

SPURRING INNOVATION IN ENTRENCHED LEGACY SECTORS

Graduate Research Institute of Policy Studies (GRIPS)
Tokyo, Japan, 27 July 2016

Charles Weiss
Georgetown University School of Foreign Service
(retired)

A legacy sector is a well-defended part of the economy that resists disruptive innovations that are needed for

- Economic Growth
- Competitiveness
- Employment
- Inequality
- Environment
- Safety
- Climate and Energy
- Security
- Public Health
- Education

Legacy Sectors in the US Include:

- Manufacturing
 - The Interstate Electric Grid
 - Transportation
 - Higher Education
 - Health Delivery
 - Buildings
 - Agriculture
 - Defense
- *These and similar legacy sectors constitute more than half the U.S. economy*

Radical innovation in “frontier sectors,” The normal U.S. approach, isn’t enough

- Disruptive innovations that may not fit existing business models are needed in “legacy sectors” to meet new social needs.
- The development and scale-up of these innovations are often blocked by obstacles defended by entrenched vested interests.
- These obstacles are well known to specialists but are not always addressed by makers of science, technology and innovation policy
- Innovation in information technology, biotech, and nanotech won’t solve these long-standing problems in the absence of measures to overcome these obstacles.

Both Policies and Research Support are Needed

- The obstacles to innovation in legacy sectors make it unprofitable for innovators to address important social problems, neither
 - Start-ups with a totally new product with no competition and no structural obstacles
 - The fertile minds of great entrepreneurs on the model of Morita, Honda, Toyoda, and Shibusawa
- This means there is a need for both
 - Support to research and innovation
 - Policies to overcome obstacles to innovation

This isn't impossible.

It's been done before and can be done again

- In the Past: The “Revolution in Military Affairs” in the U.S. Defense Sector in the 90's
 - Stealth bombers, precision bombs, drones
- In the Future: Innovation is promising in
 - Advanced manufacturing
 - New energy technologies
 - Driverless cars
 - Commercial space
 - Online education



LEGACY SECTORS

Bonvillian and I have Developed a New, Unifying Analytic Framework To Understand Innovation in Legacy Sectors

- Builds on and synthesizes work of many earlier scholars
 - Freeman, Perez, Ruttan, Christensen, Kondratiev
- Encompasses the many steps in the innovative process
- Characterizes barriers to innovation in disparate sectors
- Treats in detail the active role of government in innovation
- Explores the effect of context on demand for innovation
- Applies both to the US and to other national economies

My Tasks in this Lecture

- Present the ideas of
 - Legacy sectors
 - Barriers to innovation
 - -- Using legacy sectors in the U.S. as examples
- Define the idea of the National Innovation Context
 - And apply it to the U.S. and Germany
- Address in more detail the legacy sector of U.S. manufacturing
- Present a five-step approach for stimulating innovation in legacy sectors
- Summarize the ‘take-home lessons’

What is a Legacy Sector?

- A legacy sector is a part of the economy that is defended against disruptive innovation by a multidimensional paradigm that
 - Has technological, economic, social and cultural elements
 - Is characterized by barriers and market imperfections that
 - Favor existing technology
 - Obstruct the development and market launch of disruptive innovations that do not fit existing business models
- Provide incentives to producers that do not align with larger social objectives like environment, safety, health and security
- These obstacles to innovation are defended by powerful vested interests and share common features

Innovations Do Take Place in Legacy Sectors

- They face no special obstacles IF they fit the paradigm
- *Paradigm-compatible innovations like fracking expand smoothly*

But innovations face high obstacles if they do NOT fit prevailing business models–

- Especially if they are driven by “externalities” like environment, safety or security, not by market forces
- So the obstacles to innovation in these sectors are also obstacles to “green” innovation
 - As well as innovations in health, security, safety and other social benefits
- Governments sometimes inhibit innovation and sometimes guide it into desirable directions.
 - So government often has an essential role in facilitating important innovation
 - Although sometimes it does need to just ‘get out of the way’

Fossil Fuels Illustrate All the Features of a Legacy Sector:

- Prices that do not reflect externalities
 - (no carbon dioxide charge, no taxes for Middle East wars)
- Established infrastructure that supports incumbent technology
- Public expectations of cheap energy
- Career paths and university curricula that favor oil, gas, coal
- Regulatory requirements that place obstacles before wind and solar
- Limited R&D compared to revenue
- All defended by powerful vested interests

Market Imperfections Protect Fossil Fuels and Hinder Renewable Energy Technologies

- Perverse subsidies (depletion allowances and tax incentives)
- Network Economies (charging stations)
- Non- Appropriability (conservation investments)
- Lumpiness (minimum investment size for carbon capture & sequestration, next generation nuclear, enhanced geothermal)
- Need for collective action (for new Infrastructure, renewables research)
- Short time horizon of venture financing
- *In contrast, Paradigm-Compatible innovations like fracking expand smoothly*

