THE NEW GEOGRAPHY OF INNOVATION
Global networks, Asia’s rise and America’s challenge

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‘Big Picture’ Questions

1. Can U.S. universities keep global talent?
2. Conflicting perceptions: How robust is U.S. leadership?
3. Global innovation networks: What is new?
   - What drives these networks?
   - Who are the new players?
   - How important is Asia?
4. America’s challenge: What needs to be done?
1. Can US universities keep global talent?
### U.S. S&E labor force - the critical importance of immigrants (% share)

<table>
<thead>
<tr>
<th>Education</th>
<th>1999</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor’s</td>
<td>11.3</td>
<td>16.3</td>
</tr>
<tr>
<td>Master’s</td>
<td>19.4</td>
<td>29.0</td>
</tr>
<tr>
<td>PhD</td>
<td>28.7</td>
<td>35.6</td>
</tr>
</tbody>
</table>

NSF/SRS, SESTAT data base
The critical importance of S&E immigrants – Census estimates (% share of U.S. S&E labor force)

<table>
<thead>
<tr>
<th>Education</th>
<th>2000</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor’s</td>
<td>16.5</td>
<td>19.1</td>
</tr>
<tr>
<td>Master’s</td>
<td>29.0</td>
<td>32.7</td>
</tr>
<tr>
<td>PhD</td>
<td>37.6</td>
<td>41.1</td>
</tr>
</tbody>
</table>

Census Bureau, PUMS, 2000; Census American Community Survey, 2005
Origins of S&E PhD immigrants, 2003

Total: 276,000

Shares(%)  Emerging Asia: 48%

- China: 22
- India: 14
- ex-SU: 6  UK: 7
- Taiwan: 4  Germany: 4  Canada: 4
- Korea: 3
- Iran: 2  Japan: 2

NSF/SRS, SESTAT data base
S&E PhDs - foreign students are critical

1. Rising share of temporary residents in S&E PhDs awarded by US universities
   - 21% (1985) → 36% (2005)
2. This share is > 50% for engineering, math, computer sc, physics, economics
3. This share is lower for biosciences (26%), medical /life sc (22%) and psychology (6%).
4. >50% of post-docs at MIT and Stanford were foreign born (1998)

Sources; NSB, 2008 and 2004
Asia dominates U.S. PhD supply

- 36% of S&E PhD recipients are temporary residents
  - Asia accounts for eight of the ten most important countries of origin
  - The top four countries of origin (China, India, Korea, Taiwan) account for 52%

- Focus:
  - China (bio, physics, engineering)
  - India (computer sc plus … )
  - Korea (engineering, bio, physics)
  - Taiwan (decline from 1,300 (1994) to 488 (2005))

NSB, 2008
Are US universities losing global talent?

PhD traffic

<table>
<thead>
<tr>
<th>Share of world S&amp;E PhDs granted by US universities (%)</th>
<th>1975</th>
<th>2004</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt; 50</td>
<td>&lt; 20</td>
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</tbody>
</table>

U.S. S&E PhD awards stagnate

<table>
<thead>
<tr>
<th></th>
<th>1985</th>
<th>1997</th>
<th>2002</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18,934</td>
<td>27,229</td>
<td>24,582</td>
<td>27,974</td>
</tr>
</tbody>
</table>

NSB, 2008; Ernst, 2006
<table>
<thead>
<tr>
<th>Source</th>
<th># of PhD degrees earned, 2004</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>27,974 (2005)</td>
</tr>
<tr>
<td>Europe</td>
<td>71,273</td>
</tr>
<tr>
<td>EU</td>
<td>45,398</td>
</tr>
<tr>
<td>Asia</td>
<td>34,322</td>
</tr>
<tr>
<td>East Europe</td>
<td>24,469</td>
</tr>
<tr>
<td>China</td>
<td>14,858</td>
</tr>
<tr>
<td>Russia</td>
<td>16,003</td>
</tr>
<tr>
<td>Japan</td>
<td>7,658</td>
</tr>
<tr>
<td>Ukraine</td>
<td>3,199</td>
</tr>
<tr>
<td>India</td>
<td>6,318</td>
</tr>
<tr>
<td>Romania</td>
<td>1,221</td>
</tr>
<tr>
<td>Korea</td>
<td>3,501</td>
</tr>
</tbody>
</table>

→ intensifying competition for global S&E talent, from Asia and Europe

National Science Board, 2008
China - growth of science & engineering PhDs

- 64% of the 23,446 PhD degrees in 2004 are in S&E
- between 1995 and 2003, first year entrants in science and engineering PhD programs in China increased six-fold, from 8,139 to 48,740
- **China will produce more S&E doctorates than the US by 2010**

National Science Board, 2008; Freeman, 2005
Stay rates of foreign S&E PhDs are rising again (with exceptions)

1. All foreign S&E PhDs:
   50% (91-95)  71% (95-97)  74% (02-05)

2. From China:
   - 51.5% (94-97) → 62.1% (98-01) → 60.2% (02-05) (decline mostly in engineering).

3. From India:
   - 56.3% (94-97) → 66.5% (98-01) → 62.7% (02-05) (decline mostly in comp sc & engineering)

NSB, 2008)
2. Conflicting perceptions: How robust is U.S. leadership?
The optimists say: the US...

