CLASS TWO: ELEMENTS IN THE INNOVATION SYSTEM – DIRECT AND INDIRECT FACTORS

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Class One: RECAP –

Solow – "Technological and Related Innovation" = dominant causative factor in economic growth

Romer – "Human Capital Engaged in Research" = talent base behind the R&D system

Jorgenson – proves the model in the IT innovation wave

Merrill Lynch – vision/enabler/talent on task; financial support only for the very short term – 2 yrs from mfg.

- *FIRST Class:* Two **DIRECT/EXPLICIT** Elements in Innovation – R&D AND TALENT.
  *NOW: **INDIRECT/IMPLICIT** Elements
  *Definition: **INNOVATION:** system for introducing a tech. advance – examples:
  EX.: steam engine, track, steel rails, time-keeping;
  EX.: mix of - auto, steel, aluminum, plastics, highways, oil industry, pipelines, gas stations

Opening Illustration - The Edison Story:

- Limited Education, mother home schooled, visual imagination
- Telegraph applications (stock ticker)
- Bridge to decision makers (Morgan)
- Lightbulb is only the invention – has to conceive of the whole innovation mix
- Invents industrial R&D organization

Edison, Continued

- Menlo Park–100' long wooden lab on his farm - calls it, "invention factory"
- Dozen artisans, eat pies at midnight around a wood stove, gaslight, songs, 24/7; wife almost kills him with .38 revolver when he forgets key, enters house by roof after researching until 3am
- Electric light
  - Saw large electric arc in Ansonia, Ct.
  - Gets idea of making it small, fills gap with filament
  - Vacuum tube – carbon filament
- Then: has to invent all of electricity infrastructure:
  - Generators, wiring, fire safety
  - Invents structure of Electric Utility Industry
  - Gets J.P. Morgan to finance
- Edison Effect – Edison has to derive electron theory to explain results – leads to atomic physics

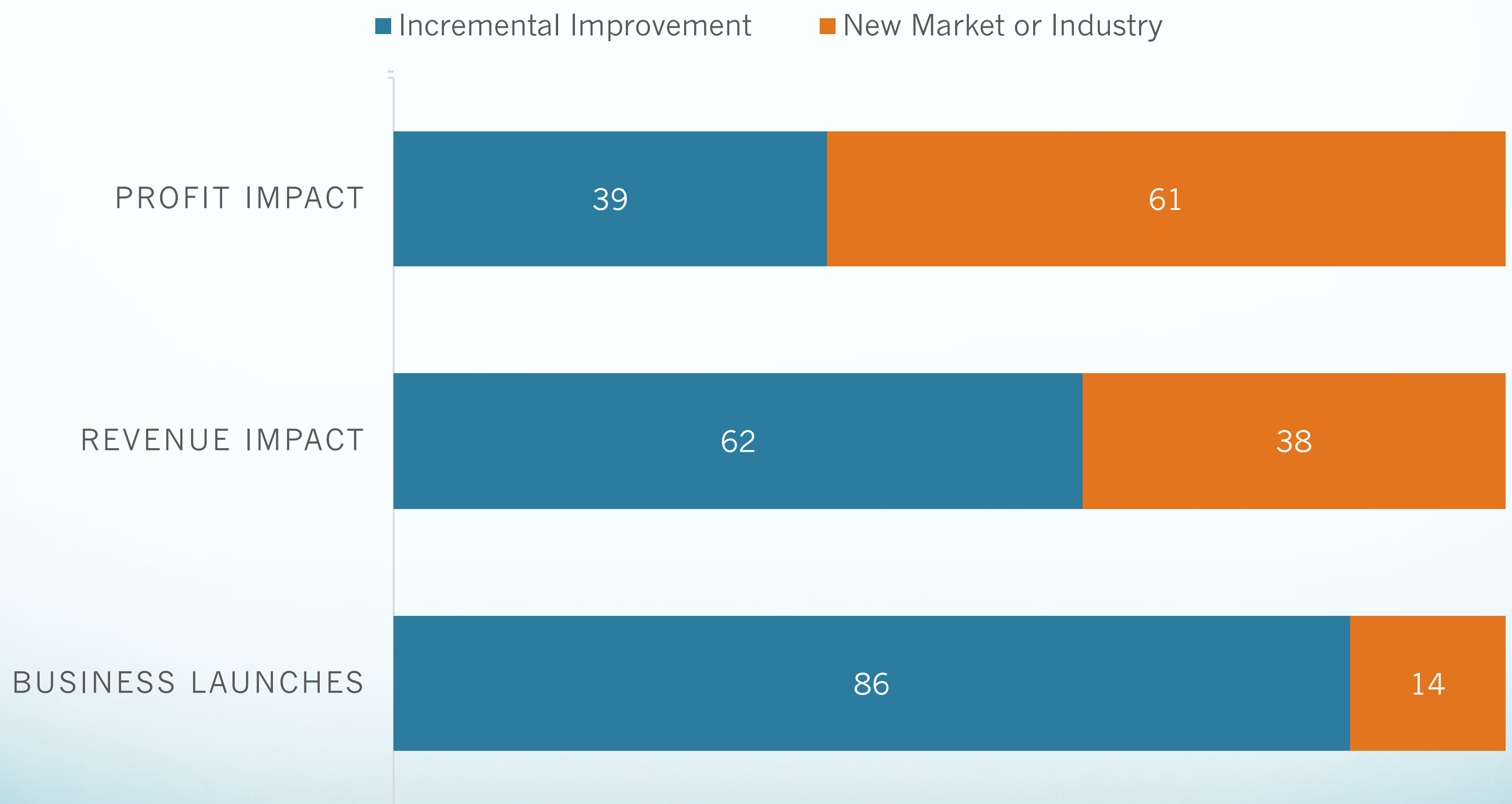
Basic Ideas and Terms: Steps in Technology Development (Charts: C.Weiss)