These U.S. Legacy Sectors Face Obstacles Similar to Those Facing Renewable Energy

- The Interstate Electric Grid
 - Network economies
 - Non-appropriability
 - Vested interests (state regulators)
- Industrial Agriculture
 - Needs for collective action for research
 - Vested Interests (agribusiness)
- Transport
 - Infrastructure
 - Regulatory impediments (to driverless cars)
 - Network Economies
 - Standards and Legal Regimes
- Health Delivery
 - Network economies
 - Lack of performance standards (for digital patient records)
 - Non-appropriability
- Buildings
 - Non-appropriability (for conservation investments)
 - Need for collective action (for R&D)
 - Regulatory Impediments (building standards)
 - Need for agreed standards
- Higher Education
 - Fixed career paths
 - Institutional structure
 - Public expectations
 - Perverse pricing
 - Needs for collective action (for learning science research and implementation)
 - Vested Interests (faculty)
- Military – both legacy and innovative
 - Disruption-resistant services and financial models
 - Disruption-fomenting DARPA and change agents like Perry, Admiral Rickover



THE NATIONAL INNOVATION CONTEXT

Encouraging Innovation in legacy sectors requires support to the national innovation system (supply side)

- Innovative firms
- Education
- Research and Development
- Links between universities and industry
- Venture Capital
- Protection of Intellectual Property
- Technical services and publications
- Consulting and engineering organizations
- Standards and metrology
- Geological survey and resource evaluation
- Policies and prizes to encourage innovation
 - *All of these are familiar to policy makers and innovation researchers*

-
-
- Encouraging innovation in legacy sectors also requires support to the national innovation context (demand side)
 - The national innovation context has political, economic, legal, social and cultural aspects
 - *This context is less familiar and is frequently neglected*

Aspects of the U.S. National Innovation Context that are Favorable to Innovation

- Economic
 - Huge, growing, relatively unregulated internal market
 - Flexible, mobile labor market
 - Well developed capital markets
 - Including for housing
 - Stable macroeconomics
 - Favorable business climate
 - Portable pensions
 - Liberal trade policy
 - Anti-trust regulations to enforce competition
- Legal
 - Functioning, honest courts
 - Commercial and property protections
 - Bankruptcy flexibility
 - Easy to start and close businesses
 - Good pollution and safety regulation
 - Relatively weak labor protection

Social and Cultural Dimensions of the U.S. Innovation Context

- Applauds entrepreneurship
- Welcomes and rewards novelty and disruption
- Proud of individualism
- Expects to face competition
- Willing to take risks
- Accepts possibility of failure
- Rewards merit
- Skeptical of authority
- Relatively indifferent to national or social origin, family, religion, gender, education, ethnicity, sexual preference, alumni connections
- Does not defer to age
- Expects labor mobility
 - Many jobs in a lifetime
- Encourages university-industry collaboration
- Strong consumer movement

Even so, the U.S. Innovation Context suffers from

- Spotty educational system
- Neglect of physical infrastructure
- Neglect of legacy sectors, especially manufacturing
- Weak policies on greenhouse gases
- Quirky corporate taxation regime
- Variable corporate governance
- Regulatory capture in some industries
- Serious inequality in income and education:
 - Big rewards to the very top earners
 - Working- and middle-class incomes have stagnated

The National Innovation Environment

- National innovation environment = National innovation system + National innovation Context
- An enabling context is as important as the more familiar innovation system
 - For *encouraging* innovation
 - For *guiding* innovation to address issues of environment, safety, security, health and inequality
- In a *disabling* innovation environment, efforts to stimulate innovation are “pushing on a string”

