



Impacts of Globalization on Engineering Employment in the Personal Computing Industry

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Presented at the National Academy of Engineering
October 24, 2006



Agenda

- Globalization of the PC industry
- Nature of innovation and global trends
- Impacts of globalization on engineering employment
- Policy issues



The Personal Computing Industry

- Worldwide revenues in 2005: US\$235 billion
 - \$191 billion in desktop and portable PCs
 - \$28 billion in PC servers
 - \$16 billion in smart handheld devices
 - Also drives revenues for software, storage, peripherals and services.
- Over 200 million units sold
 - 135 million desktops, 65 million notebooks
 - Largest markets are U.S. (61 million), Europe (47 million), Asia-Pacific (40 million), and Japan (14 million)



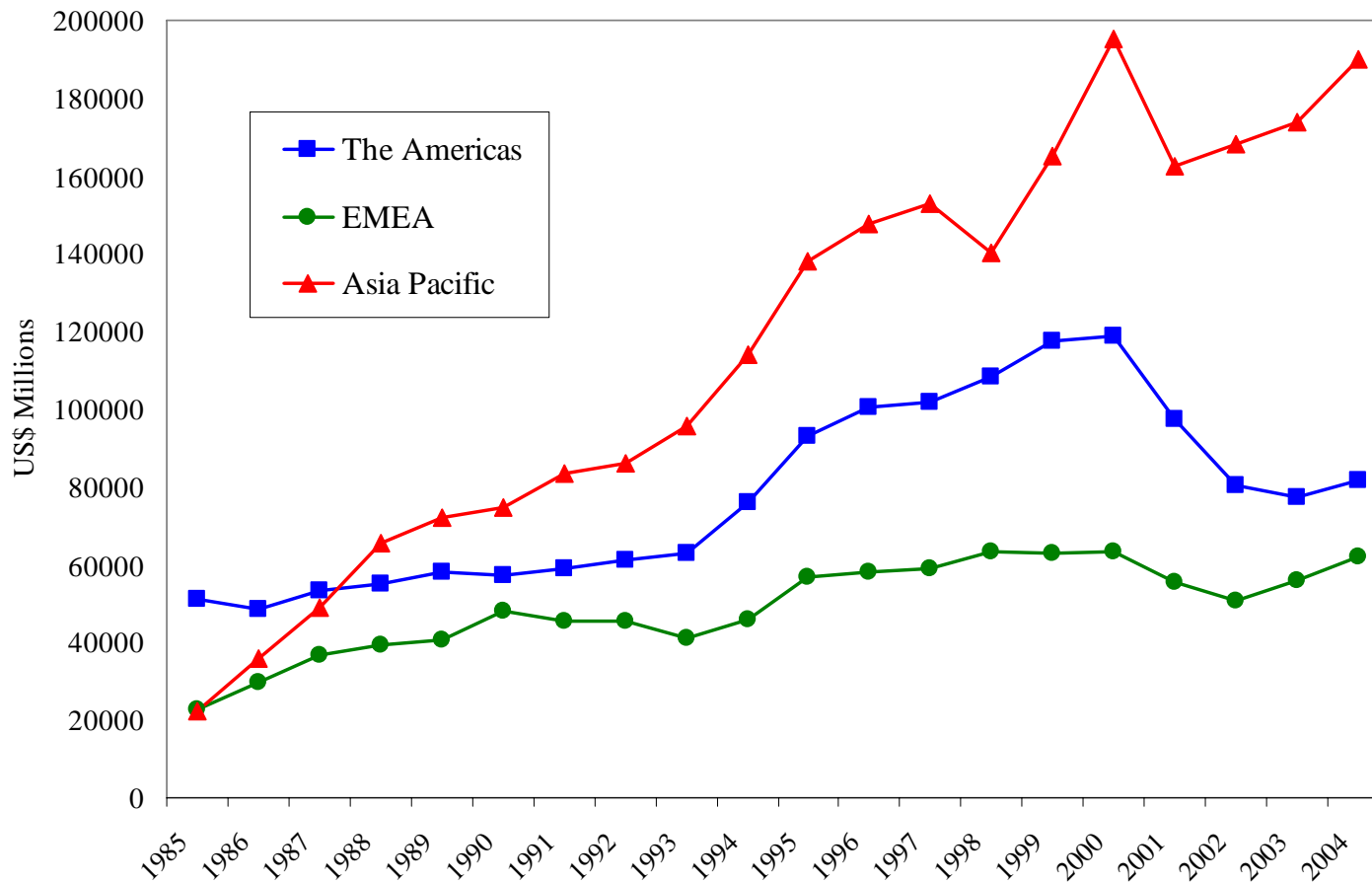
Globalization of the PC industry

- PC makers started outsourcing and offshoring production in early 1990s.
