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

William B. Bonvillian

"Innovation Systems for Science, Technology, Mfg. and Health and Energy"

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MIT

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

Kent Hughes, Building the Next American Century: The Past and Future of American Economic Competitiveness (Woodrow Wilson Press- Johns Hopkins Press 2005)

- 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)

- Cong. Rep's: Rep. Jack Kemp, Sen. Bill Roth, Pres. Reagan:
  - 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

Hughes: New Growth Compact, Con't.

- 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

Japan and the Rebirth of Manufacturing (next slides drawn from C.Weiss)

- 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 Ends the Quality-Price Trade-Off:

- 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

Speeding the Product Cycle:

- 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

Industrial Policy Emerges in Japan:

- 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: incemental, 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
  - But now what? Globalization speeds product cycle and export of mfg. technology –US faces "hollowing-out" of their mfg.
  - 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)

Barry Lynn, End of the Line Con't

- 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

Barry Lynn, End of the Line, Con't

- Edward Lorenz (MIT meterorologist) – 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

Barry Lynn, End of the Line, Con't

- All: globalism equals an economic determinism akin to Marx

- Main point: 3 Periods of US Economy:
  - Hamilton to 1945: rational national self-dependence in mfg.
  - 1945 – 1991 (end of Cold War) – US gov't entwines US-Europe-Japan in mutual dependence on Amer-centric mfg. system
  - 1993 – Clinton- complete laissez-faire in mfg. – bind world into interdependent economic system tied by joint mfg. and common economic system

Barry Lynn, End of the Line, Con't

- 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

BACKGROUND: Competitive Challenge to US Manufacturing

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

Manufacturing Challenge, Con't

- 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

Glenn R. Fong, "Follower at the Frontier: International Competition and Japanese Industrial Policy," Int'l Studies Quarterly 42, 339-366 (1998)

- 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)

Fong-- MITI's Evolution:

- 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)

Fong-- MITI's Evolution, Con't.:

- 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"

Fong -- MITI's Evolution, Con't.:

- 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

LINSU KIM, "IMITATION TO INNOVATION" (Harvard Bus. Sch. Press 1977)

Elements in the Evolution of Korea to High Growth Economy: (Kim)

- 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

Elements in Korea's Growth Economy, Con't.: (Kim)

- **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

Elements in Korea's Growth Economy, Con't: (Kim)

- **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

Elements in Korea's growth Economy, Con't.: (Kim)

- **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 forece 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

BACKDROP: Economic Realities Forcing New Public Policy:

