Innovation Systems
In the U.S. and Asia

September 27, 2007

Richard B. Dasher, Ph.D.
Director, US-Asia Technology Management Center
Executive Director, Center for Integrated Systems
Stanford University
Outline

♦ About this series
  ♦ Important notes to for-credit students

♦ Innovation and corporate competitiveness

♦ Innovation as a process
  ♦ University-industry-government roles in an innovation system

♦ Comparison of the innovation systems of the U.S., Japan, and China
About this series

♦ Produced by the US-Asia Technology Management Center, School of Engineering, Stanford University

♦ <http://asia.stanford.edu> for details about this series, past series

♦ This is our 15th annual series: different theme every year

♦ Thanks to Squire, Sanders & Dempsey, LLP, for a gift in support of this series

♦ Our 5th year of support from SSD !!
Everyone is welcome!

♦ Mixed audience: students, industry

Stanford students - to receive credit:

Register for the seminars (EE-402a)

(1) Email written comments on nine sessions (see Syllabus for details), AND

(2) Attend in person eight sessions at the auditorium

♦ Auditorium attendance waived for official SCPD students

♦ See Syllabus for details
For today:

♦ Please fill out & submit survey
  ♦ This is your attendance record for today 9/27

♦ Get syllabus, find course webpage via http://asia.stanford.edu

Send any questions and email summaries to:

**Instructor:** Richard Dasher
rdasher at stanford dot edu
650-725-3621

**Assistant:** Hari Govindaharan
harig at stanford dot edu
Why innovation?  
Because things change

<table>
<thead>
<tr>
<th>Past</th>
<th>Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Film camera</td>
<td>Digital camera</td>
</tr>
<tr>
<td>Phonograph record</td>
<td>CD</td>
</tr>
<tr>
<td>One team builds entire automobile</td>
<td>Assembly line</td>
</tr>
<tr>
<td></td>
<td>Combo i-Phone / camera / game player . . . (?)</td>
</tr>
<tr>
<td></td>
<td>Download from Internet</td>
</tr>
<tr>
<td></td>
<td>Supply chain (different companies for parts, systems, assembly, sales)</td>
</tr>
</tbody>
</table>
Some types of innovation

- Develop new product (or service) for existing market
- Develop new market or application for existing product (or technology)
- New combination or package of technologies, products, services
- Change business process (e.g. outsourcing)
- Develop new business model
  - What to sell versus what to give away for free (cellphones)
  - Subscription or leasing, instead of sale (software, webhosting services)
- Completely new idea (“breakthrough” -- rare)
Various types of innovation

<table>
<thead>
<tr>
<th>New Product</th>
<th>Nintendo “Wii” (new feature added to existing product category)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Market for existing product</td>
<td>(Hypothetical: use Wii to improve athletic training programs)</td>
</tr>
<tr>
<td>New Combination</td>
<td>Apple i-Phone</td>
</tr>
<tr>
<td>New Business Process</td>
<td>Company outsources employee medical services to specialist firm</td>
</tr>
<tr>
<td>New Business Model</td>
<td>Flat rate for cellular phone service</td>
</tr>
<tr>
<td>Completely New …</td>
<td>Personal computer ?</td>
</tr>
</tbody>
</table>
Innovation as a process

♦ “The process leading from the discovery or invention of a new idea or technology to its practical implementation (often via commercialization)”

♦ Early stage (basic research): typically without a practical implementation (product) in mind

♦ Late stage (development): driven by technology and cost demands of a real-world application

♦ Usually, different people are involved at the different stages: together, they make up an innovation system
University, industry, government roles in an innovation system

Funding source

Industry → Government

Mfr. and Market → Product Development → Applied Research → Basic Research

Implementing organization

Knowledge Transfer

Development Division → Central Lab

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Natural division of labor

- Basic research: government funds, university conducts
- Product development: industry funds, industry conducts

Transition of roles at “Applied Research”

- Both industry and government fund applied research
- Both industry and university conduct applied research

Knowledge transfer

- Internal to industry: central lab to product division
- From university to industry
“Innovation system”

- **The institutions**
  - At national level, primarily: universities (and other research institutes), industry, government

- **The mechanisms**
  - Funding
  - Transfer
    - Rights licensing, new company creation, …

- **The underlying policies**
  - Provide overall direction, may provide constraints
Factors in comparing national innovation systems - 1

♦ How government money flows to R&D in university, industry, and government labs
  ♦ Does the flow promote cooperative relationships?

