CLASS THREE: THE COMPETITIVE CHALLENGE TO U.S. MANUFACTURING

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“Innovation Systems for Science, Technology, Mfg. and Health and Energy”

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Brief Synopsis of Class:

- Look at Manufacturing: way to profit from innovation -- historical review--
- Review of last competitiveness challenge to US mfg., 70-80’s, and how it responded in 90’s
- Review of Japan’s mfg. innovations in the 70’s-80’s
- Review of “distributed” manufacturing – US model
- Review of mfg. shifts in Japan and Korea
- Nature of competition is changing, too
- innovation in process as response?
KENT HUGHES – Former Director – Woodrow Wilson Center - Project on America and the Global Economy—— Expertise: International Trade, Finance, and the Global Economy; U.S. Competitiveness and Technology

Policy Experience
Associate Deputy Secretary of Commerce; President, Council on Competitiveness; Chief Economist Congressional Joint Economic Committee and to Senate Majority Leader, Robert C. Byrd

Education
Ph.D., Economics, Washington University in St. Louis; LL.B. Harvard Law School; B.A., Political and Economic Institutions, Yale University.

Honors
Woodrow Wilson Center Public Policy Scholar, International Legal Center Fellow
1970’s – US Faced:
- Intractable inflation
- Declining productivity growth; slow growth
- Rising economic competition
- Rising national anger, frustration with gov’t
- **US:** unfettered markets, limited gov’t support for industry
- **Japan & Germany:** controlled closed markets and major gov’t role with industry
- **LED TO:** national competitiveness strategy
Initial Responses: (Hughes)

  - reduce marginal tax rates
- Cong. Dem’s: industrial policy – reconstruction bank for
  - lending to failing industries for turnarounds – later: focus
  - on “sunrise” industries

Then: “New Growth Compact:”

- Young Commission – John Young, CEO of H-P
- Focus on national competitiveness
- Fiscal and monetary policy creating favorable climate for investment
- Not only basic research but basic technology,
- industry led
- tech development policy and programs –
- “partnership nation”
- Rapid commercialization of technology – gov’t to
- support in labs, Univ’s and R&D programs
CRADA’s (Cooperation R&D Agreements with industry) at DOE

Bayh-Dole at Univ’s (Univ’s get IPR’s for results of federally-funded R&D)

ATP and MEP programs at Commerce

Aim: End isolation between Univ’s and industry R&D efforts

Education – attempts to revamp K-12, esp. science & math

Pro-international trade – led to Clinton ”compete not retreat” – NAFTA, China WTO

Note: movement built on the Sputnik era and WW2 experiences of industrial-gov’t cooperation and common nat’l purpose
60’ s-70’ s – Japan’s mfg. innovations reestablish mfg. as way to competitiveness

Pre: 70’ s - Quality-Price Trade-Off:

- Mass Production
  - Don’t stop the production line
  - Inspectors throw out what isn’t quality
  - Statistical quality control: find acceptable level of quality based on cost

Definitions:

- Quality – how good is the product
- Quality Control – is each unit of equal quality?
Toyota builds quality into the product – source: Edward Demming
- Every worker can halt the production line
- Total quality control

Just in time inventory – produce to order
Integrate dealers and suppliers – long term partners in design and product improvement
Japan’s best engineers start on factory floor, then move to design, not vice-versa

Result: “Lean Manufacturing”

More recently: Motorola- “Six Sigma” – GE mantra for all aspects of co. operations
Time is a competitive factor – so:

- Eliminate time delays
- Concurrent engineering design:
  - Ex.: Chrysler: late 80’s – Neon – fraction of Saturn dev. costs
  - Design in parallel, integrate design team
  - Factory floor manufacturability factor built into design – mfg. no long separated from design
- Once production starts, re-design in real time as bugs are found
Labor Trade-Off Emerges in Japan:

- Lifetime employment makes labor a fixed cost
- Trade-off: flexible work/job def. accepted for lifetime work assurance
- Labor becomes collaborative not adversarial
- Labor accepts new technology and productivity gains
- US – auto industry was moving toward this model until competition with China
Matsukata story – export orientation because resource poor

MITI (Ministry of Int’l Trade and Industry) – “Japan Inc.” (now: “METI”)