- Vision
- Enabling Technologies (ex. -scanning tunneling microscope for nanotechnology)
- Idea
- Research
- Invention of Prototype
- Engineering Development
- Production/Manufacturing Prototype
- Commercial Production
- Supporting Infrastructure System
- Additional applications (ex. - internet)
- 2nd, 3rd, 4th generation of product

Models of Technology Change:

- **"Technology Push"** – technology evolves and creates new markets
  - Atomic power: pre WW2 nuclear physics (obscure area)
  - Atomic bomb ends WW2, transforms geopolitics
  - Nuclear power is side product - "endless cheap power"
  - Other ex's- TV, microwave from radar from wave theory
- **"Technology Pull"**- relies on market pull to force technology development
  - Ex.: DSL, cable modem,
- **Incremental Innovation** – improves: function, aesthetics, performance, efficiency, manufacturability, dependability, repair-ability – sustained stream of incremental improvements can multiply productivity and sustain competitiveness for decades (ex.: RR's, mining, autos) - DIFFERENT FROM Radical Innovation

Radical Innovation Yields Disproportionate Profit Impact



Kim and Mauborgne, Harvard Bus. Rev, 1/97,
Cited: E.Milbergs, Innovation Metrics, NII, 1/2004

Image by MIT OpenCourseWare.

Radical vs. Incremental Innovation

- Radical innovation potentially far more profitable – but incremental far easier
- Established firms resist change-because:
  - "disruptive technologies" – Clayton Christianson - from radical innovation - disrupt established markets
  - "destructive competition" – Schumpeter - new technologies preempt existing markets
  - Ex.: Bell Operating Co.'s resist true broadband
- Innovation requires a playing field open to new players
  - How does an established firm retain ability to innovate? Lockheed's "skunk works"? IBM's PC project separate from rest of company

Traditional Product Cycle Theory:

- Firm defines product
- Develops market
- Standardizes product
- One design dominates
- No. of competing companies reduced
- Product becomes a commodity (high volume, price drops, low profit margin, product not unique)
- Production technology often then goes offshore
- Barriers to entry increase
- Surviving firms have:
  - Capacity to advance their technology
  - Large scale production
  - Strong distribution and marketing
  - Management talent to grow firm

End of Product Cycle Theory?

- Some companies learning how to bring on continuing radical innovations
- Globalization spurs competitiveness, speeds product cycle & export of mfg.
- Manufacturing process rebirth – process productivity leap can redo competitiveness picture
- Emergence of very sophisticated IT-based service sector – sometimes these firms integrate with manufacturing for new mix

Dynamic vs. Static Competitive Advantage:

- 19th Century Economist David Ricardo:
- STATIC Comparative Advantage – intrinsic to a country, based on its natural resources
  - England-sheep/wool –trades with --Portugal-port – neither side can capture the other's advantage
- DYNAMIC Comparative Advantage:
  - Resource-based economies decline
  - Dynamic advantage created in a nation by investments in R&D, education, transparent and efficient governance
  - Note: US in '90's thought it was creating comparative advantage in EARLY part of product cycle (innovation stage)
  - But: Can Dynamic Comparative Advantage be Captured??

1) Richard Nelson, Prof. of Economics, Columbia Univ.

National Innovation Systems – A Comparative Analysis (Oxford U. Press 1993)

- "Technological capabilities of a nation's firms are a key source of their competitive prowess"

  →Nelson develops the term:

  "***national innovation systems***"

Does the term make sense despite transnational businesses? – yes

"innovation" - Nelson uses broad def., "process by which firms master and get into practice product designs and new manufacturing processes"

2) "Schumpeterian Innovator"

- Destructive Capitalism occurs via innovation - it's not necessarily the first innovator that captures most of the economic rents associated with the innovation
- Therefore, a nation's concern is in broader "innovative capability"
- Not limited only to firms or only to science research but to a SYSTEM – " a set of institutional actors" that influence innovative performance
- Q: What's "the way technical advance proceeds" – what are the "key processes"?–A: science and trial and error learning
- Q: **Institutional actors**? A: univ.'s, firms, government agencies and policies
- Q: is there a "common analytical framework" across nations?