♦ Employment patterns of R&D workers
  ♦ E.g., high mobility (change companies often), or not

♦ Patterns of university-to-industry knowledge transfer (mechanisms and policies)
  ♦ Rights ownership and licensing
  ♦ Ownership of start-up companies and their assets
Factors in comparing national innovation systems - 2

- **Infrastructure issues**
  - Degree of macro-economic development; speed of growth
    - Advanced economies typically rely on innovation for competitiveness more than do developing economies
  - Sector-internal characteristics
    - E.g., Is there much M&A inside the industry sector?
  - Other national policy objectives
    - E.g. to spread out capital more than just to a few big companies or business groups)
  - Legal framework for IP and enforcement
Stanford mini-case: Professors must obtain own research funds

♦ Direct cost to a Stanford EE professor of a 50% time graduate student RA: about $50 - 60,000 / academic year

♦ Cost of a 50% time RA plus university overhead (~ 58%): about $85,000 / academic year

♦ Number of Ph.D. students in a typical EE professor’s research group: about ten

♦ Percentage of EE Ph.D. students with “own” fellowships or other funding: around 10%

♦ On average, professor must get funding from outside for about nine Ph.D. RAs: turn funds over to Stanford, which hires the RA
Sources of Funds: Stanford School of Engineering

2005-06 Sources of Operating Funds
$214.6 M (including $119.2 M for research)

- University funds 21.0%
- Endowment income 11.0%
- “Sponsored” research (contracts) 45.0%
  - About 3/4 sponsored by U.S. government
- Other (gifts, centers, licensing, etc.) 23.0%
Companies fund research via “unrestricted” channels at SU

♦ Contract Research (“Sponsored Projects”)
  ♦ Largest source of funds, but most is from governments or private foundations (not from companies)

♦ The “other” channel: unrestricted funding
  ♦ More economical for the sponsor (not charged full 58% overhead)
  ♦ But, channel provides much less control to the sponsor
  ♦ Creates a different type of relationship between company and professor than does a research contract
  ♦ Professors often use these funds as matching funds in their government grant proposals

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How “matching funds” work

♦ Let’s say, … university professor applies in competition for $1 million grant from U.S. government

♦ Formally promises (in budget proposal to government) to do $1.5 million worth of work
  ♦ Leverages / stretches the government money
  ♦ Shows that someone else values the research

♦ Professor must obtain $500,000 of “matching funds”
  ♦ Not permitted to use other U.S. government grants as matching funds
  ♦ Most likely source of matching funds: industry support
Stanford mini-case: Some sources of “unrestricted” funding

- Expendable gifts to support research by specific professors
- Membership fees to “industry affiliate programs”
  - Include channels to provide support for research by specific professors (and even specific Ph.D. students)
- Fees (via gifts or affiliate programs) for accepting visiting researchers from companies to be in residence at Stanford
- Licensing royalties (only about 1% of School of Engineering budget)
## Comparing the U.S. and Japan systems - 1

<table>
<thead>
<tr>
<th>Government money</th>
<th>U.S.</th>
<th>Japan</th>
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<tbody>
<tr>
<td></td>
<td>Competition-based</td>
<td>Still mostly allocated</td>
</tr>
<tr>
<td></td>
<td>Each agency funds both university &amp; industry research</td>
<td>Separate systems: companies &lt; METI, universities &lt; MEXT</td>
</tr>
<tr>
<td></td>
<td>Direct subsidy of industry R&amp;D politically difficult</td>
<td>R&amp;D policy: for industry / economic development (not much for defense)</td>
</tr>
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<td></td>
<td>Matching funds: industry - university partnerships</td>
<td>Matching funds within industry for government projects</td>
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## Comparing the U.S. and Japan systems - 2

<table>
<thead>
<tr>
<th>Employment patterns</th>
<th>U.S.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>High mobility: industry “buys” Ph.D. graduates</td>
<td>Many examples of successful new company spin-out</td>
<td>Lifetime employment: hire young &amp; assign to research in company lab</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Patterns of transfer from university</th>
<th>U.S.</th>
<th>Japan</th>
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</thead>
<tbody>
<tr>
<td>Highly developed licensing and also “spillover” relationships</td>
<td></td>
<td>New laws and patterns since 1998; still “bugs” in working out implementation</td>
</tr>
<tr>
<td></td>
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<td>No superstar examples of successful spin-out (yet)</td>
</tr>
</tbody>
</table>
## Comparing the U.S. and Japanese systems - 3

<table>
<thead>
<tr>
<th>Infrastructure</th>
<th>U.S.</th>
<th>Japan</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Companies strong at M&amp;A to acquire knowledge, tech</td>
<td>Highly developed company-internal knowledge transfer</td>
</tr>
<tr>
<td></td>
<td>Need innovation for high value-added business (to sustain high cost of living)</td>
<td></td>
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<td></td>
<td>Legal system well-established in general, consistent enforcement</td>
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</tbody>
</table>
The result: comparing university-industry cooperation in U.S. and Japan

