Class Six – Crossing "The Valley of Death" Between Research and Development: The Public-Private Partnership

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"Innovation Systems for Science, Technology, Manufacturing, Energy and Health"

STS.081/17.395 - MIT

Overview of Class 5:

- David Hart – ideologies of US innovation
  - Associationalist vs. conservative vs. nat'l security
- Alfred Loomis – the Rad Lab as the ancestor – the FFRDC
  - Flat, non-hierarchial, teams,cross-disciplinary, collaborative, keep out of the services and civil service
- Vannevar Bush – Endless Frontier – the Pipeline Model – linear
  - Created the Federally-Funded Research University – but Basic Research. only >>> Many tents not one
  - A disconnected system – R separated from D
- Peter Singer, 22 Examples of Federal R&D
  - Basic R&D has yielded massive tech development

Overview of Class 5, Con't

- William Blanpied – NSF
  - Truman veto decentralized federal R&D
  - Steelman Report – pushed NSF much more into an integrated role – not Bush's "leave science alone" approach
  - More Associationalist than Conservative
- Donald Stokes – Pasteur's Quadrant
  - V.Bush saddled us with a disconnected system
  - Oriented to fundamental research
  - But missed a stage - use-oriented basic research – Pasteur's Quadrant
  - Being conscious of this quadrant should enable us to reorganized our R&D approach

Lew Branscomb & Phil Auerswald

Image courtesy of Joi Ito on Flickr.

- Lew Branscomb-Prof. Emeritus, Kennedy School, Harvard.; VP & Chief Scientist – IBM; Director of NIST; physicist – atomic and molecular ions; NSF's V.Bush Award winner
- Phil Auerswald–Ass't Prof. at George Mason-> Branscomb's student & collaborator at Harvard

LEWIS M. BRANSCOMB & PHILLIP E. AUERSWALD, BETWEEN INVENTION AND INNOVATION – AN ANALYSIS OF FUNDING FOR EARLY-STAGE TECHNOLOGY DEVELOPMENT (Commerce Dept., NIST Report GRC 02-841, 11/2002)

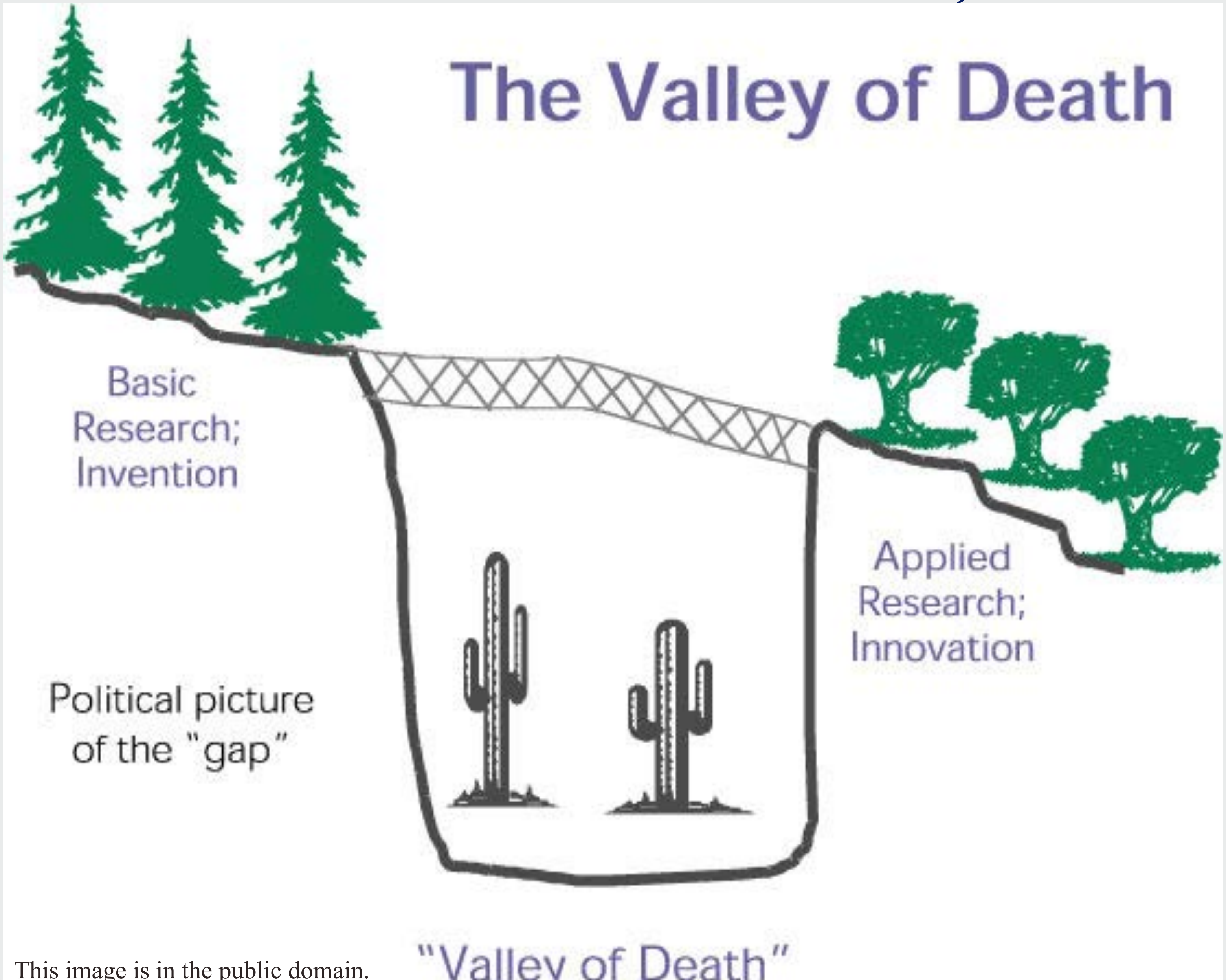
- FINDINGS:
  - 1) Funding for technology development in the stage between invention and innovation comes from:
    - Individual private-equity "angel" investors
    - Corporations
    - Federal gov't programs
  - Does NOT come from Venture Capital