 - PC makers moved production to Southeast Asia, Ireland, Scotland, Mexico.
 - Desktop production outsourced to contract manufacturers (CMs) in three major regions
 - Notebooks outsourced to Taiwanese original design manufacturers (ODMs), who now manufacture 80% of world's notebooks.
- Production now concentrated in China.
 - Largest producer of computer hardware
 - Mostly Taiwanese CMs and ODMs.



Globalization of computer production

Production of computer hardware by region



Source: Reed Electronics, Yearbook of World Electronics Data

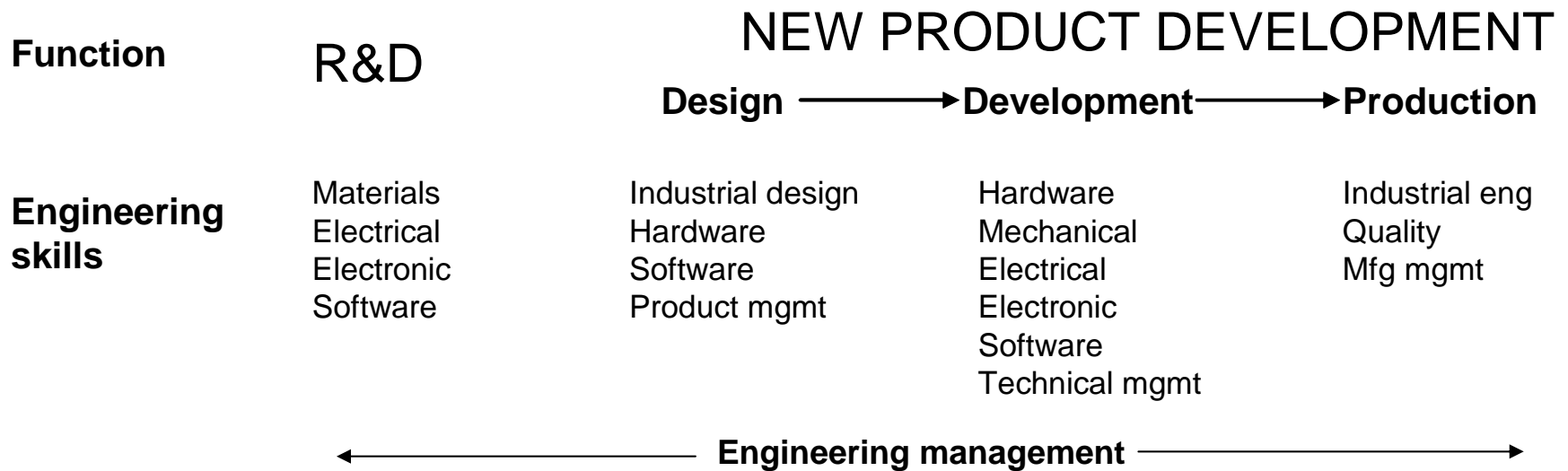


Innovation in the PC industry

- Much PC innovation is done by suppliers
 - Microsoft and Intel set standards
 - Component makers – semiconductor, storage, displays, power, wireless -- innovate core technologies
- PC makers focus on “systems innovation”
 - Incorporating upstream innovations into products. Some R&D needed to integrate innovations.
 - Designing and developing products for target markets