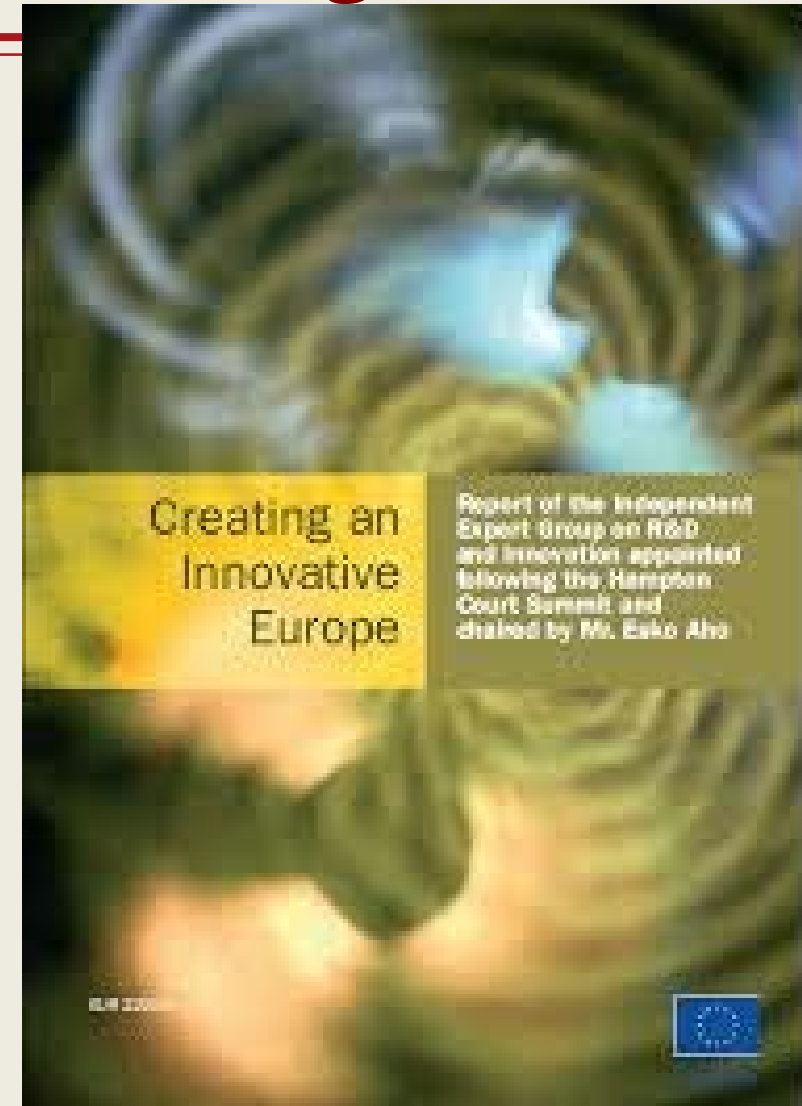
-
- A national innovation context creates both strengths and weaknesses
 - The national innovation context creates obstacles to “next big thing” innovation in
 - **Germany** – though strong in high-quality manufacturing
 - **France** – though strong in infrastructure
 - **China** – though strong in
 - manufacturing scale-up,
 - infrastructure (railroads, tunnels),
 - IT adapted to local markets
 - We can all learn from the strengths of other countries

The German Innovation Context Discourages Cutting-Edge Innovation but Pays Special Attention to Small- and Medium-Scale Manufacturers

- Economic and financial
 - Local financial institutions understand the local economy and value manufacturing
 - Membership in euro provides artificially low exchange rate
- Cultural
 - Appreciation for manufacturing
 - Industry-university-government manufacturing collaborations
 - Avoid risk (exception: Berlin)
 - Punish failure
- Human Resources
 - Difficulty in firing workers (in expanding economy) encourages worker training
 - Lengthy apprenticeships enhance skilled labor but limit workforce flexibility
 - Strong, manufacturing-oriented educational programs
- Legal
 - Inheritance laws favor family business
 - Union representation required on business boards – leads to labor/firm collaboration

“Creating an Innovative Europe” - A 2006 Report Calls for a New Paradigm:

- An innovation-friendly market
- “A culture that celebrates innovation”
 - Mobility in
 - Human resources
 - Finance
 - Organization
 - Knowledge
- In short,
 - An enabling innovation context,
 - In addition to an improved innovation system





MANUFACTURING: A MAJOR SOURCE OF EMPLOYMENT AND INNOVATION

Manufacturing as an Important Source of Innovation

- The U.S. thinks that research and development are the key steps in innovation
- It hasn't recognized production as a source of innovation
- Yet it's highly creative and critical to the innovation system
 - Both for processes and products
- Germany, Japan, Korea, Taiwan, China all organize their innovation systems around manufacturing

Manufacturing and the Loss of 'Full-Spectrum Innovation'

- After 1950, U.S. Gained from every stage from R&D through production at scale:
 - “Innovate here/Produce Here”
- But both multinationals and start-ups are now shifting production offshore:
 - “Innovate here/Produce There”

Manufacturing Becomes a Legacy Sector

- The result of the offshoring of manufacturing: Loss of the “industrial ecosystem”:
 - Thinning out of supply chain support, applied research laboratories, technical publications, vendors, consultants, university research and education, training
 - Small and medium manufacturers find it hard to expand
- So U.S. manufacturing has become a ‘legacy sector.’
 - -- Massachusetts Institute of Technology,
Report on *Making in America*, 2013

Risk of Loss of Innovative Capacity

- Loss of innovation in sectors where manufacturing and innovation are linked: Aerospace, capital goods, pharma
 - Risk of “*Produce there/Innovate there*”

New Advanced Manufacturing Networks: Government/Industry/University Partnerships

- Additive (3-D) manufacturing
- Digital manufacturing and design
- Lightweight metals
- New power electronics
- Advanced composite materials
- Photonics
- Flexible hybrid electronics
- Advanced functional fabrics
- -- On the model of the Fraunhofer Institutes in Germany