Branscomb & Auerswald, Con't

FINDINGS, CON'T –

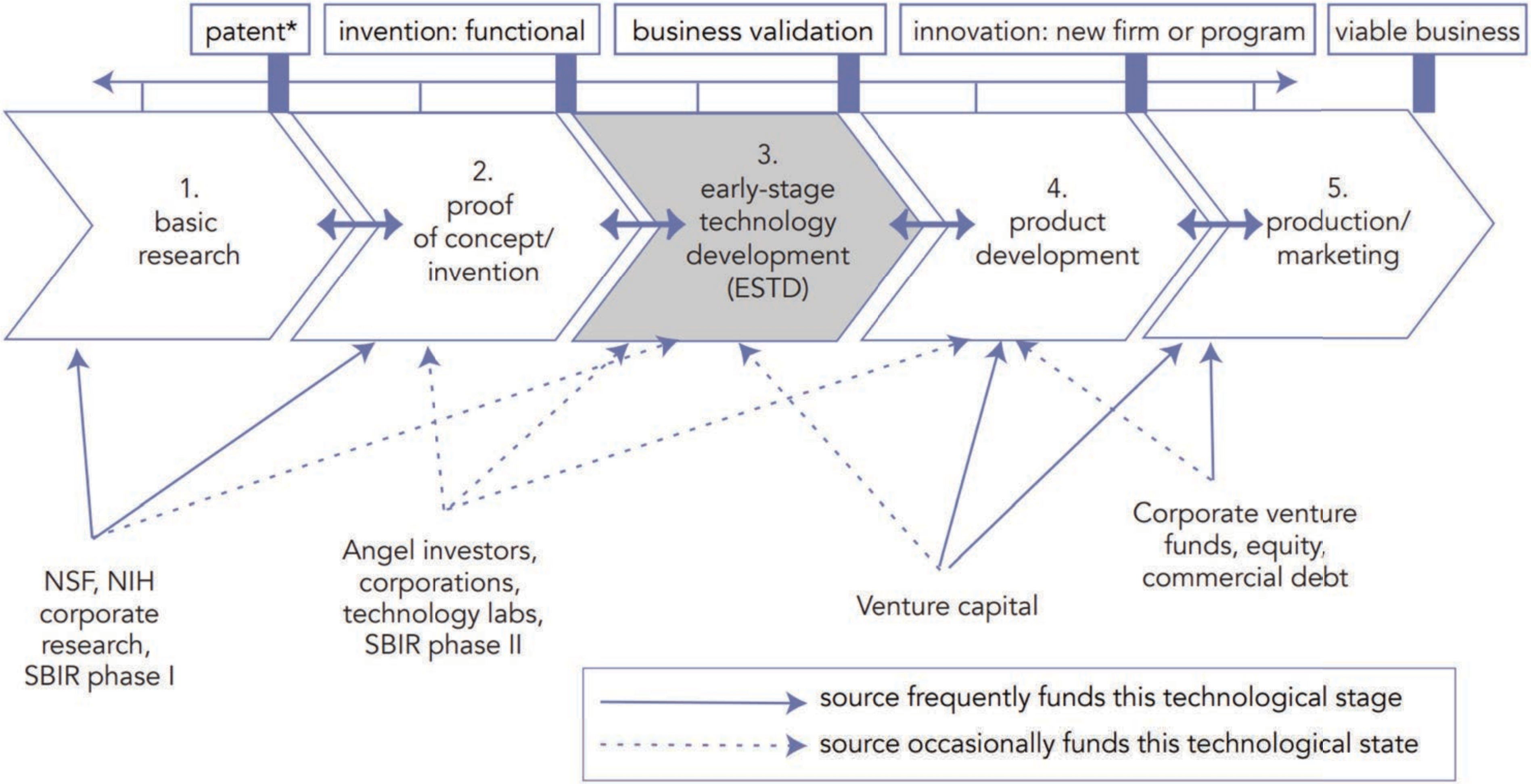
- Markets for allocating capital to early-stage tech ventures are NOT efficient
- In response to these inefficiencies, institutional arrangements have evolved for early stage funding
- Conditions for success in science-based tech innovation are concentrated in a few geo. areas
- Innovator-investor proximity req'd
- Federal role in early stage tech transition is very significant
- Fed. tech development funds complement and don't substitute for private funds

