational Mechanics
Design/CAD
Dynamic Systems and Controls
Energy Systems
Manufacturing/CAM
Mechanics of Engineering Materials
MEMS/NEMS
Thermal Systems and Heat Transfer
Tribology

Examples of Sub-Areas of Mechanical Engineering Used in Study

ACOUSTICS & DYNAMICS

- Acoustics
- Nonlinear Phenomena
- Computational Models
- Experimental Methods
- Complex Systems

TRIBOLOGY

- Hydrodynamic phenomena (inc. hydrostatic and elastohydrodynamic lubrication with liquids and gases, seals)
- Friction and wear
- Tribomaterials (inc. liquid, gas, and solid lubricants; fatigue)
- Contact mechanics and surface engineering (inc. nanoscale effects)
- Diagnostics of tribosystems

1. What is the current position of U.S. mechanical engineering research relative to that of other regions or countries?

Publications

Citations

Sources :
Thomsen ISI Essential Science Indicators
NSF Science and Engineering Indicators

Citations per Paper

Publications in Top Journals

Most Highly Cited Papers and Authors

Virtual Congresses

Awards

Virtual World Congresses

- Specialized Imaginary Meetings in ~5 sub-areas for each of our 11 major areas of mechanical engineering

- 8-10 organizers (leading mechanical engineers in each sub-area) each selected 20 speakers (scientists or engineers they'd invite to their meeting)

Virtual World Congresses

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Leadership Assessments

Use data on most cited papers, hot papers, and virtual congresses to assess research leadership in areas of mechanical engineering:

- 75 percent or more – the strong leader
- 50-75 percent – the leader
- 30-50 percent – among the leaders
- < 30 percent – lagging behind the leaders

Example: Tribology

Subareas

Contact Mechanics and Surface Engineering	53%	
Diagnostics of Tribosystems	37%	
Friction and Wear	46%	
Hydrodynamic Phenomena	45%	
Tribomaterials	52%	
Subarea average		48%