Keiretsu: integrated capital, trading, producer-supplier firms – own each other – pre-WW2 model for rapid industrialization, retained postwar

MITI adds gov’t support and trade policy to keiretsu model
- Mistakes – Honda, aerospace – Honda, Sony - outliers

Gov’t R&D focused on industry not Univ’s.
- Comparable % of GDP as US, but US focused on basic research and defense R&D

So: Japan lead in industrial R&D
- Issue: incremental, not revolutionary/radical?
90’s US Response:

- Match Japan on mfg. quality
- Pursue “destructive innovations”
  - Destroy/displace existing business models, technologies
  - Existing co’s can do radical innovation if existing customers seek improvements
  - Established firms move up-market and abandon low end – expands future profits
  - “destructive innovations” originate with lower end markets from outside existing competitor bases and improve until replace dominant
  - US did this radical innovation in 90’s with IT
US PURSUES INNOVATION, CON’T.: 

- So -US pursues radical innovation –IT– in 90’s:
  - Rebuilds mfg. from 2nd class status – mfg. process is key, too
  - Unlike US, Japan saves management control and advanced technologies
  - IT revolutionizes the service sector, high and low end

- 90’s – Japan faces macro-economic, population growth and banking problems; missed lead in IT, biotech revolutions
NOW WE JUMP AHEAD:

Q: WHAT IS HAPPENING NOW, POST-90’S, TO US MANUFACTURING?
Barry C. Lynn (Fellow, New America Foundation) End of the Line (2005)
Hamilton: mfg. independence is key to American “independence and security” – made US independent from other nations

Cold War- US pursued mfg. interdependence – integrated industrial complex from Europe to Japan - this promoted US independence

Outsourcing: vertically integrate elements in mfg. process but divest control to spread risk – formerly domestic, now: international

Now: participating nations: integrate their technology, capital and labor – control decentralized among participants – belongs to all participants and to none
Edward Lorenz (MIT meteorologist) – slight alternations in data would over time have dramatic effects – chaos theory

“deterministic chaos” – way to make sense of complex, dynamic systems

Labor Sec. Robert Reich – economic globalism is an unstoppable natural force – will crush the state but leave more room for the individual

Thomas Friedman, NYT - globalism of cultures unstoppable, so can forge global community of interest

Milton Friedman, Chicago Sch. of Economics – global marketplace as a sentient being, wisely directing human activity

William Greider – globalism is a bleak machine
All: globalism equals an economic determinism akin to Marx

Main point: 3 Periods of US Economy:
- 1993 – Clinton- complete laissez-faire in mfg. – bind world into interdependent economic system tied by joint mfg. and common economic system
China – West’s production system is merging with China’s

Defense Perspectives:

- **Integrationists**: extending the West’s mfg. production system will bind China to the global economic system, benefiting US needs long term

- **Realists**: profound differences in the two nation’s geopolitical goals and political systems remain – only question which nation gains the advantage from economic interdependence
Role of Manufacturing:
- 90’s – was 30% of US economic growth, 2x productivity of services sector
- Higher paying jobs – 23% higher in 2001 than services sector
- Current Mfg. Data:
  - Manufacturing remains an important part of the U.S. economy. It accounts for $1.6 trillion of U.S. GDP (12%) and nearly three-fourths of the nation’s industrial research and development.
  - Manufacturing firms account for 70% of US industry R&D and employs 64% of scientists/engineers
  - Manufacturing generated a greater percentage of real GDP in 2008 than real estate, finance, insurance, health care sectors.
  - Manufacturing is also an enabler for the other sectors – each mfg. job supports 2.5 to 5+ other jobs throughout the U.S. economy – multiplier effect. This contrasts with the retail sector and the personal service sectors, which have much lower rates.
  - In direct production jobs, mfg. employs 12.3 million in 2016
This multiplier effect reflects how manufacturing’s linkages run deep into the overall economy and means that improvements in manufacturing productivity translate broadly into the economy as a whole.

Many service sector jobs are tied tightly to domestic manufacturing; their number will expand or contract with the size of the manufacturing base.

Must embrace new technologies, processes and efficiencies for productivity gain in manufacturing.