Branscomb & Auerswald, Con’t



Branscomb & Auerswald, Con't- The Linear Model

FIGURE 2. Sequential model of development and funding

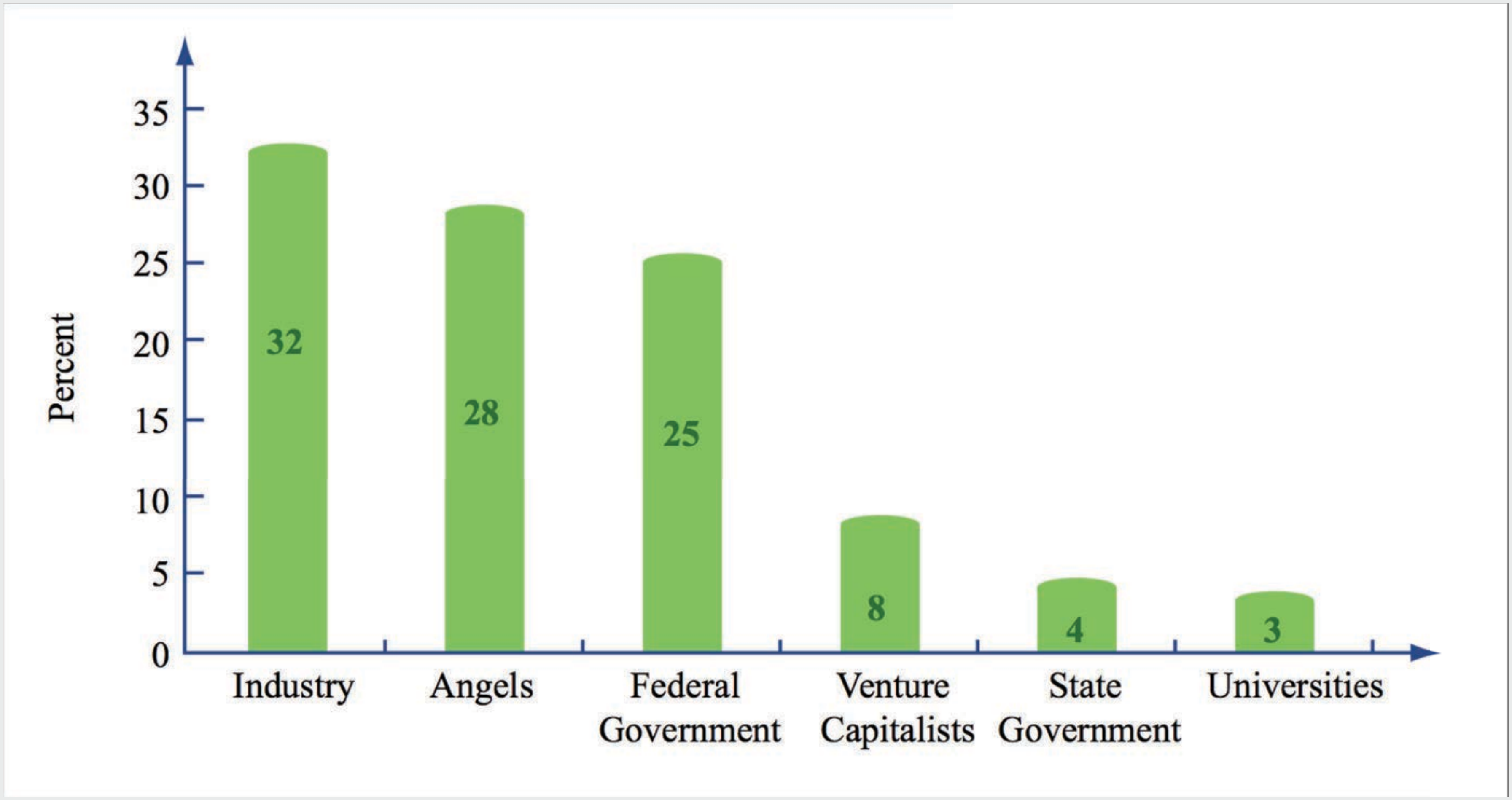


Branscomb & Auerswald – The Linear/Pipeline Model, Con’t

- The linear model is unrealistic – “the actual pathway included multiple parallel streams, iterative loops through the stages, and linkages to developments outside the core of any single company”
- realistically, “patents occur throughout” the phases
- The top line of the chart does not capture “the full range of exit options, the alternatives and branches of where projects go, and what happens to them”
- “Darwinian Sea” of interaction between R and D and development stages better term ---

Branscomb & Auerswald, Con't

Branscomb & Auerswald, Con't
Funding Sources – Early Stage Technology Development ($5-$36B):



Branscomb & Auerswald, Con't

- Early stage tech development: product specs for an identified market are developed and production processes are reduced to practice, defined, and product cost established. So in this stage: Invention turned into prototype(s), engineering design, design for mfg., and product market set.
- Venture capital funding is spent on product development and business development not early stage tech development
- Between \$5B (2%) and \$36B (14%) of overall US R&D spending was devoted to early stage tech development – the 2 numbers were modeled based on different definitional "early stage" interpretations