PC innovation and engineering skills



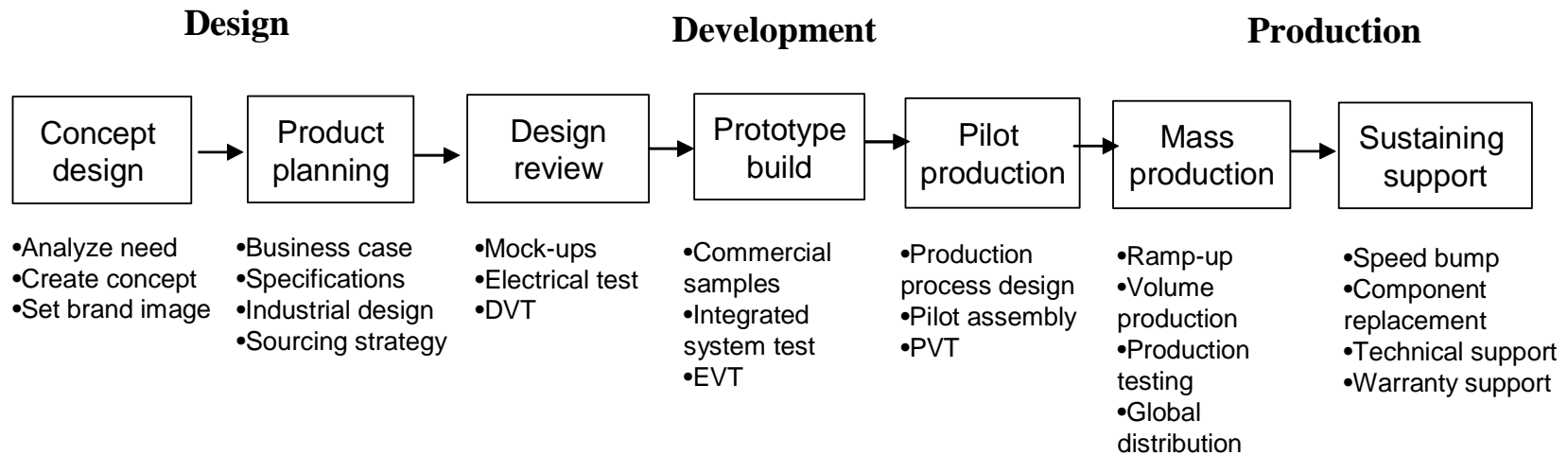


Systems innovation in PCs

R&D

Electrical Mechanical Thermal Power Software Wireless

New Product Development





Engineering skills and costs by location

- Average salaries for electrical engineers
 - U.S. \$78K (all industries: \$84K in computers)
 - Japan: \$63K
 - Taiwan: \$20K
 - China: \$10K
- Characteristics
 - U.S./Japan: strong analytical skills, good management skills, creative problem solving
 - Taiwan: strong hands-on experience, weaker analytical and management skills but learning
 - China: core skills vary, gaining hands-on experience, weak analytical and independent problem solving skills.