Manufacturing is the currency of int’l trade, not services – but trade deficits –
- $812B in mfg. goods 2008 (pre-recession; surplus in services: only $139B)
- too big a gap for US int’l services sector to offset huge role of mfg.
- similar $800B+ deficit in mfg. goods in 2016
Manufacturing Job Loss:

- 2.7m jobs lost in the 7/00 to 9/03 recession
- 5.8m jobs lost in 2000-10
- 62,000 factories closed 2000-10
- Job creation still marginal
- 00 Recession - Mfg. 15% of non-farm labor force, but 90% of job loss
  - Mfg. fell from 13.27% to 11.4% of total labor force
  - Similar in 08-10 recession
  - But: C on C study - may be 46M jobs dependent on mfg
- Mfg. output as a share of US economy – falling for 50 years, 14.01% IN ’03; around 12% in 2016
  - Germany, 21%
  - Italy, 19%
  - Japan, 22%
  - South Korea, 31%
- Structural Recession in 08-19, not business cycle = permanent structural loss of jobs
JAPAN’S INNOVATION RESPONSE TO THE US

3 Historical Stages to Japan’s competitive pattern:
- “pursuer after pioneer”, THEN,
- “follower at the frontier”, THEN,
- “world class competitor”

Old Thesis re: Japan:
- National industrial performance and
- Corresponding competitive balance between nations, is
- Set by “national political economies” (gov’t role)
MITI’s role parallels evolution of Japan’s own technology leadership role –

PRAGMATIC TECHNOLOGY INITIATIVES:

- Older Period: specifically selected by high-level gov’t leaders
- Recent Period: now – industry selected, collaboratively with participation of low-level officials close to industry
  - (because high level officials can’t keep an eye on rapidly evolving complex technologies)
TECHNOLOGY TARGETING:

OLDER PERIOD: direct gov’t targeting of one or two specific technologies

- Funded at late development stages - prototyping and engineering development stages

NEWER PERIOD: shift toward BASIC research funding as well as applied,

- of broad range of alternative technologies supported --
- “shotgun” not a “rifle shot”
INDUSTRY TARGETING:

OLDER PERIOD:

- MITI picked winner co’ s by designating specific co’ s for funding
- Influenced corporate mergers to force development of strong co’ s

NEWER PERIOD:

- MITI funds range of co’ s and collaboration models
- Over 30 year period, MITI goes from funding 3 firms, to 25 firms in key computing initiatives
By 60’s, Korean firms on a “leadership trajectory” – Elements:

- **Gov’t** – “forced march industrialization”
  - Gov’t supplies education through college
  - Demand side – created chebols (cartels of dominant firms)
  - But: Corruption – made gov’t highly uncertain factor for business
    - Strong gov’t – asset in early stage; later, rigid bureaucracy inhibited market responses

- **Chebols** – key to capturing large scale industries --
  - But took toll on free market by blocking Small and Medium enterprises (SME’s)
  - Problem misallocation of resources, inefficiency
Education – widespread education – but failure to evolve beyond colleges to research universities

Export Strategy – created business opportunities, exposed firms to life- or-death world competition crises – this built competitive strength
  - Gov’t available to help in these crises

Tech Transfer Policy – policy was largely reverse engineering of foreign technology – critical capability
**R&D Policy** – since no Korean research univ. base, gov’t R&D centers become key
- Gov’t Research Institute’s (GRI’s) led by Korean Institute for Sci and Tech (KIST)
- Gov’t efforts to force joint GRI-industry R&D failed in early stages
- But GRI’s did contribute experienced researchers to industry – critical

**Cultural Factors** –
- Merger of Confusian culture (of family and collective orientation), and Christianity (pragmatic, goal-oriented individual values)
- Korean War left country destroyed, with nothing – major north-south exodus amalgamated people form different regions, economic levels, and families – created flexibility
- Universal military service – group management, strong organization broke down class lines
Learning Tech Culture -
- firms go from:
  - Poaching, to
  - Reverse Engineering, to
  - R&D, to
  - Innovation

R&D Investment –
- Heavy R&D investment by industry chebols
- But: few SME’s to spur out of the box innovation, only the pressure of relentless world competition
- Korea – very high R&D to GDP ratio
Problems for Korea: (Kim)

- Limited university R&D
- Needs SME/entrepreneurial base
- Needs network of technical support (mfg. extension programs)
- Needs liberalized economy away from domination by small elite and chebols
- Chebols need downsizing, decentralizing, and democratization of workforce