Branscomb & Auerswald, Con’t

- ***Corporate Innovation:*** Generally has to be within firm’s core business
- focused on incremental innovation, rarely radical innovation
- Corporate management tends to drive investment toward products where the commercial case is stronger – i.e., incremental R&D in core business
- Outsourcing R&D: Corp’s increasingly using external alliances/partnerships/consortia – more reach for less money and risk, enabling early stage investment justification
- Some corp’s establish their own venture funds to locate and support innovation outside firm

Branscomb & Auerswald, Con't

- OTHER PLAYERS:
- Univ's – 19 have own venture capital funds to push Univ. research to commercial range; use Bayh-Dole Act (Univ. holds patent for federal R&D it conducts)
- States: a few starting commercialization funds
- Angels–initially family members, friends; now "Band of Angels" and solo professionals
- Federal – strongest programs: SBIR, ATP

Vernon W. Ruttan, is War Necessary for Economic Growth? (2006)

Ruttan, Con't

- **INTERCHANGEABLE MACHINE MADE PARTS - CHAPT. 2**
  - Mfg. goes from 10% of US commodity production in 1800 to 50% by 1900
  - "The American System" is key
  - 1797 War Dept. bought arms from private contractors - Washington substituted arsenals - esp. Springfield, Mass. and Harpers Ferry, W.Va
  - Mfg. was a handicraft process; armies had logistic tails of blacksmiths and armorer trains
  - Eli Whitney story - 1798
    - - bogged down in patent litigation over his cotton gin, turns to War Dept. musket contract - early industrial bailout
    - - proposes interchangeable machined parts
    - - invents cost plus contracts and massive cost overrun
    - - right idea but doesn't have the machine tools yet
    - takes 11 years to deliver - and not interchangeable parts

Ruttan, Con't

- Next Key Figure - John Hall of Portland, Me.
  - Develops early breech-loading rifle
  - Becomes armorer at Harper's Ferry and develops the machine tools to build interchangeable musket parts
  - War Dept. goes to second private contractor using Hall's system - parts made in Middletown, Conn. for rifle can be interchanged with Harper's Ferry parts
  - System copied all up and down Conn. River Valley - for clocks, guns, simple machines
  - By 1850 English industrialists visiting US - trying to understand "American System"
  - Leadership in industrial revolution shifts from Britain to US
  - By the end of the 19th century US factories attain high volume production - Colt's is model for Henry Ford
  - Only Army had resources and risk timetable to stand whole new system of production

Whirlwind - 1st real time, magnetic core memory, CRT/keyboard computer, networked over phone lines

Photograph of Whirlwind computer has been removed due to copyright restrictions.

Photograph of Whirlwind technicians has been removed due to copyright restrictions.

Ruttan, Con' t

- **DOD STANDS UP COMPUTING - CHAPT. 5**
  - DOD funds the first all digital computer - ENIAC in 1946 at Penn
    - for calculating the artillery firing tables
    - Used in calculating hydrogen bomb ignition
    - John Van Neumann architecture - CPU pulls instructions from central memory
    - UNIVAC 2nd gen does the '50 census
  - Whirlwind and Sage at MIT
    - George Valley of MIT convinces the USAF that US is defenseless against air attack and needs radar defense - SAGE
    - Jay Forrester of MIT was developing Whirlwind computer for Navy' s ONR as flight simulator - but Navy winds it down
    - Valley sees that Whirlwind can provide real time processing for SAGE system
    - Whirlwind - First real time computer - not just fast calculator
    - Operators sit in front of CRT' s with keyboards inputting data and making commands - use light pen (mouse)
    - SAGE messages over phone lines (internet) - networked

Ruttan, Con’t

- **Semiconductors**
  - transistors at Bell Labs - w/initial DOD contracts (Bardeen, Brattain, Shockley) - fundamental advance and technology advance simultaneously
  - Next two big steps - Integrated Circuit (TI-Kilby)and Fairchild Semiconductor - Kilby and Noyce
  - The Microprocessor (Intel - Noyce)
  - Both DOD & NASA purchase - Minuteman and Apollo
  - Lithography - backed by DOD
  - Sematech - recovery of US sector in 80’s DARPA backed
- **Supercomputers**
  - Nuclear and missile design and ballistic tracking requires supercomputing
  - Cray machines - DOD, DOE labs was the market
  - To this day, market for supercomputers is DOD, DOE labs (“stockpile stewardship”) IBM and Cray successor

Ruttan, Con't

- ***Software***
  - *As late as the 80's DOD is the largest purchaser of software in the US*
  - *DOD role in software is through DARPA creating the first computer science dept's (at MIT, Carnegie Mellon and Stanford, then others) - software programming is the initial heart of the curriculum - different pattern from role in computing and semiconductors*
  - *Software has yet to follow the productivity curve of computing and semiconductors*
- ***Personal Computing and the Internet***
  - *We will study but DOD builds these (Chapt. 6)*
- ***Other 20th Century DOD tech revolutions:***
  - ***Aviation, nuclear power, space***

Glenn Fong, "Breaking New Ground or Breaking the Rules" (2000)