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…

Payroll Job Growth in Recoveries

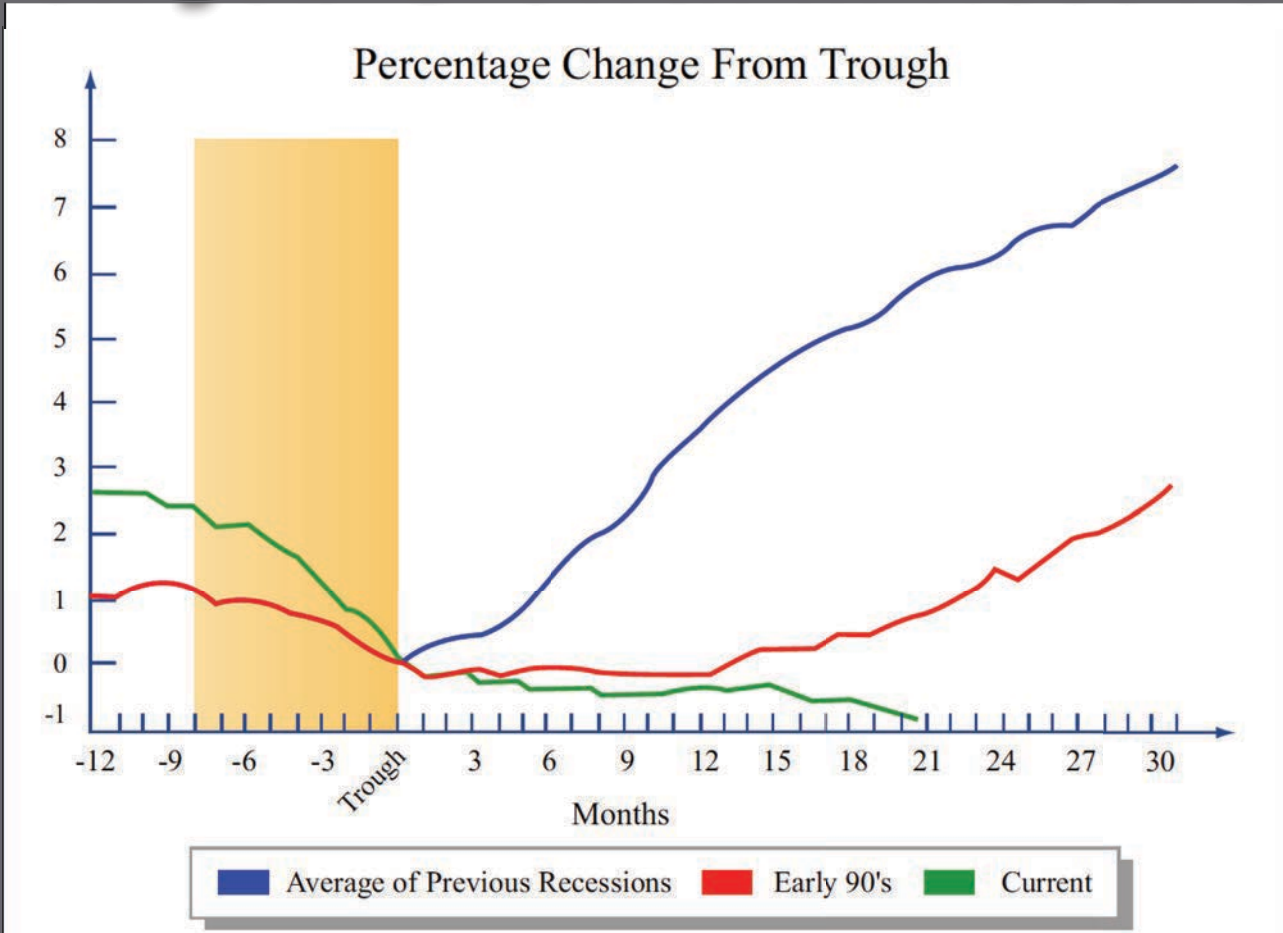


Image by MIT OpenCourseWare.

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

Sources: U.S. Bureau of Labor Stathetistics; authors' calculations.
Note: The shaded area indicates length of the 2001 recession.