3) Science as Both Leader and Follower:

- "New science gives rise to new technology" ***<u>(and vice versa)</u>***

- Electricity – Science as Leader:
  - Faraday 1831 – electromagnetic induction
  - Incandescent light, gramaphone–Edison, telephone-Bell
  - Hertz 1887 – radio waves – radio, TV
  - Radio/TV, electricity – NOT because scientists seeking applications

- Chemistry- Science as Follower:
  - First-alchemy, tanning, dyeing, brewing – practical applications
  - 1860's – Kekule – molecular structure of benzene – leads to organic chemistry
  - Polymer chemistry – grew from industry needs
  - "Chemical Engineering" – merger of chemistry and mechanical engineering – interdisciplinary advance

4) More Science *as Follower:*

- Steam engine workings– J. Willard Gibbs creates science of thermodynamics
- Edison – develops electricity-based lighting (flow of electricity across gap)– has to develop electron theory – yields much of 20th century physics, electronics
- Aircraft technology (starts with Wright Bros – bike mechanics) – yields aerospace engineering
- Transistor (Bardeen, Shockley, Brittain - Bell Labs) in 1940 leads to growth of solid-state physics
- Computing – yields computer science
- Lasers and optical fiber yield science of optics
- SO: science yields technology but technology yields science – rich and complex interaction
- **Need both science and technology leadership for both science and technology leadership - interact**

5) Limits of Science:

- Innovation in high tech – is not only invention but:
- → Design – choosing the right "mix of performance characteristics" – ex.-modern aircraft wing
- Most R&D spending is "incremental improvements" – ex., jet engines added to aircraft replacing propellers
- process of incremental advance is not classic science breakthrough

6) Who are the ***Innovation "Institutional Actors"?***

- 1. Industry Lab- by WWI industrial research lab staffed by Univ.-trained scientists and engineers – dedicated to "invention" and incremental enhancements
  - More impt. than univ. or gov't lab –
  - because: after initial tech. in place users have knowledge of strength and weaknesses that transcends general public scientific knowledge
- Reverse engineering is R&D in many countries
- Note: R&D only part of larger innovation picture – management style, man. org., including for R&D, also impt.

7) Innovation Institutional Actors, Con't.

- 2. University Labs –
  - Univ.-Firm Connection – modern industrial research lab and modern research univ. grew up as companions/partners
  - Many academic science fields are applied-oriented: material science, computer science, engineering
  - If a Univ. supports technical advance – how channeled to nation's firms? Some argue it isn't
- 3. Government Labs
  - US gov't. labs key to advance in agriculture, health, nuclear energy – they act via public service missions
  - [Gov't. labs substitute in many countries for Univ. research – Korea, Finland]

8) Innovation "Institutional Actors" Con' t

- 4. Public Sector Support for Industry R&D
  - ***Controversial in the US, assumed everywhere else in world.***
  - In US-industrial R&D is rationalized under gov' t. agency mission - ie, defense R&D with industry- for defense

There are Inter-industry Differences in Innovation Actors:

*affected by role of suppliers/users, etc.

*no standard model

*in complex technologies: supply chain and customer/users play role in innovation; also--
*component and systems producers

*So: "innovation networks: - result of a community of actors

9) Comparison – ***U.S./Japan*** Innovation Systems:

- '45-'75 US Innovation System :
  - US firms larger in scale/serving continental sized markets
  - US firms spend more on R&D
  - US gov't spends more on R&D, via defense mission
  - US Univ. research stronger – better connected to industry than in Europe – tied to strong public financing for Univ. R&D after WW2
  - Most US goods sold into US market – little export orientation
    - Note: US research Univ's (Hopkins, Columbia are first) are modeled on German Univ.'s; R&D of US chemical industry (first large scale industry R&D) modeled on Germany

- '70's-'80's Japan Innovation System Model:
  - Resource poor so strong export orientation since 1880's
  - R&D more tied to industry
  - Gov't via MITI has explicit technology development policy

10) Country Innovation System Differences:

- 3 Basic Categories of Countries:
  - 1) Large high income countries
    - Large fraction of economy in R&D-oriented industries
  - 2) Small high income countries
  - 3) Lower income countries
- Countries without resources have export orientation – Germany, Japan, Korea
- National security imputed to/connected to innovation system – in US,UK, France
  - Defense R&D is majority of gov't industrial R&D
  - Japan – industrial cartel structure set with high industry R&D pre-WW2 period
- Differences in gov't role:
  - US, UK – limited gov't role in industrial R&D outside defense
  - Low income countries and resource short, export-driven countries – large gov't industrial R&D role

11) What Leads to *Innovation Success*?