- Former White House Chief of Staff John Sununu – "We don't do industrial policy."
- Federal tax incentives, subsidies, credits, etc. to business: $100B/year
- Nine case studies of US "industrial policy"-
  - **DARPA:** ARPANET, Sketchpad (graphics), Strategic Computing Program (micorelectronics, VLSI, parallel processing, AI), Sematech, Advanced Lithography Program
  - **Undersec of Def. for AT&L:** VHSIC (Very High Speed Integrated Circuit Program – advanced data signaling), National Flat Panel Display initiative (NFPDI)
  - **Multiagency**(11 agencies incl. DARPA): High Performance Computing Computing and CommunicatonsProgram (HPCC)

  - **Commerce (NIST)**: Advanced Technology Program

Glenn Fong, Con't

- Cases demonstrate increasing capability of governmental industrial policies – federal ability to craft major tech advances
  - IT sector the nation's largest output sector in 2000 – 8% of US output, 7.4m ee's, 64% higher wages, cause of 45% of US industrial growth in the 90's
  - The 9 case studies - leading edge of US IT advances over 3 decades
  - Economic policy and academic communities: no confidence in gov't ability to shape industrial growth – but look at the 9

Glenn Fong, Con't

- Except at DOD: basic gov't role is basic R&D and mission agency R&D
  - market failure justification for this: high-risk, uncertain, long term nature of research means private sector can't appropriate gains and manage the risk
- But: "The US gov't has had a technology policy by default since WW2, based on "trickle down spinoffs from military research…" – Mary Good, UnderSec of Commerce (Clinton Admin.)

Glenn Fong, Con't

- **Models for Intervention:**
  - **By-product model**: military R&D unintended spillovers into commercial sector (Sketchpad, ARPA-NET)
  - **Intentional Spinoff Model:** commercial spinoffs expressly contemplated during program planning and implementation (VHSIC, Strategic Computing)
  - **Explicit Dual Use Model:** defense tech project have explicit goal of meeting commercial and military needs (HPCC, Advanced Lithography)

Glenn Fong. Con’t

- **Models for Intervention at DOD – con’t:**
- **Industrial Base Model:** retain industrial base on commercial side to assure military benefits (Flat Panel Displays, Sematech [and as of 2012-16: Manufacturing Institutes])
- Re: Economic Competitiveness: there hasn’t been a clear national security rationale; one non-DOD program of support for commercial technology advances – ATP, ended in 2007

Rick Yannuzzi, In-Q-Tel: A New Partnership Between the CIA and the Private Sector 2001

- CIA in the 90's saw that it was falling behind both its understanding of and ability to utilize IT
- Ruth David, former CIA Deputy Director for Science and Technology, saw the IT revolution and designed a unique CIA response – In-Q-Tel
- Essentially, it was a Venture capital firm owned by the CIA, aimed at the early stage of tech development

Yannuzzi, In-Q-Tel, Con't

- CIA not new to tech. development – U2 and SR-71 reconnaissance aircraft (USAF contract agent, Lockheed contractor) and spy satellites
- CIA being "left behind," not connected to the "creative forces" building digital economy
- Could not compete with private sector for creative talent
- Had little understanding of the exploding Internet communications medium

Yannuzzi, In-Q-Tel, Con' t

In-Q-Tel Structure:

- In-Q-Tel founded as private sector non-profit firm by Norm Augustine (ex-Lockheed CEO)
- CEO from Silicon Valley VC
- Talented Board of tech & business experts
- Bd. Tied to IT innovators, academic researchers, VC firms, tech co' s; 30 ee' s from these sectors
- Can establish:
  - Joint ventures (ie, can co-own companies–big change)
  - Fund sole source grants
  - Set up open competitions
  - Award sole-source development contracts
- CIA does not review its business deals
- Collaborates with CIA but independent

Yannuzzi, In-Q-Tel, con't

Aims of In-Q-Tel:

- "Agile" – respond fast to CIS needs, commercial imperatives, tech opportunities
- "Problem-driven" – challenge system for R&D
- "Solutions-focused" – applied development, wants new technologies and products – has IT roadmap
- "Team-oriented" – diverse sectors/elements brought together to solve problems
- "Technology aware" – leverage and integrated technology solutions to CIA needs
- "Output measured" – quantifiable results
- "Innovative" – move beyond state of the art IT
- "Reduce reliance over time on CIA funding" - 1st year budget - $28m

Yanuzzi, In-Q-Tel, Con't

In-Q-Tel's "Space":

- Data warehousing and data mining
- Knowledge management
- Profiling Search Agents
- Geographic information system
- Imagery analysis, pattern recognition
- Statistical data analysis tool
- Automatic language translation
- Mobile and secure computing
- Info security – strong encryption, data integrity, authentication and access control, secure digital signatures, etc.