Most-cited articles in *Wear**

1995	1997	1999	2001	2003	2005
26%	34%	14%	12%	22%	34%

Note: other journals were analyzed

Conclusion:
U.S. among the leaders

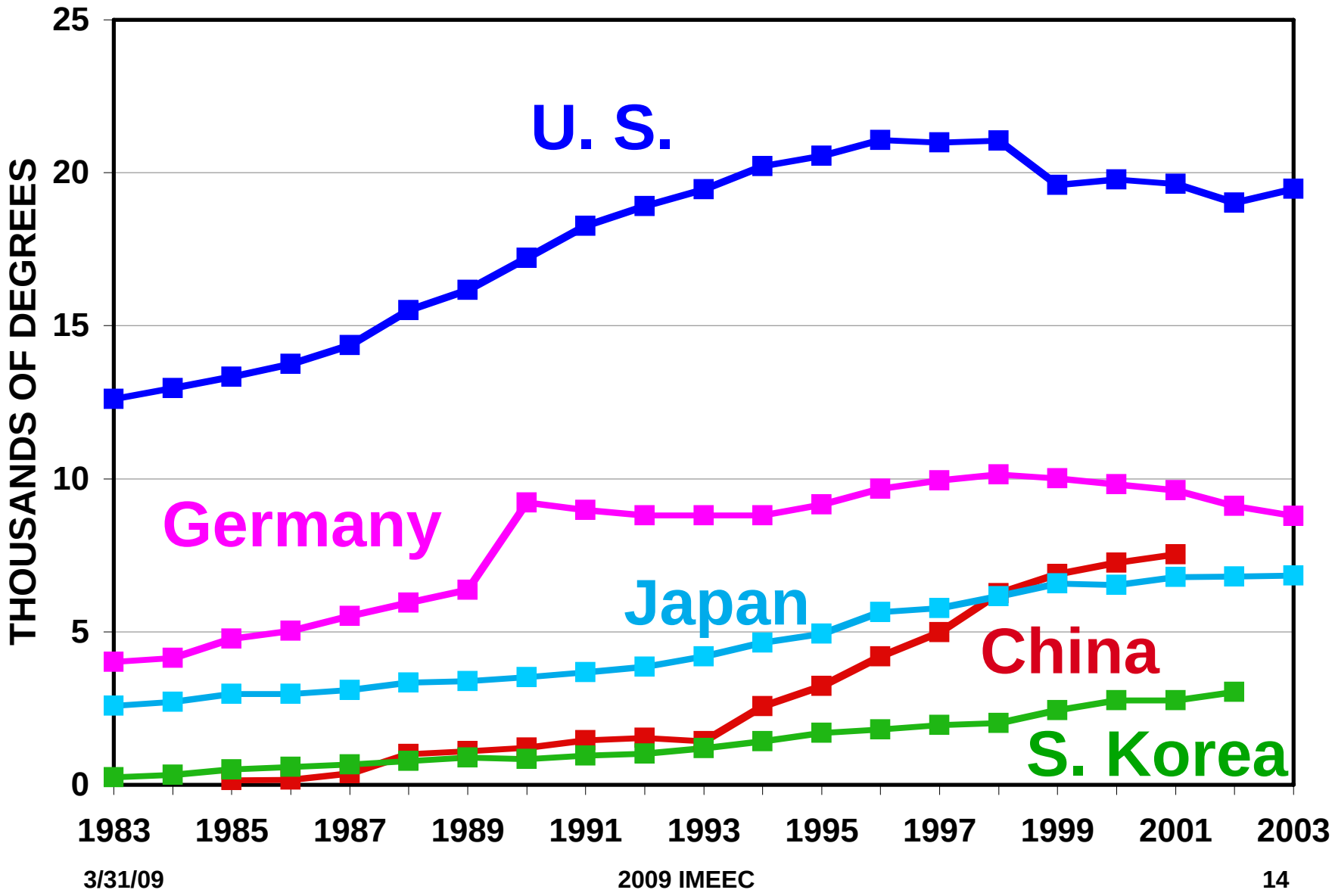
Tribology Article count[#]: 1999 (35%), 2003 (32%), 2005 (33%)

[#]*average of contributions to: Journal of Tribology, Tribology Transactions, Wear, Tribology International, Tribology Letters*