- has maintained its share in world GDP
- has maintained its lead in purchasing power and productivity
  - Large relative productivity gains elsewhere (e.g. in China) fail to close absolute per-worker output gaps with the US
- Hence: on macro-economic measures, the US remains “robustly competitive”
  - **Is this good enough?**
Is R&D still the engine of growth?

- 2 drivers (credit-driven consumer expansion; wild financial innovations)
- 2 sectors benefited (finance; energy)
- All other sectors: companies increase capital efficiency by **selling more without making proportionate investments (and R&D)**
- Plus: “worst financial crisis since the 1930s” may further reduce funds for R&D…

McKinsey, 2008; Soros, 2008
Dark Clouds: Is US leadership declining?

<table>
<thead>
<tr>
<th>US share of global annual totals (%)</th>
<th>1986</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D</td>
<td>46</td>
<td>37</td>
</tr>
<tr>
<td>Science publications</td>
<td>38</td>
<td>30</td>
</tr>
<tr>
<td>Science researchers</td>
<td>42</td>
<td>29</td>
</tr>
<tr>
<td>bachelors, S&amp;E</td>
<td>38</td>
<td>29</td>
</tr>
<tr>
<td>PhDs, S&amp;E</td>
<td>52</td>
<td>22</td>
</tr>
</tbody>
</table>

Council of Competitiveness, 2007
Shrinking U.S. corporate research

Between 1991 and 2003, the shares of corporate R&D
- declined for
  - basic research (-2.5%)
  - and applied research (-4.8%)
- increased for
  - development (+ 7.3%)

Brookings-ITIF, 2008
Weak public innovation system

- No explicit national innovation strategy
- Federal innovation investments are fragmented, diffuse, and grossly under-funded (=0.02% of GDP) <---> Sweden (0.07%), Japan (0.04%), Korea (0.03%)
- Focus on large global corporations and a few top research universities
- Neglect of SMEs and service innovations
- Broken patent system
- Large firms dominate standard-setting

Brookings-ITIF, 2008; Ernst, 2008
Corporate R&D in the US is declining

<table>
<thead>
<tr>
<th>Share of US corporate R&amp;D sites (%)</th>
<th>1997</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>within the US</td>
<td>59</td>
<td>52</td>
</tr>
<tr>
<td>in China and India</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>

Brookings-ITIF 2008
3. What is new?

- Global innovation networks
  - reflect a shift in corporate strategy to open and integrated innovation
  - are driven by the changing economics of innovation
- US firms are key drivers
- Diverse actors, locations, business models and network arrangements are emerging
- Asia’s role in these networks is increasing (driven by the resurgence of China and India)
- But: established centers in the US, Europe and Japan retain their dominance.
EWC research on global innovation networks

- Interviews with 150 ICT companies (US, Japan, Asia, EU)
- Diverse sample (size, ownership, business model):
  - large global industry leaders
  - specialized technology suppliers and service providers
  - trans-pacific VC funded start-ups
- Drivers and characteristics of GINs
- Impacts on learning, capability formation and innovation at diverse locations in China, Taiwan, Korea and India.
Global innovation networks - a taxonomy

I. Global companies “offshore” stages of innovation to Asian affiliates
   - *intra-firm* global innovation networks

II. Global firms “outsource” stages of innovation to specialized Asian suppliers
    - *inter-firm* networks

III. Asian firms construct their own (mostly intra-firm) networks

IV. Informal social networks (students, knowledge workers)
‘Open & Integrated Innovation’

Open innovation
- Firms complement in-house R&D with outsourcing and licensing.
- Innovation is fragmented (‘modularized’) and dispersed across boundaries (firms; geographic; sectors).

Integrated innovation
- Innovations in operations and business models are as important as new products and services
Pressures to internationalize innovation

- ROI $\leftrightarrow$ rising cost, complexity and uncertainty of R&D
- Shorter product-life-cycle $\rightarrow$ speed-to-market
- Surging demand for knowledge workers
- Winners and losers are defined by their exposure to emerging markets $\leftrightarrow$ slow demand growth in core OECD countries
- New competitors and emerging centers of excellence
- Resistance (inertia; vested interests; to protect society and environment)
Enabling factors

- Liberalization/privatization → ‘deregulated’ markets
- ICT-enabled information management
- Globalizing markets for technology, knowledge workers and innovation finance
- Globalization of IP protection (TRIPS)
- Globalization of standards

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## Intel’s Global Innovation Network