Yannuzzi, In-Q-Tel, Con't

<u>In-Q-Tel represents a completely new federal gov't development stage model:</u>

- Gov't forms a private sector firm to engage in Venture Capital support for early or later stage development in sectors supporting agency mission
- Aim is to leverage and tilt ongoing tech development for agency mission
- Potentially far more intrusive in the marketplace than ATP or SBIR
- But – in David Hart's term, clear "National Security" rationale operating here

WB Bonvillian, The New Model Innovation Agencies (Science & Public Policy 2014)

- 5 Periods of U.S. Science Organization:
  - From a "connected model in WW2 to a disconnected model in the Postwar
- Fundamental divide in design of US R&D agencies
  - "Connected" model in the wartime period
  - "Disconnected" postwar model
    - Subsequent decades: reconnect

- 5 Periods: Postwar
- Sputnik
- Competitiveness
- Energy
- Advanced Manufacturing

PERIOD 1: The Postwar

- **Wartime Era 1940-45**
  - Vannevar Bush, Roosevelt’s Wartime Science Czar
  - Highly connected model – research/development/implementation closely connected, as were innovation actors
- **Postwar – the disconnect**
  - Bush proposed basic research-only
  - Writes Science The Endless Frontier
    - Defining document for U.S. Science organization
    - Model for postwar U.S. R&D agencies
    - NSF, DOE OS, NIH, etc.
    - **The pipeline Model sets up the Valley of Death**

PERIOD 2: Sputnik

- Sputnik in 1957 forced US innovation acceleration
- U.S. Dept. of Defense could not take a disconnected model…
  - DOD rebuilt the connected model of WW2 for the Cold War
  - Launched: aviation, nuclear, space, computing, internet – major 20th century innovation waves
  - DOD: Pervasive role at all stages of the pipeline –

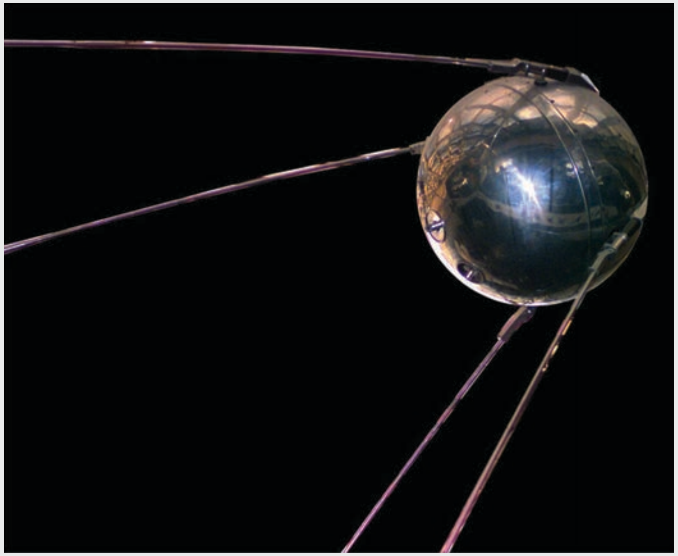


Image is in the public domain.

Period 2: How far down the innovation pipeline does the Federal Government role go?

THE INNOVATION PIPELINE:

Research-> Dev-> Prototype-> Demo-> Testbed-> Production-> Market

NSF, DOE OS, NIH, etc.: →

DOD: →

DOD has a "Connected System"

Period 2: Defense Advanced Research Projects Agency - DARPA

- --- Back to the Connected Model

- DARPA Formed from Sputnik Challenge in 1958

- Mission: Avoid "technology surprise"

- Spurred fundamental military and commercial breakthroughs – high speed computing, internet, precison strike, UAVs, stealth, etc.

PERIOD 3: 1980s COMPETITIVENESS

- From 1973-1991, U.S. economy slowed
  - Historic U.S. GDP growth: ~3%, productivity growth: ~2%
  - 1973-91 – GDP in 2% range, productivity growth below 2% range
  - U.S. had organized its economy around innovation but missed an innovation wave
    - Japan led "quality manufacturing" wave, Germany also production leader
    - U.S. missed it – had to catch up
    - Took a series of innovation system steps

PERIOD 3: 1980s
Competitiveness, Con't.

- The Bayh Dole Act
  - Universities own federal research results
    - Pushed university researchers in pipeline to technology development and company creation.
- The Manufacturing Extension Partnership (MEP)
    - bring the latest manufacturing technologies and processes to small manufacturers.
- Adv'd Technology Program at NIST (ended)
    - tech. commercialization for companies
- SBIR –
    - development support for small co's – "tax" on R&D agencies
- Sematech at DOD – semiconductor mfg. consortia

PERIOD 4:
2000s – PROBLEM OF ENERGY INNOVATION

- DARPA – tends to innovate in defense-supported sectors, and related frontier technology areas
- But: innovation in established, complex, established sector like energy is a much more complicated proposition
- Energy demands drove new organizational model away from Office of Science basic research model toward implementation – ARPA-E

PERIOD 5 ? – ADVANCED MANUFACTURING

- Realizing: Initial Production – highly innovative stage – design, engineering, innovation feedback – it's an element of the innovation process
- Manufacturing is part of the Innovation System – must be better connections
- To keep strong innovation, need manufacturing

Conclusion: The Five Periods:

- Period 1 – Postwar - Moved from "connected" innovation system in WW2 to "disconnected" system with federal research role paramount
- Period 2 – Sputnik – DOD reconnected its innovation system – DARPA model:
  - - "right-left", use basic research capability to enable upfront" research visioning"
  - - Take advantage of launching innovations into Defense innovation system-join Risk/Innovation/Connected
- Period 3 – 80s Competitiveness
  - - Series of models to better connect R&D to"back-end"
- Period 4 – Energy Challenge – ARPA-E model
  - - DARPA Plus approach – deeper into implementation
- Period 5? – Advanced Manufacturing
  - - Manufacturing Institutes – industry/univ./gov't collaboration – testbeds around adv'd mfg. technology

Bonvillian and Weiss, *Technological Innovation in Legacy Sectors* (2015)

- Innovation in Legacy Sectors vs. Frontier Sectors greatly complicates the entry problem for new technologies
- It greatly widens the Valley of Death

"Taking Covered Wagons West"

U.S. is good at the NEXT BIG THING

Don't like your neighborhood?