- ***KEY FACTOR: STRONG FIRMS*** (not necessarily large), highly competent in:
  - product design,
  - management,
  - fitting consumer needs,
  - linked to upstream suppliers and downstream markets,
  - access to investment,
  - -must compete in world markets to be strong, &
  - -the bulk of their innovation has to be by firms themselves [even if networked to others]

12) Other Key Innovation Success Factors:

- EDUCATION & TRAINING – science-based industry depends on univ. ed. – key gov't role here
  - Hightech sector requires broad base of educated talent in and outside R&D
    - Korea, Taiwan – education led growth
- FISCAL, MONETARY, TRADE POLICY – key gov't role
- PUBLIC SUPPORT OF UNIV. OR GOV'T LAB RESEARCH --
  - Critical in key fields – ex., electronics
  - For univ. or gov't labs – key is direct interaction between firms or groups of firms and particular researchers or research programs – you want a "technological community
  - Role of defense research – key to US success in electronics, computing, semiconductors, aerospace – but "declining spillover" because US military has shifted from new generic technology to specific hardware – And note: US public R&D funds much lower outside defense

13) Q: What About ***Explicit Gov't High Tech Innovation Role?***

- Backdrop: High tech advance key to high wages, high skills, top competitive management ability
- Innovation System Goal: create systematic technical advance in series of areas
- Much value occurs downstream in industries incorporating these advances
- Active gov't policies can be effective in generating competitive advantage in tech advances and are comparatively low cost
- And – these active gov't policies can play a role in helping an industry take advantage of upstream technology advances
- Overall – advances in key tech sectors are "building blocks" for advances in downstream industries, as well as upstream

REPEAT: MENU OF <u>DIRECT/EXPLICIT</u> U.S. INNOVATION SYSTEM FACTORS:

- DIRECT/EXPLICIT – GOV'T –
  - Univ. R&D
  - Gov't Labs
  - Education, Training
  - Support for Industry R&D (primarily via Defense, agency missions)
    - Primarily research, but support through all stages if agency mission
- DIRECT/EXPLICIT – PRIVATE SECTOR
  - Industry R&D
    - Primarily Development
    - Goes through engineering, prototyping and production
  - Training

MENU OF <u>**INDIRECT/IMPLICIT**</u> U.S. INNOVATION SYSTEM FACTORS:

- INDIRECT/IMPLICIT FACTORS – SET BY GOV'T:
  - Fiscal/tax/monetary policy
  - Trade policy
  - Technology standards
  - Technology transfer policies
  - Gov't procurement (for mission agencies)
  - Intellectual Property protection system
  - Legal/Liability system
  - Regulatory system (environment, health, safety, market solvency and market transparency, financial institutions, etc.)
  - Accounting standards (via SEC through FASB)
  - Export controls
  - ETC.

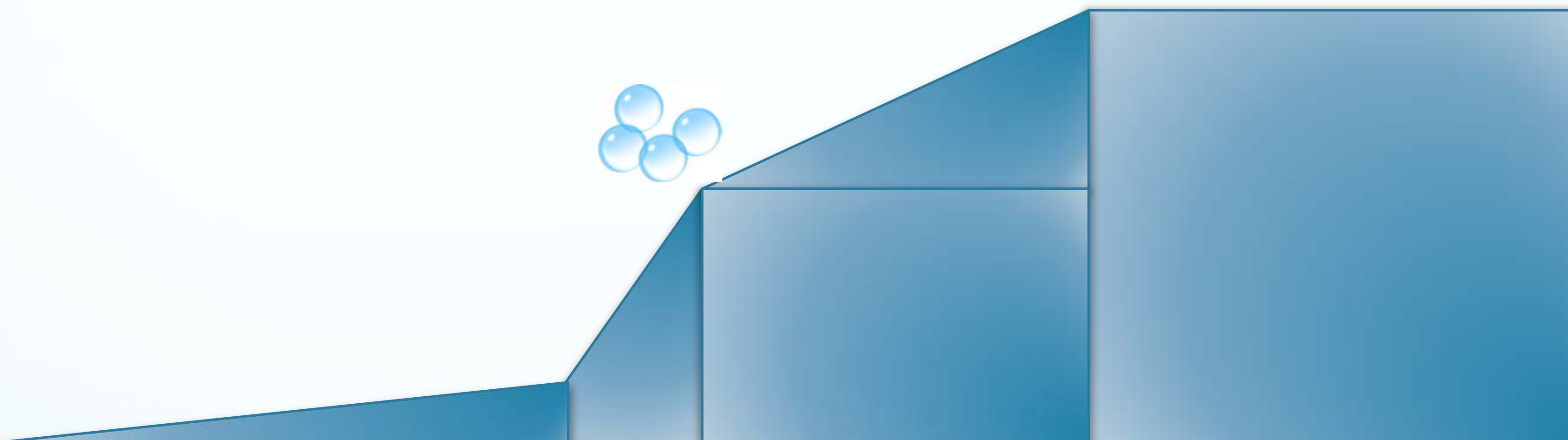
MENU OF **INDIRECT/IMPLICIT** U.S. INNOVATION FACTORS, CON' T.:

- INDIRECT/IMPLICIT FACTORS – SET BY PRIVATE SECTOR:
  - Investment Capital – angel, venture, IPO;s, equity, lending
  - Markets
  - Management & Management Organization, re: innovative and competitive quality of firms
  - Talent Compensation/Reward
  - ETC.