Lessons From Korea:

- Strong gov’t leadership role – created chebols and force them into competition worldwide
- Gov’t education programs facilitated tech learning by industry
- Gov’t used crisis creation to force firms to compete effectively worldwide
Economy facing major structural changes –

- globalization challenges
- loss of both mfg. & outsourcing IT services
- companies recover without creating jobs
- major demographic shift –
- what will a new economy look like?

threatening process…
BLS data – Cited: E. Milbergs, Innovation Metrics, NII, 1/2004

Sources: U.S. Bureau of Labor Statistics; authors’ calculations. Note: The shaded area indicates length of the 2001 recession.
Number of Jobs Lost to Structural vs. Cyclical Change in Recessions

BLS Data; Cited In E. Milbergs, Innovation Metrics, NII, 1/2004

Image created by MIT OpenCourseWare.
Even slower job recovery after 2007-09 recession (Brookings 2016):

Figure 2: Jobs Gaps After Last Four Recessions

- 1981 Recession
- 1990 Recession
- 2001 Recession
- 2007 Recession

2001 jobs gap did not close before 2007 recession began.
Declining Median Income for US Working Class (Brookings 2016):

Percent Change in Median Real Earnings for Men and Women from 1990 to 2013, by Educational Group

Source: Authors' calculations using the 1990 Census and 2013 American Community Survey.
Note: Each bar shows the percent change in real median earnings for that gender and education group. The sample includes men and women aged 30–45 who are employed at the time of the survey and worked 750 or more hours in the previous year. For more details, see the technical appendix.
<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Average Length of Time a Person Who Lost a Job Remained Unemployed:</th>
</tr>
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<tbody>
<tr>
<td>December 2007</td>
<td>16.6 Weeks</td>
</tr>
<tr>
<td>June 2009</td>
<td>24.1 Weeks</td>
</tr>
<tr>
<td>September 2011</td>
<td>40.5 Weeks</td>
</tr>
</tbody>
</table>

Note: Those who lost jobs in 07-09 recession paid 17.5% less when reemployed – H.Farber, Princeton

Source: BLS data
Change in Median Household Incomes 2000-2011 (inflation adjusted)

Source: G. Green, J. Coder (10/11, based on Census Bur. Data)
COMPETITIVENESS THEN AND NOW:

Japan:
- High-cost, high-wage, advanced tech - “just like us”
- We have Entrepreneurial advantage, they have Industrial Policy advantage
- Rule of Law
- IP Protections
- Subsidized currency, buying our debt
- National Security: allies

China: New Mix
- Low-cost, low-wage, advanced tech
- Entrepreneurial
- Using Industrial Policy
- Limited Rule of Law
- IP Theft model – FBI: $300b/year
- Subsidized currency, buying our debt
- Nat’l security – peer competitor
Basic point - new “varieties of capitalism” emerging in digital era between U.S. and Asia in advanced tech goods

IT is Driver: codeable specs enable a split between design and manufacturing

- Previously, need for tacit knowledge kept these two closely tied together
- Digital fragments the mfg. process, distributes it

Model Airplane vs. Legos

- Model plane - each kit a bit unique, everything has to fit, lots of gluing and sanding unique to each, whole process has to be integrated together
- Legos - co’s can make different parts that are IT standardized that fit together - can split mfg. and design, distribute mfg.
Ipod - the classic example - Apple picked a mix of MP3 best technologies, tied it to a new accessible and legal music database and now a video base -

- Crossover product - key: combined player and data
- Stood up very fast because IT-standardized legos, the parts fit together - Apple doesn’t have to build its own mfg plant - great speed to market, competitive advantage
- Apple provides core competence, contract manufacturers worldwide do the rest
- Vertical integration not needed anymore - can distribute mfg. functions via IT specs
US using Lego model - open network for innovation; can move innovation offshore

Asia - contrasting model
- Korea - Samsung controls key components, allows assembly offshore // Dell: final assembly, components made offshore
- Japan - keeping integrated innovation model - and co’s very successful
  - Building plants in China but keeping IP in a “black box”
  - Japan keeps “mother factories” in Japan to innovate
  - If integration capability and tacit knowledge are still key to radical innovation then Japan may have the right model
  - Japan owns its plants in China, so it understands these markets on the ground, new US distributed mfg. model precludes this new market know-how
  - Japan - talented production workforce is innovation process key; US treats workforce as disposable