Take your covered wagon over the mountains to new territory!

This is true in technology –

- The U.S. likes standing up technology in new territory, in open fields - like computing
- We pack our Tech Covered Wagons and Go West, leaving Legacy problems behind

Image is in the public domain.

U.S. Innovations Like to Land in Unoccupied Territory -- ***Legacy Sectors are Occupied Territory…***

- In Legacy Sectors, new technology must ***parachute into occupied territory*** -- and it will be shot at
- U.S.: not good at going ***Back East*** over the mountains
  - - at revisiting established territory and bringing innovation to it - ***we don't do West to East***
  - We do biotechnology, we don't go back and fix the health care delivery system
- ***Yet huge economic and environmental gains,*** not just from the new but fixing the old

Can we innovate our way out of our big 21st Century problems?

- The big problems –
  - Climate and Energy – including food and water
  - Jobless Innovation
  - Health care delivery
  - Improve Education/address inequality
- To do this we have to confront our Legacy Sector barriers
  - These are "hidden in plain sight"
  - To solve our big public challenges, we have no other move …
- So how do we do it?

Bringing emerging technologies into Legacy Sectors is not "*Mission Impossible*" --

- Areas where innovation has transformed Legacy Sectors:
  - The "Revolution in Military Affairs" in the Defense Sector in the 90's
- Sectors where we now see the potential for new innovation – but many challenges remain:
  - Advanced manufacturing
  - New energy technologies
  - "Intelligent" cars
  - Online education
  - Commercial space

Take-home Lessons:

- Obstacles to disruptive innovation in legacy sectors hinder innovations that would address environmental issues
  - Innovation is not restricted to cutting-edge "***shining lights***"
- The barriers to environmental innovation in disparate ***Legacy sectors have much in common*** and are found in the ***U.S. and in foreign economies***
- Encouraging innovation in Legacy sectors requires ***attention to the entire innovation process***.
  - This includes both **support to R&D** and **policy and institutional measures** to anticipate and confront **barriers to scale-up and market launch.**
- The economic, political, cultural, social, and legal ***context of innovation can be as important as the innovation system***

Entrenched Legacy Sectors Resist Disruptive Innovation

Legacy Sector Characteristics:

- Provide incentives to producers that **do not align with societal objectives**
- Are defended by **technological/ economic/ political/ social/cultural/legal paradigms:**, and by numerous **market imperfections**
- These enable **resistance to disruptive innovation**

Innovations in Legacy Sectors:

- Face **no special obstacles IF they fit the paradigm**
- Face **high obstacles** if they do **NOT** fit prevailing business models–
  - -- especially if driven by externalities
- So the obstacles to innovation in these sectors are also obstacles to environmental innovation
- These obstacles **are defended by powerful vested interests** and share **common features**
- Governments sometimes inhibit innovation and sometimes guide it into desirable directions.

The Features of a Legacy Sector:

Legacy Characteristics:

- Perverse prices that do not reflect externalities
- Established infrastructure
- Public expectations
- Career paths and university curricula favor oil, gas, coal
- Regulatory requirements place obstacles
- Limited R&D compared to revenue
- **All defended by powerful *vested interests***
- ***Constitute "technological/economic/political/social" paradigm***

Market Imperfections Hindering New Technologies & Renewables:

- Perverse subsidies
- Network Economies
- Non- Appropriability
- Lumpiness
  - minimum investment size
- Need for collective action
  - (for new Infrasturcture, research)
- Short time horizon of venture financing
- ***In contrast, Paradigm-Compatible innovations (e.g., fracking) expand smoothly***

Five Models of Innovation Dynamics

-- **Legacy sectors create barriers to innovation – *understanding them helps us to choose policy instruments to overcome these barriers*.**

1. The Pipeline -

- Technology-Push, Technology-Supply
  - Federally supported research pushes basic research
  - New technologies develop and push into markets
- Dominant model underlying US innovation policy

2. Induced -

- Technology-Pull, Demand-Pull
- Industry spots market niche
- Technology advances (often incremental) are pulled to meet demand
- Innovation can be induced by changes in markets or policy - gov't regulations, incentives, prizes

Models of Innovation Dynamics, Con't

3. The Extended Pipeline - *NEW*

- Technology-Push
- But Government technology support at every stage
- Defense Department support to R, D, demonstration, testbed, initial market creation

4. Manufacturing-Led Innovation - *NEW*

- Initial production can be highly innovative –
  - Design a product to fit a market, redo the science, highly creative engineering
  - Example – Japan's creation of Quality Manufacturing
  - An important but underappreciated source of innovation