Innovation Wave Theory – Rob Atkinson

Image courtesy of ITIF on Flickr.

Innovation Wave Snapshot:



Long build up |Fast| Stable | Tech Maturity

Growth Growth

15/20 yrs? -> 10 yrs?-> 20 yrs? -> Indefinite

Robert D. Atkinson, The Past and Future of America's Economy – Long Waves of Innovation that Power Cycles of Growth (2004)

- Four Phases of the US Economy – "Long Waves":
  - 1840's - local small firm mfg. industries (N.Eng. Textiles)
  - 1880's-90's - regional factory-based system (steel plants)
  - 1940's - national corporate mass production (autos, aircraft)
  - 1990's - "New Economy" - global, entrepreneurial, knowledge-based (IT)
- Waves start with the gushing enthusiasm of new technologies:
  - Henry Adams at 1900 Paris Exposition sees huge dynamo producing electricity - sensation of having his "neck broken by the sudden irruption of forces totally new"

Dimensions of the IT/New Economy Wave

- 1990's rapid growth; '00s - dot com bubble burst
  - NASDAQ fell from 5000 in 2000 to 1850 in 3/02
  - 2000 - 225 dot-coms failed; 2001 - 535 failed
  - 110,000 jobs lost in dot-coms in 2001
- BUT: productivity: 4.9% in '02, 4.2% in '03
  - '04 NASDAQ still 43% higher in '04 than in '96
  - More $ invested in VC in 99-00 than in previous 20 years
  - Internet Revolution far bigger than anticipated:
    - '97 Forrester Res: BtoB e-commerce would be $186B by '01
    - In fact, BtoB e-commerce was $715B by '01
    - '98 PPI Index predicted by '03 broadband would have 9m subscribers
    - In fact, by '03 20 to 25m households subscribed to broadband
    - Between '00 and '02 - 8m new domain names, and 54m new interent hosts
    - Investment in IT in 2003 lower than 2000, but still 5% higher than in 1999
  - To come: Next Gen Internet, intelligent cars, optical computing and switching, nano tech applications etc.

Political System Slow to React:

- Keynes: "Practical men who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist."
- The old left: old mass production economy, Keynesian, Great Society framework
- Today's right: supply-side classical economics of capital supply, factory era
- Neither embrace: Growth economics of spurring innovation, major portions of which are gov't led, need for workforce skills updating, continuous learning, laying digital infrastructure
- New Economy demands: networks not hierarchy, more civic, private sector roles, more technology, less rule-based bureaucratic programs

Technology and Social Transformation

- 2 views: social and economic structures independent verses economic determinists - economic change drives social order
- Hegel: western society driven by the competition of ideas
- Marx: "in acquiring new productive forces, men change their mode of production, and in changing their mode of production they change their way of living - they change their social relations."
- US and USSR in '50'-60's Cold War: different political systems, but both relied on mass production hierarchical organizations
- Heilbroner: "the general level of technology may follow an independently determined sequential path, but its areas of social application certainly reflect social influences."
- Prevailing technology system sets parameters on social organization

Technology & ***Economic Cycles***

- Kondratieff: 30's depression was the trough of a 50-year cycle/wave of business investment
- Classical economists - depression view: wait for wages and prices to fall far enough for rebound (Hoover approach)
- Keynes: agreed that would happen in the long run, "but in the long run we are all dead" - so: gov't intervention through deficit spending offsetting decline -- but like classical economists still saw problem as fundamentally driven by monetary/capital forces
- Schumpeter: saw Kondratieff's long waves, but saw them as driven by innovation not just in technology but in the accompanying aspects of production and distribution
- Saw "destructive capitalism" where a new radical (not incremental) technology destroys prior technologies

Tech & Economic Cycles, Con't

- Technology is the skeleton on which an economy is formed; every half a century or so the technology skeleton changes in waves
- Changes not steady but intensely clustered in particular periods
- Not just the economy changes but politics, social relations, how and where we live, how we organize our education system, how our culture shapes our beliefs - because "the logic of the techno-economic paradigm reaches well beyond the economic sphere to become general and shared organizational common sense of the period." - **Carlotta Perez**
- Chris Freeman of Sussex: a techno-economic paradigm is a "combination of interrelated product and process, technical, organizational and managerial innovations, embodying a quantum leap in potential productivity in all or most of the economy and opening up an unusually wide range of investment opportunities."
- AND: it becomes the natural order of things - easy to be complacent

Tech & Economic Cycles, Con't

- Note that old economy stakeholders usually have more political and economic power than innovators in the advancing economy, so transformation is disruptive
- **Daniel Bell** - "Societies tend to function reasonably when there is a congruence of scale among economic activities, social activities, social organization, and political and administrative control units."
- Today's neoclasical economists, like predecessor classical economists, tend to have difficulty understanding economic slowdowns - like low productivity 1973-93 period (hard to eke out big productivity change from low power, non-pervasive computing) or dot-com bust of '00-'03
- **Nathan Rosenberg**: this is because the causes were in the "black box of organizational and technological changes, and therefore were outside the scope of conventional economic analysis.