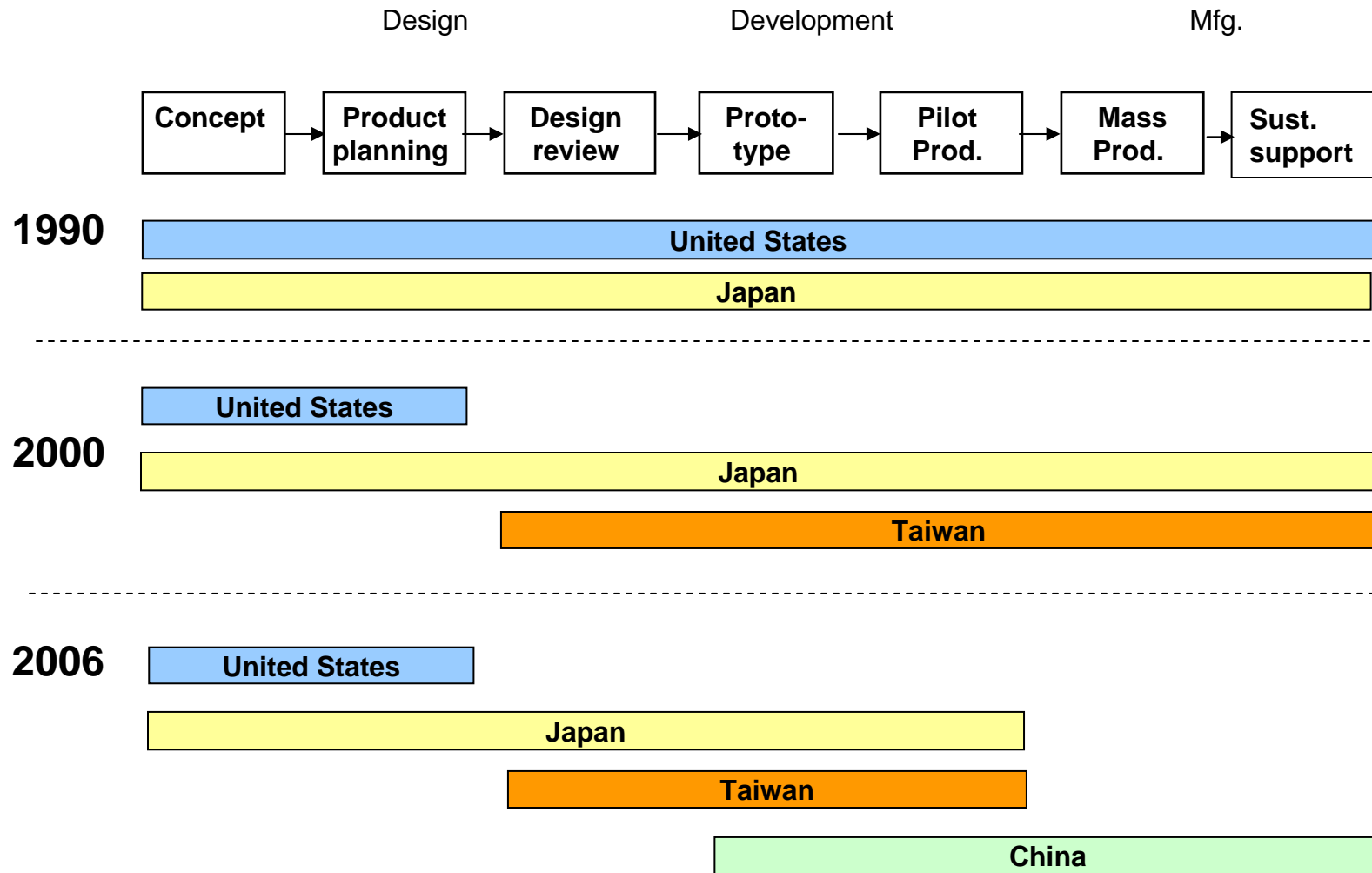


Globalization of innovation

- New division of labor: PC makers and ODMs collaborate on product development.
 - PC makers: design, product management, marketing
 - ODMs: development and production engineering
- Location of engineering: Shift to Taiwan and now to China
 - To reduce costs
 - Engineering follows manufacturing



Shifting location of innovation





Impacts on engineering employment: what we know and don't know

- Data only available on computer industry as a whole
 - Not for PC industry
 - Trends likely to be similar
- Time series
 - Break in data between 2001 and 2002, when SIC was replaced by NAICs.
 - Hard to track trends in 1990s when outsourcing to Taiwan was occurring
- We have gathered qualitative data on skill requirements and availability. Survey data would be valuable.
- No standard data on engineering employment in other countries.



Engineering jobs in U.S. computer industry

	2002	2003	2004	2005
Computer software engineers-applications	10,250	9,890	12,110	12,800
Computer software engineers – systems software	18,809	18,148	19,430	18,240
Computer hardware engineers	11,140	12,030	11,880	12,940
Electrical engineers	4,580	4,020	3,200	2,900
Electronics engineers, except computer	4,360	4,030	3,490	3,710
Industrial engineers	3,520	3,640	3,570	3,430
Mechanical engineers	2,100	2,470	2,160	2,280
Engineering managers	5,270	5,460	5,690	5,630
Industrial designers	260	290	190	180
Total	60,289	59,978	61,720	62,110

¹ Computer industry is defined as NAICS 334100 (Computer and Peripheral Equipment Manufacturing). **Data from years prior to 2002 was based on SIC code 357 (Computer and Office Equipment) which is incompatible.**