Models of Innovation Dynamics, Con't

5. Innovation Organization – *NEW*

- Encompasses the four other models
- Goes beyond them to take account of broad context and structure into which innovation is to be introduced
- To innovate in legacy sectors, need all four models,
- Need *change agents* to orchestrate the full innovation environment and the actors within it to address new technology and broader policy and institutional issues

→ *Manufacturing has not been considered a source of innovation;*

→ *Three of the Five models involve a major government role*

Summary of the Five Models

- Pipeline: Support research; innovation will follow: Tech-Push.
- Induced: Change prices (or policies); innovation will follow: Tech-Pull.
- Extended pipeline: Government supports not only research, but also demonstration, testbed, and initial market creation.
- Manufacturing-led: Design and initial production of a manufacturable, marketable product require creative engineering.
- Innovation organization: Research support, policy and institutional change are needed for an innovation context that poses obstacles to innovation scale-up.
  - Must apply all 4 dynamics for a legacy sector.

Implications of these Models for Spurring Innovation in Legacy Sectors:

- Active government role:
  - Support research on disruptive technologies
  - Remove obstacles to market launch
- Need to support -
  - The "front end" of the innovation process: R&D
  - The "back end" of the innovation process -- demonstration, testbed, manufacturing, market launch
- Manufacturing as an important source of innovation and jobs

Launching Innovation into Legacy Sectors:

A Five-Step Framework

Step 1: ***Strengthening the Front End*** of the Innovation System

- No innovation without innovations
- Form critical innovation institutions,
- Build a "thinking community" to build and support ideas,
- Link technologists to operators,
- Create "connected science and technology" – links between front and back end stages and actors
- Use the "island bridge" model exemplified by DARPA -- put innovators on a protected island but linked to decision makers

Launching Innovation in Legacy Sectors (2)

Step 2: Identifying the Launch Paths for Emerging Technologies

Step 3: Matching Support Policies to Technology Launch Pathways

Step 4: Analyzing Gaps in the Innovation System

- Ex's – ARPA-E, Adv'd Manufacturing Institutes

Step 5: Filling the Gaps in the Innovation System

Launching Innovation in Legacy Sectors (3)

The Role of the <u>Change Agent</u>

- Innovation in legacy sectors requires *<u>orchestration</u>*:
  - institutions and individuals prepared to intervene in legacy systems
- They must apply the "Innovation Organization" Model

How do we know these steps work in Legacy Sectors?

- These steps were way DOD did "Revolution in Military Affairs"
- Also the essential design behind Advanced Manufacturing initiatives and recent Clean Energy Initiatives

Summary of Class 6 Points:

- The Backdrop: the Donald Stokes – Pasteur's Quadrant critique –
  - Vannevar Bush's linear/pipeline model is inaccurate portrayal of development process
  - Science is interactive between basic and applied – each contributes to the other
  - Science organization requires interaction between these two elements for progress
  - Federal support for Basic alone created dysfunctions in US R&D support system
  - contributed to continuing disconnect between US discovery and commercialization

Class 6 Summary, Con’t

- Branscomb &Auerswald – Between Invention and Innovation:
  - There is a “market failure” because of information shortfall for early stage technology development
  - “Valley of Death” (linear view) vs. “Darwinian Sea” (dynamic view)
  - Venture Capital funds the initial production stage not the development stage
  - Other players – gov’t is the overwhelmingly dominate research funding source
  - Corp’s, Angel investors and Gov’t (ATP, SBIR, DARPA in its initiative areas, etc.) dominate funding of early stage technology development

Summary of Class 6 Points

- Vernon Ruttan -
  - DOD played profound role an nearly every stage of major technology advance of 20th century
    - Interchangable machine made parts
    - Aviation
    - Nuclear power
    - Computing/semiconductors/software/super-computing
    - Personal Computing/Internet
    - Space
  - DOE does connected science (largely through DARPA for computing) - supports R,D, prototyping and serves as initial market

Class 6 Summary, Con’t

- Glenn Fong – Breaking New Ground or Breaking the Rules –
  - DOD practices “technology policy” in critical IT areas
  - US Tech Policy - Uses 5 models:
    - By-Product Model
    - Intentional Spin-Off Model
    - Explicit Dual-Use Model
    - Industrial Base Model
    - Economic Competitiveness Model

Class 6 Summary, Con't

- In-Q-Tel
- Completely new and potentially far more intrusive gov't model
  - CIA formed venture capital private sector firm aimed at early stage IT tech development
  - Can form joint ventures (w/shared ownership) with private sector firms as well as form consortia and give grants to firms (the more traditional federal approach in SBIR and ATP)
  - To be self-sustaining through profits over time
  - This profit-making and ownership return approach marks major changes in the federal role
- Bonvillian – New Model Innovation Agencies
  - New entities driving towards later-stage implementation role: energy/adv'd mfg.

Class 6 Summary, Con't -- Bonvillian and Weiss, Legacy Sectors

- Innovation in Legacy Sectors vs. Frontier Sectors greatly complicates the entry problem for new technologies
- It greatly widens the Valley of Death
- There are characteristics of Legacy Sectors and Market Imperfections they share
- Note the 5 dynamics of innovation – need the "Innovation Organizaiton" model
- Note the 5 Steps to launching innovation in legacy Sectors