Technology and US Social Order – Technology Determinism

- US Civil War: battle between first wave innovators (large scale plantation agricultural economy) and second wave innovators (emerging industrial economy)
- Meiji Restoration in Japan - feudal vs. industrial economy
- As innovation forces new industries and occupations, social classes alter:
  - Mercantile/craft economy of early 19th century - largest class is farming class in both north and south, but industrial economy emerging in north and dominating, accelerated by the war
  - Rise of the industrial economy - blue collar industrial class dominates
  - Rise of the corporate economy of the 1950's - suburban white collar worker
  - Rise of the IT new Economy - knowledge worker

World Economic Forum, Competitiveness Rankings 2015-16

- Pillars in "**Global Competitiveness Index**" (a medium term macroeconomic index) –in 2013 U.S. #5; in 2010 US #4; in 2008 US#1; in 2006 US #6; 2015-16, Switzerland #1, Singapore #2, U.S. #3

- "Competitiveness": the "set of institutions, policies and factors that determine the level of productivity of a country"; level of productivity "sets the level of prosperity that can be earned by an economy"

- #1-1 1) -- Pillars of Competitiveness -- Basic Requirements –key for "Factor Driven Economies":
  - Institutions (state of country' s public institutions)
  - Infrastructure
  - Macro-economies (quality of macroeconomic environment)
  - Health and primary education – etc.
- 2) Efficiency Enhancer - key for "Efficiency Driven Economies" s:
  - Higher education and training
  - Market efficiency
  - Technological readiness
- 3) Innovation and Sophistication –key for "Innovation Driven Economies":
  - Business sophistication
  - Innovation capacity

Global Competitiveness:

- Key for **Factor Driven Economies:**
  Pillars -
  - Institutions
  - Infrastructure
  - Macro economic environment
  - Primary education/ health
- Key for **efficiency driven economies:**
  Pillars -
  - Higher education/training
  - Goods market efficiency
  - Labor market efficiency
  - Financial market development
  - Technological readiness
  - Market size
- Key for **Innovation-Driven economies:**
  Pillars -
  - Business Sophistication
  - Innovation

World Economic Forum Competitiveness Rankings, Con' t.:

- **"Sustainable Competitiveness Index"** – ("sustainable" feature was new in '14-'15; previous surveys focused on underlying microeconomic conditions defining current level of productivity - accounts for 80% of GDP differentiation):
  - Human Capital – education; health; social cohesion
  - Market Conditions – labor market efficiency; financial market development; market size; good market efficiency
  - Technology and Innovation: technological readiness; business sophistication; Innovation
  - Policy Environment and Enabling Conditions: institutions; infrastructure; macroeconomic environment; environmental policy
  - Physical Environment: resource efficiency; management of renewable resources; environmental degregation

World Economic Forum – Competitiveness Rankings, Con't

Previous **measures of "Business Competitiveness":**

- 1) Microeconomic strength/competitiveness
- 2) Competitive strengths and weaknesses in terms of -
  - In business environment
  - In company operations and strategies
- 3) Sustainability of countries' current level of prosperity
- *Overall* - this index looks at - sophistication of operating practices and strategies of companies and
- Quality of microeconomic business environment where companies compete.
- Underlying Idea: microeconomic factors/impediments needed to benefit from macroeconomic conditions.

World Economic Forum Competitiveness Rankings, Con't -

- So: World Competitiveness Index –Factors Include:
  - Human capital
  - Labor and financial market efficiency
  - Openness and market size
  - Quality of infrastructure
  - Etc.
- Q: are the Competitiveness Rankings looking at the right factors??
- Compare: Solow, Romer, Nelson

2015-16 Ranking, Con't – U.S. = #3

- Note: November *'07 (prior to '08 recession):*
  - The World Economic Forum (based in Geneva) issued its latest "Global Competitiveness Index."
  - That year the U.S. rebounded from 6th place from last year to regain its status as the world's most competitive economy. *Reasons:*
  - Thanks to "strong innovation and excellent universities." The Forum indicated a critical factor boosting the U.S. ranking was the collaboration between universities and business on research and development.