<table>
<thead>
<tr>
<th>U.S.</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>♦ Most common pattern: university-based research with real-time industry participation</td>
<td>♦ Most common:</td>
</tr>
<tr>
<td>♦ Motivations for research cooperation:</td>
<td>♦ Research outsourcing</td>
</tr>
<tr>
<td>♦ Two-way, long-term knowledge exchange</td>
<td>♦ Rare: company visitor in university research group</td>
</tr>
<tr>
<td>♦ Recruiting</td>
<td>♦ Motivations:</td>
</tr>
<tr>
<td>♦ Industry expects to pay to participate</td>
<td>♦ Company’s specific commercial objectives</td>
</tr>
<tr>
<td>♦ But not pay full cost</td>
<td>♦ Close, lasting personal relationships between professors &amp; graduates</td>
</tr>
<tr>
<td></td>
<td>♦ May marginalize revenue to university</td>
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</tbody>
</table>

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<table>
<thead>
<tr>
<th>Infrastructure: transitional economy</th>
<th>Some funding for S&amp;T development still comes from World Bank, UNESCO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lack of large domestic companies with resources or needs to fund research in universities (but university research funding is coming from foreign firms)</td>
</tr>
<tr>
<td></td>
<td>Industry cooperation with university focuses on recruiting, long-term relationships for later use</td>
</tr>
<tr>
<td></td>
<td>Reorganization of university sector, still many Soviet-style research institutes</td>
</tr>
</tbody>
</table>
Background: Higher Education in China - 1

- Western-style shifted to Soviet style from 1949
  - Universities specialized in single disciplines / fields
  - Advanced research done more in government research institutes
  - Research topics defined (only) by government

- Shut-down of universities during cultural revolution (1964 - 1976)
  - Nationwide college entrance exams resumed: 1978
  - Chinese government sends grad students, visiting scholars to U.S.: from late 1970’s
  - (Re)appearance of university graduate schools
Chinese government policy statement (1998):
build some Chinese universities into world-class institutions

- Major shift back toward Western-style, comprehensive universities
- Mergers: between 1996 - 2000, 383 universities into 212
- Hiring of returnee-professors (from universities abroad)
- Government gives major increases of S&T funding to universities
  - Relative share of government R&D budget shifts away from national institutes
- Focus also on innovation
S&T funding in Chinese universities, 1991 - 2003

Unit: 100 M RMB; cited in Chen and Kenney, 2005
Total R&D spending in China (from all sources of funds)

- **2003:** total R&D spending was RMB 154 billion
  - Increase of 20% over 2002
- **Universities** accounted for 10.5% of total R&D spending
- **Government research institutes:** 25.9%
  - But research institute share of R&D spending had been 42.8% in 1996
- **Company R&D:** 62.4% of total spending
  - Had been 43.3% in 1996

*China Nat’l Bureau of Statistics, cited by Chen and Kenney 2005*
Background: High-Tech Business in China

- Tend to compete more on cost than on the most advanced technologies
  - R&D mostly for product development, localization, some re-engineering (e.g. to cut manufacturing cost)
- Hiring from U.S. (including returnees): for management roles, not for company research
- Foreign R&D labs in China: active programs with Chinese universities, hire recent graduates
- Little direct interaction between Chinese companies and U.S. universities
China innovation system: Distinctive features - 2

<table>
<thead>
<tr>
<th>Government money</th>
<th>Apparently still not trying to obtain leverage from matching funds; not concerned with promoting cooperation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment</td>
<td>High mobility, but industry is probably still much less important market for Ph.D.s than in U.S.</td>
</tr>
<tr>
<td>Patterns of transfer</td>
<td>Robust spin-out of start-up companies, which the university may own !!</td>
</tr>
<tr>
<td></td>
<td>No famous start-up companies from universities (yet), but Lenovo came from CAS Institute of Computing Technology</td>
</tr>
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</table>
Highlighting some differences

<table>
<thead>
<tr>
<th></th>
<th>U.S.</th>
<th>China</th>
<th>Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Government funding</strong></td>
<td>Promotes univ-industry symbiosis</td>
<td>Separate systems for funding university and industry</td>
<td></td>
</tr>
<tr>
<td><strong>Industry wants &lt; top</strong></td>
<td>Real time partnerships</td>
<td>Research outsourcing</td>
<td></td>
</tr>
<tr>
<td>universities**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>National labs</strong></td>
<td>Special purpose</td>
<td>Historically dominant</td>
<td>Leverage industry R&amp;D</td>
</tr>
<tr>
<td><strong>University start-ups</strong></td>
<td>Robust</td>
<td></td>
<td>Still weak</td>
</tr>
<tr>
<td><strong>Innovation goal</strong></td>
<td>Sustained competitiveness, but specifics vary according to the national economy</td>
<td></td>
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</table>

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Looking ahead to the rest of the series

♦ Several sessions on industry case studies

♦ Will look at a government policy or two
  ♦ E.g. Japan: “Innovation 25”

♦ Regional industry conditions

♦ Next week: Prof. Lin Xu on “The Diversity of Start-Ups in China”
Some sources used