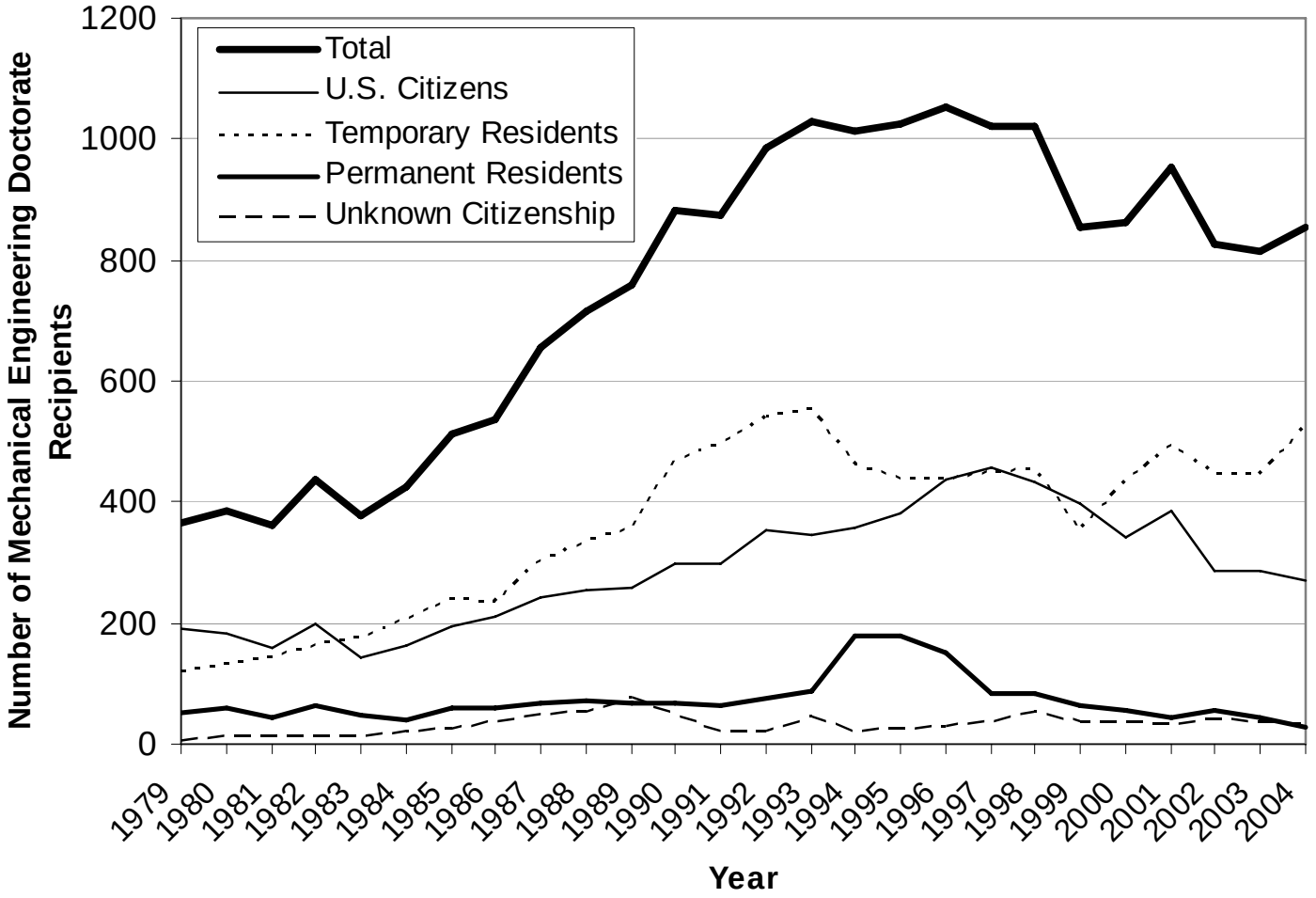
2. What key factors influence U.S. performance in mechanical engineering?

- **National imperatives:** Historical events and policy decisions that have influenced leadership in mechanical engineering.
- **Innovation:** Investment and technology development mechanisms that facilitate introduction into the marketplace of new technology derived from mechanical engineering research.
- **Major facilities, centers, and instrumentation:** The physical infrastructure and materiel for conducting mechanical engineering research.
- **Human resources:** The national capacity of mechanical engineering students and degree holders.
- **Funding:** Financial support for conducting mechanical engineering research.