<table>
<thead>
<tr>
<th>Location</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>US (11 labs)</td>
<td>core technology development in Santa Clara, Folsom and Austin</td>
</tr>
<tr>
<td>Asia (7 labs, more planned)</td>
<td>- <strong>Bangalore</strong> (2700 = largest lab outside US), <strong>leading-edge processor development</strong></td>
</tr>
<tr>
<td></td>
<td>- Penang (500), design implementation</td>
</tr>
<tr>
<td></td>
<td>- Shanghai (100++) Linux based solutions for telecom; new applications for emerging markets</td>
</tr>
<tr>
<td></td>
<td>- Beijing (50++), platform and architecture lab</td>
</tr>
<tr>
<td>Israel, Russia</td>
<td>- Haifa (1400, since 1974), processor research</td>
</tr>
<tr>
<td></td>
<td>- Nizhny Novgorod (200++): software</td>
</tr>
</tbody>
</table>
ODM Inter-Firm Network - Notebooks

Tier 1: Flagship

Tier 2: ODM

Tier 3 - Suppliers

Tier 4(and below) - Suppliers

Core Component Suppliers
(HDD, Displays, CPU)

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New Entrants: Huawei

Kista/Stockholm, Sweden
• base station architecture and system design; analog-mixed signal design (RF); algorithms

Moscow, Russia
• algorithms; analog-mixed signal design (RF)

Bangalore, India
• embedded SW and platforms

Basingstoke, Hampshire (UK)
• communications equipment for BT’s 21CN network strategy

Plano/Texas (Dallas telecom corridor)
• total solutions for CDMA; G3 UMTS; CDMA Mobile Intelligent Networks; mobile data service; optical; VoIP
2005 Survey of the world’s largest R&D spenders

- China is the 3rd most important offshore R&D location (after the US and the UK)
- India is 6th and Singapore 9th
- China is the most attractive location for future foreign R&D, ahead of the US and India
- Leading global corporations also intend to expand their offshore outsourcing of R&D to Asian firms
Chip design moves to Asia

- Hsinchu, Taipei (Taiwan)
- Shanghai and YRD, Beijing, Shenzhen and PRD, Xi’an (China)
- Seoul (Korea)
- Bangalore, Noida, Chennai, Hyderabad, Mumbai, Pune, Ahmedabad (India)
- Singapore
- Penang and KL (Malaysia)
China Market

- largest market for telecom equipment (wired & wireless) (test bed for 3G)
- ditto for semiconductors and handsets (launch market)
- 2nd largest market for cars
- Lead market for digital CE (#2)
- Leading export market for US, Japan, Taiwan and Korea
- ‘bottom-of-the-pyramid’ markets for less over-engineered products and services with substantially lower costs of acquisition and operation
But: established centers retain dominance

- all 15 leading companies with the best record on patent citations are based in the United States (9 in the IT industry)
- The 700 largest R&D spenders (mostly large U.S. firms) account for 50% of the world’s total R&D expenditures and >2/3 of the world’s business R&D
- > 80 percent of the 700 largest R&D spenders come from only five countries (United States dominates, followed by Japan, Germany, United Kingdom, France)
R&D Intensity in 2004 and Annual Average Growth Rate (AAGR) of R&D Intensity, 1999–2004*


* R&D intensity is R&D expenditure as a percentage of GDP.
Who controls ICT standard consortia?

- about 50 global corporations determine what 250 ICT standard consortia do, and more importantly, how they do it.
- the top ten leaders: IBM, Microsoft, Fujitsu, Intel, Hewlett Packard, Hitachi, Sun Microsystems, Nokia, Ericsson and Texas Instruments.
- Of the 50 major players, 25 are from the US, 12 from the EU, and 8 from Japan.
- Only 5 companies from emerging countries (all from Asia) are members (Samsung, Huawei, LG, Lenovo, ZTE)
4. America’s challenge - search for new sources of growth through innovation

- Weaknesses of US innovation system are left unattended at the very moment when fundamental adjustments are needed to cope with the new geography of innovation
  - Will policy-makers understand that the rise of Asia does not have to be a zero-sum game?
- Current crisis highlights limits of the existing model
  - Can we use the crisis as a catalyst for policies to repair home-made weaknesses of US innovation system?
US needs a national innovation strategy to

- reverse the decline of the US public innovation system
- reverse the ‘hollowing-out’ of corporate R&D
- realign incentives for studying, research and innovation
- upgrade the U.S. talent pool of knowledge workers
- attract and retain global talent
- enhance the governance of the global knowledge economy

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An Agenda for the New Geography of Innovation

1. Improve access to and collection of innovation-related data to inform the national policy debate.
   - “Ironically, the measurement of innovation is one of the least innovative of all our measurement systems” Samuel J. Palmisano, IBM chairman

2. Address “home-made” causes of innovation offshoring by sustaining and building upon existing strengths of the U.S. innovation system
   - This requires massive investments in infrastructure and human resources.

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3. **Support corporate innovation by**
   - providing tax incentives to spur early-stage investments in innovative start-ups;
   - reforming the U.S. patent system to make it more accessible to smaller inventors and innovators;
   - reforming the financial sector (hedge funds, private equity, VC) to generate more patient innovation finance;
   - reforming both formal and informal standard-setting organizations to make it more accessible to smaller inventors and innovators
4. Upgrade the U.S. talent pool of knowledge workers by
   - providing incentives to study science and engineering,
   - encouraging the study of management, interpretive, cross-cultural, and other “soft” capabilities, and
   - encouraging immigration of highly skilled workers.