Number of Jobs Lost to Structural vs. Cyclical Change in Recessions

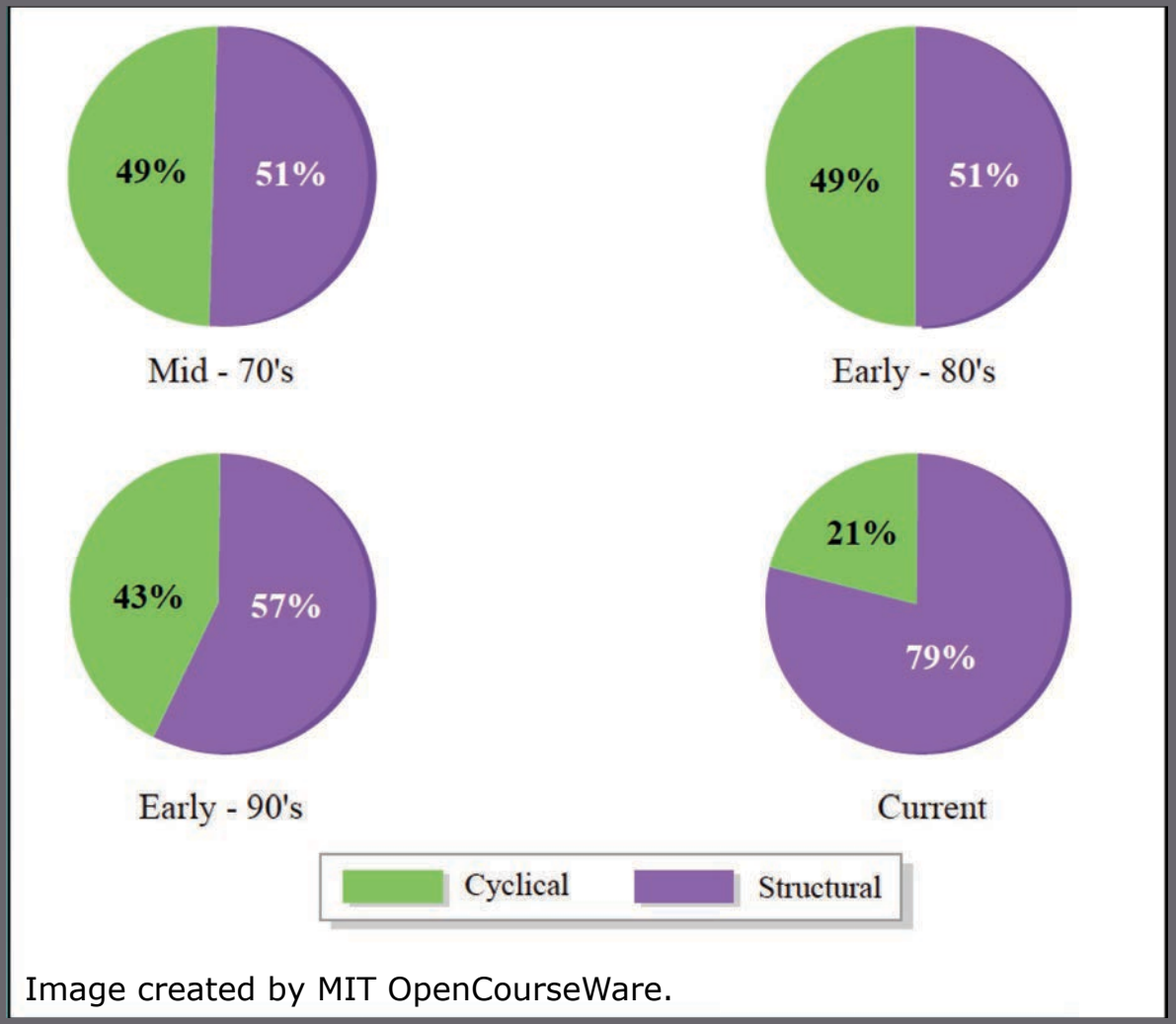
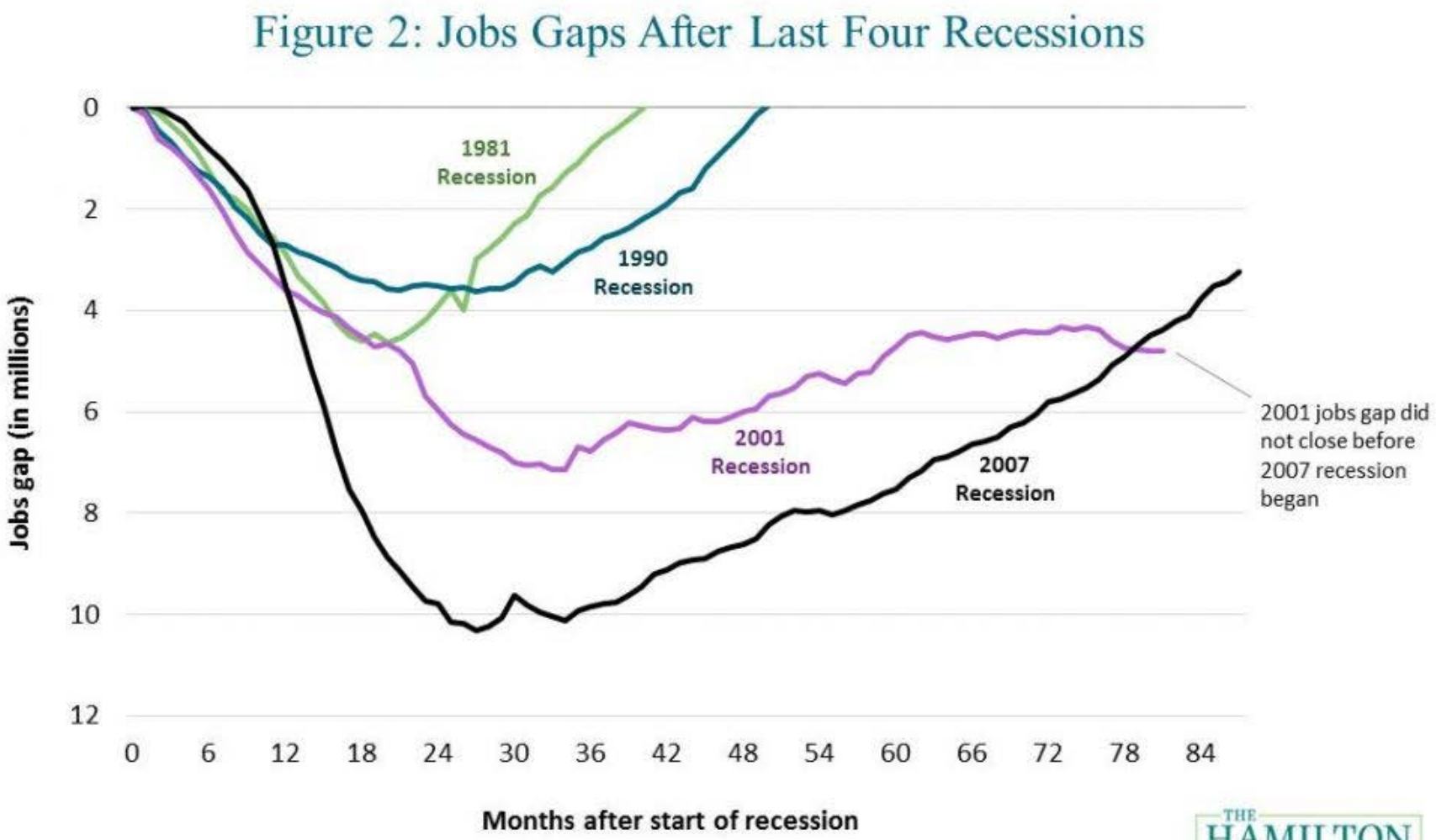