Source: Bureau of Labor Statistics, Occupational Employment Statistics <http://www.bls.gov/oes/home.htm>



Engineering salaries in U.S. computer industry

	1999	2000	2001	2002	2003	2004	2005
Computer software engineers-applications	\$70,630	\$74,350	\$78,240	\$81,270	\$85,570	\$95,180	\$94,760
Computer software engineers – systems software	\$70,150	\$76,130	\$81,180			\$91,430	\$92,030
Computer hardware engineers	\$74,880	\$78,760	\$83,940	\$82,820	\$96,540	\$96,980	\$94,690
Electrical engineers	\$67,030	\$71,870	\$73,210	\$75,490	\$80,180	\$82,810	\$84,820
Electronics engineers, except computer	\$68,920	\$70,940	\$75,580	\$76,930	\$81,320	\$85,270	\$86,330
Industrial engineers	\$61,660	\$64,070	\$68,910	\$73,330	\$76,210	\$77,480	\$77,710
Mechanical engineers	\$59,830	\$64,810	\$67,310	\$68,460	\$73,620	\$77,250	\$78,740
Engineering managers	\$97,380	\$104,550	\$107,290	\$125,080	\$128,470	\$129,450	\$130,020
Industrial designers	\$59,570	\$63,480	\$65,180	\$66,070	\$80,280	\$91,850	\$94,800

Source: Bureau of Labor Statistics, Occupational Employment Statistics <http://www.bls.gov/oes/home.htm>



Supply and demand for engineering skills

Engineering job category	Major activity where this skill is used	Demand for engineers	Availability in U.S.	Availability in other locations where you do this activity	Cost and quality relative to U.S.
Engineering managers	R&D, design, development	Stable or growing	Tight	Tight or enough	Lower cost, lower quality
Engineering product managers	Design, development	Stable	Tight or enough	Tight or enough	Lower cost, same quality
Hardware engineers	Design, development	Stable	Tight or enough	Enough	Lower cost, same or lower quality
Electrical engineers	R&D, design, development	Falling or growing	Tight or enough	Enough	Lower cost, same or lower quality
Electronic engineers	Development	Falling	Tight or enough	Enough	Lower cost, same or lower quality
Mechanical engineers	R&D, design, development	Stable or growing	Tight or enough	Enough	Lower cost, same or lower quality
Software Engineers	R&D, design, development	Growing	Tight	Tight or enough	Lower cost, same or lower quality
Industrial engineers	Manufacturing	N/A	N/A	Enough	Lower cost, same quality
Industrial designers	Design	Stable	Enough	Enough	Lower cost, lower quality



Skills in demand

- Software engineering.
 - More functionality being built in software, especially for new product categories.
 - Standardized HW can be customized with SW, allowing economies of scale with flexibility.
- Interdisciplinary skills.
 - People with hardware (EE) and software (CS) skills to integrate applications with chips or wireless networks
 - People with deep technical expertise plus business knowledge
- Engineering managers. In short supply everywhere.



Experience and career paths

- Most companies look to hire experienced engineers in the U.S. Need to produce right away
- Where are the opportunities for new graduates?
 - Work that would be done by rookies is most likely to be offshored or outsourced.
- Some exceptions
 - One company hires interns and keeps most after graduation.
 - Another wanted new PhD's for R&D: "They don't know what can't be done."



Policy issues

- Education
 - Need for cross-disciplinary programs
 - Need to provide more hands-on experience, internships
- Immigration
 - U.S. companies concerned about ability to bring in specialized skills not available in U.S.
 - Keep foreign students after graduation
- Innovation drivers
 - U.S. falling behind in broadband and wireless diffusion
 - Innovation in these areas more likely to occur offshore in leading markets



Executives views on future of engineering in the U.S.

- “We don’t do much PCB layout, tooling or testing any more. You can’t compete with the large numbers of Asian engineers for that kind of work. We have to take what we’re great at in the U.S. and leverage the rest of the world’s skills.”
- “The jobs that are really important and are in the U.S. involve product architecture where you need senior engineers; hardware and software engineers generally; and mechanical engineers and industrial design people.”

U.S. PC company executives