Upgrading in the Global Knowledge Economy: Insights from China and India

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ILO Social Policy Lectures

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- Three-day symposium and lecture series, held every other year, focused on globalization and governance, and the rise of global outsourcing.
Background: Four Types of Jobs in Global Labor Market and Links to Upgrading

- **Assembly jobs** in export-oriented industries, based on imported inputs
- **Basic manufacturing jobs** associated with “full package” (or OEM) production (*linked to buyer-oriented upgrading*)
- **Advanced manufacturing jobs** that require ODM and OBM capabilities (*linked to supplier-oriented upgrading*)
- **Knowledge-intensive jobs** in service industries that are being outsourced, including both traditional white-collar jobs and also advanced activities associated with business process outsourcing

Drivers of Knowledge-Intensive Jobs

• Two important drivers for knowledge-intensive jobs:

  – **Manufactured exports** – Allows upgrading of jobs from assembly, full-package/OEM, and ODM/OBM through accumulation of expertise

  – **Foreign direct investment (FDI)** – Brings new technology and expertise from abroad
Figure 1: Composition of China’s Exports to the U.S. Market, 1985-2003

Source: World Trade Analyzer.
Figure 2: Composition of Mexico’s Exports to the US Market, 1985-2003

Source: World Trade Analyzer.
MNC R&D Centers in China & India: How are engineers being used?

• What kinds of work are Chinese, Indian, and American engineers actually doing?
  – **Answer:** Not just product adaptation, but cutting-edge research & commercialization

• China: More than 700 MNC R&D Centers
  – GE’s *China Technology Center*: Advanced research in energy storage, environmental management
  – *Microsoft Research Asia*: Cutting-edge graphics & multimedia research

• India: More than 150 of Fortune 500 firms have R&D centers
  – Oracle’s *India Development Centre*: Globally-oriented research on database and application development tools
A joint Engineering Management and Sociology Research Study

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www.memp.duke.edu/outsourcing
Poorly Grounded Engineering Statistics

• “In engineering, China's graduates will number over 600,000, India's 350,000, America's only about 70,000...”
  – Fortune (2005)

• “Last year more than 600,000 engineers graduated from institutions of higher education in China. In India, the figure was 350,000. In America, it was 70,000.”

• “Last year China’s schools graduated more than 600,000 engineers and India’s schools produced 350,000, compared with 70,000 in America...”
## Commonly Cited Comparative Engineering Graduation Statistics

<table>
<thead>
<tr>
<th>Country</th>
<th>Reported Graduates</th>
<th>What is Included in these Numbers:</th>
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<tbody>
<tr>
<td>United States</td>
<td>70,000</td>
<td>Four-year engineering bachelors degrees.</td>
</tr>
<tr>
<td>China</td>
<td>600,000</td>
<td>Three- and four-year engineering degrees under a broad definition of &quot;engineer.&quot; Additionally, computer science and information technology three- and four-year degrees are included.</td>
</tr>
<tr>
<td>India</td>
<td>350,000</td>
<td>Three- and four-year engineering, computer science and information technology degrees.</td>
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# Engineering Outsourcing:
## How Many Engineers?

Table 2: Four-Year Bachelors in Engineering, Computer Science and Information Technology Awarded from 1999-2004 in the United States, China and India

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<tbody>
<tr>
<td><strong>United States¹</strong></td>
<td>101,249</td>
<td>108,750</td>
<td>114,241</td>
<td>121,263</td>
<td>134,406</td>
<td>137,437</td>
</tr>
<tr>
<td><strong>India²</strong></td>
<td></td>
<td>82,107</td>
<td>109,376</td>
<td>129,000</td>
<td>139,000</td>
<td></td>
</tr>
<tr>
<td><strong>China (MoE CERN)³</strong></td>
<td></td>
<td></td>
<td>293,125</td>
<td>376,415</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>China (MoE Yearbook)⁴</strong> *</td>
<td>195,354</td>
<td>212,905</td>
<td>219,563</td>
<td>252,024</td>
<td>351,537</td>
<td>442,463</td>
</tr>
</tbody>
</table>

Notes: Gray highlighted data may constitute an overestimate. In addition, data provided by the Chinese Ministry of Education may include additional engineering and technology degrees outside traditional engineering fields, CS majors and IT specializations (example: auto mechanics)


Nanotechnology Value Chain

<http://www.luxresearchinc.com/luxni.html>
CGGC Field Research

• China (Hong Kong, Beijing, Shanghai)
  – Three weeks in late July-early August, working heavily on the Nanotechnology in Society Initiative (2 weeks) and the Engineering Outsourcing Project (1 week)
  – Met and interviewed representatives from:
    • Universities (Tsinghua, Peking, Fudan, Shanghai Jiao Tong, Hong Kong Polytechnic, City University of Hong Kong, Beijing University of Technology)
    • Companies (GE, IBM, Lenovo, Microsoft, Li & Fung, Maxscend, TechFaith, Kyocera, Veeco)
    • Organizations (AmCham-Shanghai, NCNST)
  – Conducted library research, using sources unavailable outside of China.
CGGC Field Research

• India (New Delhi, Bangalore)
  – Eight days in early October, working solely on the Engineering Outsourcing Project
  – Focused specifically on expanding the engineering numbers and understanding the policy environment.
  – Met and interviewed representatives from:
    • Universities and educational institutions (IIT-Delhi, IIIT-Bangalore, NIIT, GlobSyn, Jaypee Institute of Technology, IGNOU, ICFAI)
    • Companies (GE, IBM, Fidelity, Oracle)
    • Organizations (AICTE)
Engineering Outsourcing: Quantity and Quality Issues

Quantity
China and India are producing more engineers, but the rate of increase is smaller than expected (especially for India). This shift can further be dissected by looking at engineers per capita.