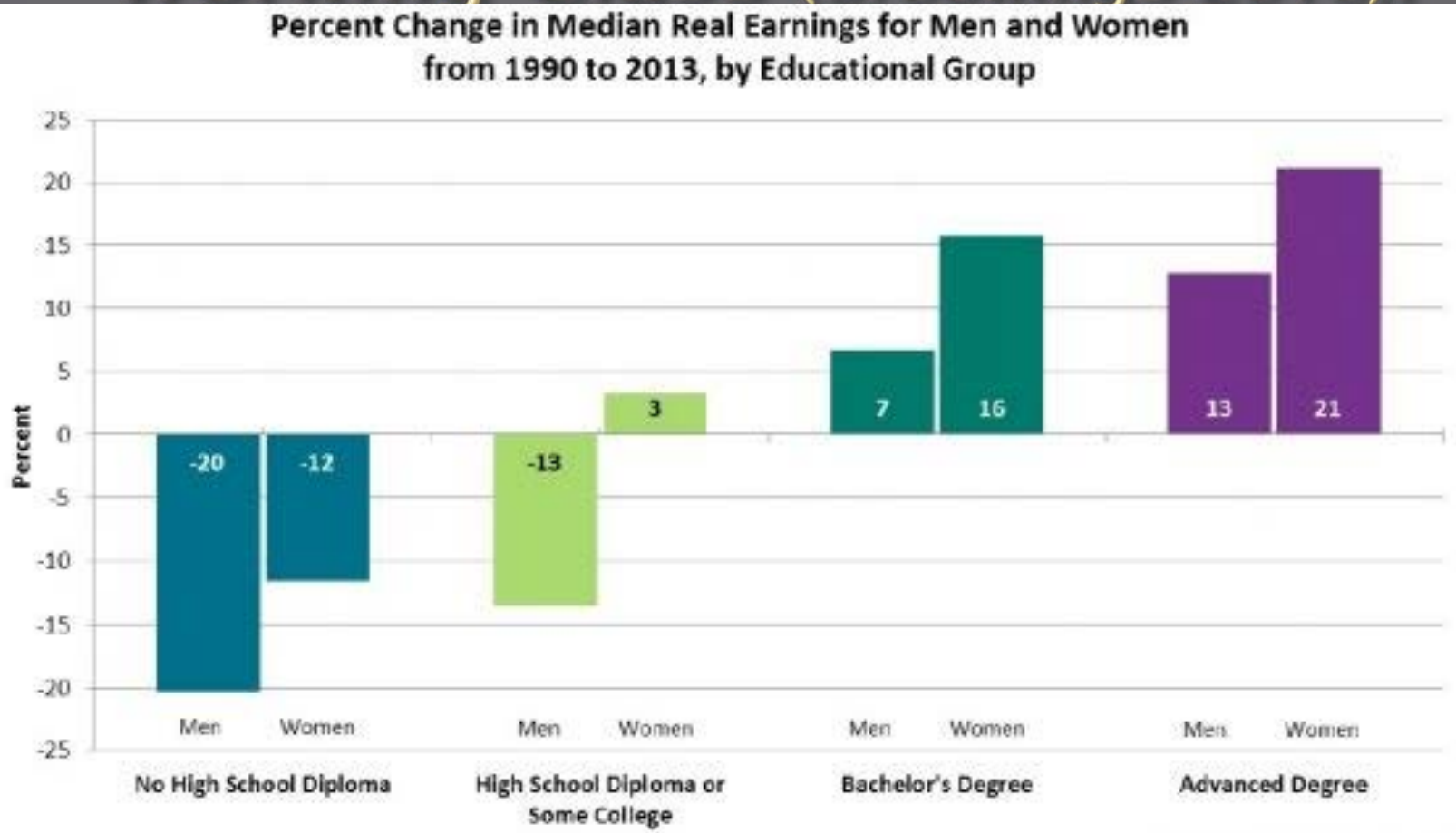
Image created by MIT OpenCourseWare.