1) Robert W. Rycroft (GWU) & Don E. Kash (George Mason U), Innovation Policies for Complex Technologies (Issues in Science and Technology, Fall 1999)

- **EXAMPLE**: DIRECT? INNOVATION FACTOR: – ORG. OF SYSTEM – NOW REQUIRES NETWORKING

2) Complex Technologies and Innovation Org.- Basic Points:

- Complex technologies drive economic performance now
- Turn the "lone inventor in the garage" into a myth
- Undermine traditional focus of US technology policy on R&D at particular institutions and on open markets
- Innovation policies need to be reformulated to include a self-conscious networked learning environment

3) Complex Technologies Force the the Innovation System to Network:

- Complex technologies dominate world exports:
  - 1970 – complex technologies = 43% of top 30 most valuable world exports
  - 1995 – complex technologies = 82%
- With rise in complex products, rise in complex organization networks to create them – firms, univ's, gov't research and agencies
  - 1988-92 were 20,000 corp. alliances in US
  - Since '85 – alliances grew 25% annually
- As product complexity grows, need for innovative networks grow in parallel
- **Technological progress requires that networks for learning, integrating and applying a wide variety of both new science and tech knowledge and "know-how"**

4) Complex Technologies Force New Learning Environments:

- Rep. George Brown, former Chairman, House Science Comm: US has " excessive faith in the creation of new knowledge as an engine of economic growth and a neglect of the processes of knowledge diffusion and application"
- Innovation Networks have special education needs – how to function in groups, teams; how to create "sociotechnical systems" of individuals and groups
- Need for shared network learning
- Need "institutional engineering" to convince regulators, legal system, etc., to encourage collaboration
- "continuous co-evaluation between complex organizations and technologies is the [new] norm"

5) New Kinds of Network Learning for Complex Technology Innovation:

- Need "**learning by doing**" –learning factory for conscious network experimentation
- Need "**learning by using**" – collaboration with potential users, including, esp., "lead users"
- Need "**learning from sci/tech advances**" – networks to understand advances in diverse but potentially related areas – intelligence system for emerging science and technology (S&T)
- Need "**learning from spillovers**" – for reverse engineering, or from leakage of knowledge
- Need "**learning by interaction**" – build competence in interaction so collaborative, interactive learning throughout network

Example: Indirect Innovation Factor – Accounting Systems

- Source: National Innovation Initiative (Egils Milbergs), Valuing Long Term Innovation Strategies Chapt. (10/12/04 draft)
- Old economy – management of "tangible assets" – plant, land, equipment, physical resources, inventory
- 21st Century - New economy – intellectual and "intangible" assets key
- But: accounting systems, which drive transparency and investment valuation, still measure the old "tangible" economy
  - Undermines the willingness of firms to invest in innovation
  - Limits investment flow into innovation because investors can't measure actual value just short term profit

Accounting for Intangibles, Con't

- By Late 90's – Investment in Intangible Assets:
  - $1 Trillion/year in R&D, business processes, software
  - Compare to: $1.1 Trillion invested in tangible assets in manufacturing sector
- Intangible Capital:
  - 82% of US firms' market value is in intangible assets (2002 Accenture study)
  - Was 38% in 1982,
  - Was 62% in 1992)
- Significant positive correlation between US firms with intellectual capital disclosure and high market capitalization
- Need new metrics for how firms invest in:
  - Qualitative innovation factors, that are
  - Sustainable for the long run

Accounting for Intangibles, Con't.

- Need new metrics:
- We now have:
  - Total company R&D investment
  - Company patent filings
- We don't have data on:
  - Customer satisfaction
  - Customer relationships
  - IT investment
  - Employee's ongoing education
  - Employee recruitment
  - Incorporation of advancedBusiness Processes
  - External research access
  - Participation in technology alliances and networks with other firms, Univ's, Gov't agencies
- Note: intangible assets subject to rapid value dissipation – ex.: inadequate recognition and compensation so lose key scientists/engineers

EXAMPLE – INDIRECT Innovation Factor – VENTURE CAPITAL

- Source: Udayan Gupta, "Done Deals" (Harvard Bus. School Press 2000)
- US Venture capital growth:
  - $30 Billion in 1999
  - $ 3 Billion in 1990
  - Now: 5000 venture capital entities and firms [In 2015 VC= $60B]
- Venture capital first built on idea that *introducing new technologies delivers much higher investor returns* than stock market

**Note chart on returns on radical vs. incremental innovation (slide 7)

Venture Capital, Con't

- VC – arose post-WW2 with nascent high tech sector – 2 patterns:
  - East Coast Model – financial engineering – less co's long term success than tax benefits and short term returns (funds Route 128 Boston)
  - West Coast Model – science and technology driven – sought new economy and new entrepreneurial culture (funds Sand Hill Rd., Silicon Valley)
- Entrepreneurial Capital Models:
  - Old: equity or debt and equity in a VC fund – return when IPO or acquisition
  - Now: VC fund, angel investors, corp. venture funds, foundation funds, Univ endowment funds
  - No longer early stage only– now, esp. on East Coast, late stage, buyouts, turnarounds, roll-ups, consolidations in addition to early stage

Venture Capital, Con't

- VC Origins: General Georges Doriot – French-born, taught at Harvard Bus School - developed first principles of entrepreneurship, '40's-'50's
- East Coast VC Origins:
  - SBIC (Small Business Investment Company) Act – Eisenhower Admin., '50s – venture funds match 3 to 1 with SBA funds – but gov't pressure against risk-taking with taxpayer funds
    - Shunned partnership model of successful VC
- West Coast VC Origins:
  - Maverick model – high risk on unproven technology
  - Pattern: fledgling technology, nurture scientists, get proof of principle, build co., build products
  - West Coast led the way in tech start-ups

Venture Capital, Con't.