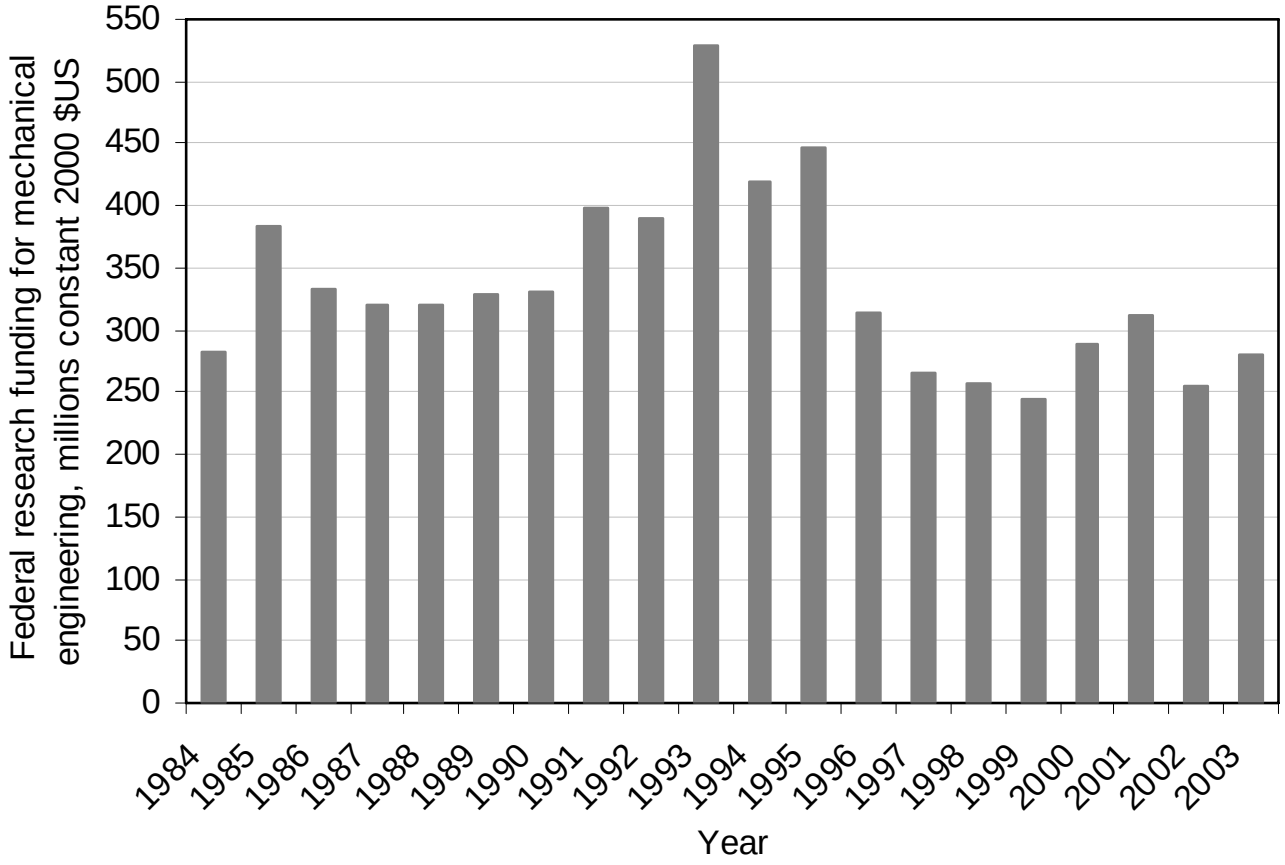
Example: S&E Doctoral Degrees



Example: Mechanical Engineering PhDs earned in the U.S.



Example: Federal Research Funding for Mechanical Engineering



Final Step of the Study

On the basis of current trends in the United States and abroad (publication rates, human resources, research funding, etc.), what will be the relative U.S. position in the near term and in the longer term?

SOME KEY FINDINGS

- From 1987-1991 U.S. authors contributed 48% of the M.E. articles worldwide, from 2002-2006 they contributed 24%
- In 2006 of the M.E. published articles worldwide China 7580 and U.S. 5660
- 1987-2006 U.S. contributed 40% of the articles and 40% of the most cited articles in the “top” 68 journals selected
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- U.S leadership in M.E. research will continue to be strong
- U.S. M.E. contributions to journals will continue to be strong, but so will those from India and China
- U.S. supply of MEs with advanced degrees is in jeopardy because of declining numbers of U.S. citizens seeking advanced degrees and uncertain prospects of attracting international students

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- U.S. will maintain strong leadership in emerging areas
- MEs will be major contributors to the main S & T issues confronting society
- Hence MEs have significant opportunities to contribute
- U.S. MEs will have competition for leadership worldwide

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Thank You!

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