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

Even slower job recovery after 2007-09 recession (Brookings 2016):



Declining Median Income for US Working Class (Brookings 2016):



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.

THE HAMILTON PROJECT
BROOKINGS

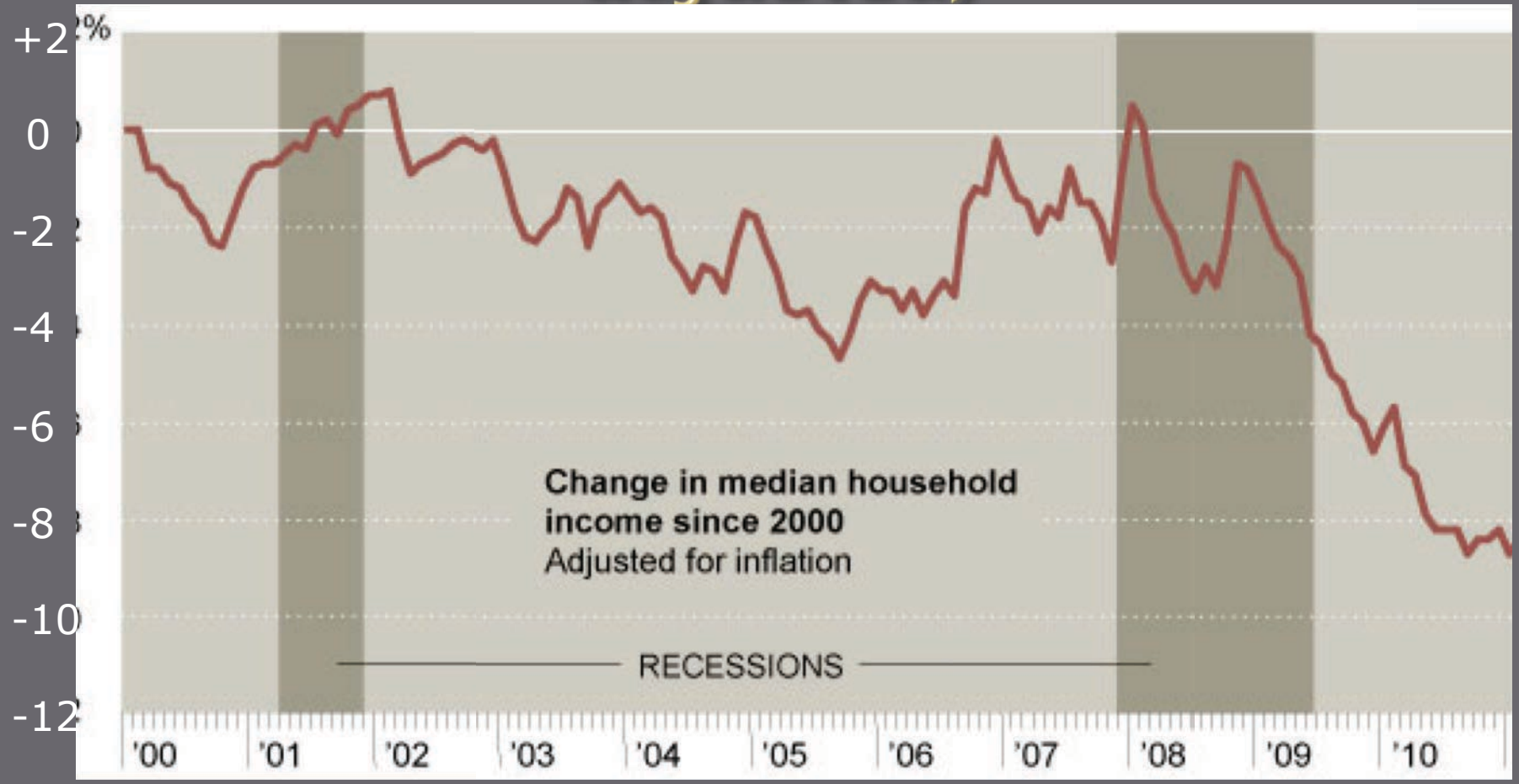
Recession of 2007-2009: Length of Time Unemployed Remained Out of Work, Through 9/2011:

Month/Year:	Average Length of Time a Person Who Lost a Job Remained Unemployed:
December 2007	16.6 Weeks
June 2009	24.1 Weeks
September 2011	40.5 Weeks

Source:
BLS data

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

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

Suzanne Berger (MIT), How We Compete (2005)

- 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.

Suzanne Berger, Con't

- 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

Suzanne Berger, Con't

- 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

Joel Moses (MIT) - 3 Fundamental Design Methodologies (2004)

- 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

Joel Moses, Con't

- 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

Class Three - Wrap-Up:

- 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

Wrap-Up, Continued

- 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

Wrap-Up, Continued:

- 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

Wrap-Up, Con't

- 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

BIG CHALLENGE - How can US stay in manufacturing, a key to wealth?

- **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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