A FRAMEWORK FOR SPURRING INNOVATION IN LEGACY SECTORS

A Five-Step Framework for Launching Innovation into Legacy Sectors

Step 1: Strengthening the Front End of the Innovation System

(There have to be innovations with which to innovate)

- Form critical innovation institutions,
- Build a “thinking community” to build and support ideas,
- Link technologists to operators:
 - “connected science and technology”
- 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

➤ Examples – ARPA-E, Advanced Manufacturing Institutes

Step 5: Filling the Gaps in the Innovation System

Launching Innovation in Legacy Sectors (3)

Orchestrators (Change Agents)

- Innovation in legacy sectors requires institutions and individuals that push innovations through the structural barriers protecting the paradigm of a legacy sector
- The orchestrator requires enablers at higher levels to defend them and to champion their ideas within the organization

U.S. experience with the 5-step model in Legacy Sectors

- They are the essential design process behind the Advanced Manufacturing initiatives and the recent Clean Energy Initiatives
- These steps were the way the U.S. Department of Defense accomplished the “Revolution in Military Affairs”

Take-Home Lessons

- Legacy sectors constitute most of the U.S. economy.
- They resist disruptive innovation that does not fit their technological, economic, political and social paradigm.
- The paradigms and barriers to the development and scale-up of disruptive innovation in disparate legacy sectors have much in common.
- Obstacles to disruptive innovation in legacy sectors hinder innovations that would address issues of environment, employment, safety, health and security.
- Innovation is not restricted to cutting-edge “shining lights.”

Take-Home Lessons (2)

- Encouraging innovation in legacy sectors requires attention to the entire innovation process from research to commercialization. It should anticipate and confront barriers to scale-up and market launch.
- Encouraging innovation requires policies to address obstacles in legacy sectors.
- Manufacturing is a legacy sector that is an important source of both jobs and innovation.

Take-Home Lessons (3)

- The national economic, political, cultural, social, and legal context of innovation can be as important as the more familiar national innovation system
- The innovation context can both encourage and *discourage* innovation and guide it to or away from addressing social problems
- A five-step process for stimulating innovation in legacy sectors

OXFORD
UNIVERSITY PRESS
ΟΝΤΟΛΟΓΙΑΣ ΚΑΙ ΕΚΔΟΣΕΩΝ

Bonvillian and Weiss



Technological Innovation in Legacy Sectors --

- **Explores the entrenched “legacy” sectors**, comprising over half the economy, that resist disruptive innovations that could stimulate economic growth, generate jobs, and improve safety and the environment.
- Argues that we **need to rethink existing strategies for promoting innovation** – the authors’ new framework identifies the barriers common to these legacy sectors and proposes a systematic approach for overcoming them.
- Creates a new, **unified, systems approach to innovation policy**, focused on overcoming two deep problems in the U.S. innovation system: **expanding economic growth** and **raising the rate of creation of well-paying jobs**.

Early Reviews -

- “Bonvillian and Weiss have written an **important book**... Of particular value is their **analysis of the structural obstacles to disruptive innovation in these sectors, and how those obstacles can be overcome.**”
- Jeff Bingaman, former U.S. Senator and Chairman of the Senate Committee on Energy and Natural Resources
- “This **remarkable book** by William Bonvillian and Charles Weiss offers **new insights, analysis, and solutions** about one of the most important long-term challenges facing our economy: how to introduce technological innovations in legacy sectors.”
- Arun Majumdar, Precourt Professor at Stanford University, and founding Director of ARPA-E

Early Reviews – Con't

- “Because innovation is central to driving progress it’s unfortunate that innovation policy analysis is all too often one-dimensional. *Technological Innovation in Legacy Sectors* provides a **sorely needed antidote, providing compelling analysis of how innovation actually occurs – or does not – and what governments need to do to accelerate the pace.**”
 - Robert D. Atkinson, President, Information Technology and Innovation Foundation (ITIF)
- “Bonvillian and Weiss show again that they are **master students of America’s innovation system.**”
 - Kent H. Hughes, Public Policy Scholar, Woodrow Wilson International Center for Scholars

Early Reviews - Con't

- **"With this book Bonvillian and Weiss shine a vivid light on one of the most critical and least well-examined challenges of American innovation policy... I hope this book can launch a vigorous national debate on a set of issues that have long hidden in plain sight."**
 - Henry Kelly, former President, Federation of American Scientists and senior official at the White House Office of Science and Technology Policy and the Department of Energy
- **"The book fills a major gap and should be read by anyone concerned with our 'jobless innovation.'"**
 - Irving Wladawsky-Berger, former IBM Vice President for Technology Strategy and cochair of the President's Council of Advisors on Science and Technology (PCAST)