Quality
China and India’s supply of quality engineers remains scarce, despite the increased number of engineers graduating from these countries’ HEIs.
Figure 3: Engineering, Computer Science and Information Technology Graduates (BA) in the US, China and India
Figure 4: Engineering, Computer Science and Information Technology Graduates (Sub-BA) in the US, China and India
Engineering Outsourcing: Importance of Quality

• ...in addition to our new findings about the numbers story, quality matters.

• Transactional versus dynamic engineers:
  – Transactional engineers “may possess engineering fundamentals, but not the experience or expertise to apply this knowledge to larger problems. These individuals are typically responsible for rote and repetitive tasks in the workforce.”
  – Dynamic engineers are “capable of abstract thinking and high-level problem solving using scientific knowledge. These engineers thrive in teams, work well across international borders, have strong interpersonal skills, and are capable of translating technical engineering jargon into common diction. Dynamic engineers lead innovation.”

Engineering Outsourcing: How do we know quality matters?

• McKinsey Report (2005): “Of 100 [engineering] graduates with the correct degree, how many could you employ if you had demand for all?”
  – US: 80.7%
  – India: 25%
  – China: 10%

• Graduate employment: China and India’s “list” of acceptable schools, difficulties in finding employment for graduates

• Levin Institute (2006): China will have a shortage of S&E workers at least to 2020 (Projected supply: 8.5 million; demand: 8.9 million)
Nanotechnology: Institutions and Funding

• In 2005, China’s public investment in nanotechnology reached 1.5 billion yuan (US $190 million), just under 1/5 of that of the US – and growing fast (2020: 2.5% of GDP?)

• Chinese government sponsoring key initiatives: National Center on Nanoscience & Technology (NCNST), National Natural Science Foundation (NNSF), 863 & 973 programs, Cheung Kong/One Hundred People programs.

• Nanotech publications: In 2005, China surpassed the US in number of English-language articles published, with more than 9,000 published.
  – Of the top 20 most-cited nanotech scientists, 19 appear to have Chinese surnames.

Nanotechnology: Research Strengths and Weaknesses

• Key research areas:
  – Nanomaterials (64% of Chinese publications, 1988-2006): carbon nanotubes, nanowires, nanopowders and quantum dots
  – Nanocomposites: nano-thin films and nano-alloys

• China still lies at the early stages of the innovation-commercialization spectrum:
  – Nanoties, nanoglass and nanofridges
  – “Nano” as a marketing tool? “Nano-water”

• Lack of interdisciplinary links: Nano-bio?

• Institutions: Nanotech Industrialization Base of China? Shanghai Nanotech Promotion Center?
Preliminary Findings: *China and India are serious*...

*(Role of the state)*

- China and India have the will and desire to seek to push this new model for upgrading at both ends of the technological spectrum.

- **China**: China’s commitment to nanotechnology – policy, funding, institutions
- **China**: Ministry of Education and the sharp increase in engineering seats
- **India**: Commitment to building high-value services (IT, BPO)
Preliminary Findings:
Demand for knowledge inputs is increasing...

(Role of market and MNCs)

• *Demand* for high-quality knowledge inputs (human capital, intellectual capital) is growing sharply, fueled by MNCs and up-and-coming domestic firms.

• *China & India*: Growing number of MNC R&D centers, with R&D increasingly global in scope
  – China: More than 700 MNC R&D Centers
  – India: More than 150 of Fortune 500 companies

• *India*: Rise of Wipro, TCS, Infosys
Preliminary Findings:
Supply is struggling to catch up…

(Role of universities/EIs)

3) Supply is attempting to respond to demand, but generally with increased quantity instead of increased quality.

- China & India: Seeming paradoxes in the labor market: oversupply or undersupply?
- China: Rise of Asian science? Quantity and quality of nanotechnology publications
Preliminary Findings: Responses based by political/economic systems...

(Role of institutions)

4) China and India’s approach to knowledge-economy upgrading have been very different, based on their individual political and economic systems.

- **China:** State-level investment versus private capital in nanotechnology
- **China & India:** Responses to education issues – Ministry of Education versus NIIT?
Preliminary Findings:
Both face serious bottlenecks & barriers…

5) Both countries face serious bottlenecks they must overcome to implement fully their upgrading plans.

• China & India:
  – Culture
  – Soft skills
  – Finance
  – Technical skills
  – Lack of experienced personnel

• China: Language, lack of equipment suppliers

• India: Infrastructure