Both models may work
There are 3 Fundamental, Different Design Methodologies:

- Historically US has used "TREE-AND-BRANCH" hierarchial firms
  - Fit a mass production economy
  - mfg. at a nat’l scale for a nat’l market, verticle integration required - think Big 3 car co’s
  - Fit an Aristotilian hierarchy of ordered knowledge
    - This is still the way the West orders science
  - But the tree hierarchy meant inflexibility and slow to change
In contrast, Japan’s enterprises of 70’s-80’s and now were “LAYERED”
- separate but connected ranks, movement and connections between ranks, but no title status
- Ex.: Plato’s philosopher king, guardians, citizens

In the 90’s the US nurtured a new “NETWORKED”
- flatter, set of enterprises
- Driven by the IT sector - demand for flexibility and speed to market
- Driven by the collaborative group innovation systems behind IT
- these appeared even more flexible and faster than “layered” systems

NOTE: Engineering: lacks model to grasp these emerging structures
AND NOW ANOTHER FACTOR- The Nature of the Competition is Changing

- **Then:** manufacturing / **Now:** fusion of services and manufactured goods – hardware for service delivery – loss of mfg. affects services side
- **Then:** Quality / **Now:** customization, speed, customer responsiveness
- **Then:** best technology / **Now:** technology plus business model
- **Then:** trade in products / **Now:** also trade in knowledge management and services tied to products
- **Then:** worker skills / **Now:** continuous learning
- **Then:** low cost capital / **Now:** efficiency in all financial services stages, esp. intangible capital
Kent Hughes – US built comparative advantage in the 80’s-90’s by becoming innovation hub, bringing on IT revolution
- Behind this, advantages in R&D, education; added partnership model

Japan’s Innovations in Manufacturing
Innovated with mfg. process – quality, just in time inventory, supply chain integration, gov’t participation, etc.

Barry Lynn – global determinism – no nation controls the world economy

Glenn Fong – MITI advanced with Japan’s economy – pursued more sophisticated industry role – let industry lead, played supporting function, stopping winners, backed basic research as well as applied
Linsu Kim–Korea emerges - factors:
- Gov’t: “Forced march industrialization”
- Chebols
- Education – esp. through college
- Merciless Export Strategy for co’s
- Tech Transfer is Reverse Engineering
- R&D via Gov’t Research Institutes
- Culture – collective & individual; diversity

Post-90’s – What happens to US Mfg.?
- 01-03 “Recession” – 2.7m permanent structural job loss in manufacturing;
- 2000-2010– 5.8m jobs lost - mfg. goes from 17m jobs, to 11.3m jobs in 2008-09 recession, to 12.3m jobs in 2016
- Disinvestment in plant and capital equipment
Manufacturing Challenges
- Manufacturing is currency of int’l trade
- It is the way nations profit from innovation
- US mfg. employment now in decline –1/3 mfg. job loss in 2000-10– this is structural unemployment
- Health of US mfg. base starting to decline, as well
- US industry employs bulk of scientists, engineers, funds most of US R&D

Suzanne Berger –
- the distributed mfg. model --
- IT based “legos” - snapping IT designed components into final products; vs. older integrated production (model airplanes)
- networked production
- Nature of manufacturing competition changing-
  - U.S. separating design and mfg. for distributed mfg. model
Suzanne Berger, Con’t
- with fast product standup, distributed risks – ipod example
- Japan’s firms retaining integrated model to learn local markets

Joel Moses
- Three fundamental design methodologies
  - Hierarchial
  - Layered
  - Networked

And – nature of mfg. competition changing
Growth Economics says only one move: 

**Innovate**

**Mfg.: key way to achieve gains of innovation**

**Revolution in Manufacturing –**
- digital mfg., robotics, high perf. computing (for modeling and simulation),
- “desktop” mfg. – 3D printing, “additive” mfg.,
- inspection simultaneous with production, small lot production as cheap as mass production,
- revolutionary materials,
- nano mfg. technology

**DOD has big stake in retaining US manufacturing capacity**
- DOD role in supporting mfg. process revolution?
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