Future of Venture Capital:

- Will be anchored in technology because of the "scalable nature of technology" ie, it's ability to defy conventional financial analysis
- VC rather than inflexible regular markets will fund innovation because innovation is time intensive not capital intensive, and capital can't substitute for time if you want sustainable co's.

The Debate on the Gov't's Explicit Innovation Role – A Classic View:

This image is in the public domain.

- Text: **Charles L. Schultze**, "Industrial Policy: A Dissent" (Brookings Review, Fall 1983)
  - – Lyndon Johnson's Budget Director and Jimmy Carter's CEA head
- Issue: Gov't INDIRECT/Implicit Innovation role widely accepted, and DIRECT/Explicit Gov't Innovation role is too (ie, in education, basic research). Problem area is more direct gov't support for industrial R&D. Schultze looks at this problem in the early 80's competitiveness crisis
- 1980 US Competitiveness concern with Japan and Germany:
  - concern that US was "de-industrializing"
  - mfg. share of national output was falling
  - "essential" US heavy industry in decline

Debate on Gov't Explicit Role, Con't

- 80's Concern: US not at cutting edge of technology advance
  - US Markets not directing investment to critical places part of the economy
  - Promising new firms can't secure capital
  - Proposal at the time was US "Industrial Policy"
- Comparison: Japan – the US perception:
  - Had government policies that promoted strong growth
  - Identified "winners" in world market competition and promoted their growth via MITI (now METI)
    - Ex: dominating world auto markets, 256K DRAM (memory) chips

Debate on Gov't Explicit Role, Con't

Early 1980's Proposed US Solution:

- US Industrial Development Bank – business, labor, gov't on board
  - Would "pick winners" – identify and support cutting edge industries with high-growth and high-value jobs
  - Would protect "losers" – lend funds to rehab failing major industries
    - Proposed: barriers against imports, special tax breaks, subsidized loans, favorable regulatory treatment, labor-management reform (wage restraint, man. Improvement, end of featherbedding labor rules)

Debate on Explicit Gov't Role, Con't

- But -- Schultze says US not De-Industrializing
  - <u>Manufacturing percentage of US economy was stable</u>
  - <u>Japan was successful</u> because of broad <u>gov't macro policies</u> not gov't run "industrial policy"
  - ***US <u>gov't is not able to select a winning industrial structure</u>***
  - ***American <u>political system can't efficiently choose between individual firms and regions for funding support</u>***

Debate on Explicit Gov't Role, Con't

- Schultze's View of Japan's Remarkable Success in the 80's:
  - Gov't encouraged large private savings by tax laws
  - Stimulative monetary policies based on large budget surpluses
  - Protected large part of home market against import competition [good idea?]
  - Japan's key to success: vigorous firms prepared to take risks in pursuing exports
- Schultze - Japan's Industrial Policy elements:
  - $80B in 1980 in direct investment, subsidized loans & loan guarantees to industry– but spread among wide range of firms, regions
  - Japan Development Bank – ¾'s of funds to shipping, elec. utilities, urban dev. – traditional infrastructure
  - MITI: did support auto and memory chip penetration
    - But - tried to create an "auto big 3" and block Honda; tried to enter aerospace and failed
- So- Japan's '80's industrial policy limited

Class Two Wrap-up:

- Innovation is an ECO-SYSTEM
- There are Explicit/Direct and Implicit/ Indirect Innovation Factors
  - Direct/Explicit – R&D (Solow), Talent (Romer)
  - Nelson – third of great Growth Economists: looks at Direct/Explicit Innovation Actors:
    - Strong Innovation Firms via Industrial R&D – most important!
    - Univ. R&D
    - Gov't Labs
    - Public Sector support for Industry R&D – but issues
  - Nelson - Science as Technology Leader and Follower – creative interaction
- Rycroft and Kash – complex technologies = collaboration and networked learning – new Explicit Innovation keys

Wrap-Up, Con't.

- Indirect/Implicit Innovation Factors – long list, gov't and private sector roles – from Intellectual Property to Management
- Indirect/Implicit Innovation Example: Accounting for Intangibles – *Egils Milsburgs*
- Indirect/Implicit Innovation Example: Venture Capital – *Udan Gupta*
- Indirect/Implicit Innovation Example: Fiscal Policy
- What should the Gov't Direct/Explicit Innovation role be? *Charles Schultze* – not "Industrial Policy" - inefficient