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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
  - Inequality
  - Education
- R&D is not enough to solve the technological dimensions of these big public challenges –

  We have to confront our Legacy Sector barriers
  - These are *"hidden in plain sight"*
- So how do we do it?

"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*

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
- Some economists argue that GNP growth from cutting edge innovation has plateaued
- ***We argue big economic and environmental gains,*** not just from the new but fixing the old

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:
  - Advanced Manufacturing
  - New Energy Technologies
  - "Intelligent" Cars
  - Commercial Space
  - Online education
- Can we do this in renewable energy?

To understand innovation in Legacy Sectors, we need to expand our Analytic Framework so that it:

- Builds on and synthesizes work of many earlier scholars
  - Schumpeter, Freeman, Perez, Ruttan, Christensen, Kondratiev
- Encompasses the many steps in the innovative process
- Takes into account the different dynamics of innovation
- Characterizes the barriers to innovation in many 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

Take-home Lessons

- Fossil fuel energy is a **legacy sector resistant to sustainable but disruptive innovation**
- ***Manufacturing is a Legacy sector,*** an important source of ***jobs and innovation***
- The barriers to innovation in disparate ***Legacy Sectors have much in common (****and are found in the* ***U.S. and in economies abroad)***
- Encouraging innovation in Legacy sectors like energy requires ***attention to the entire innovation process***
  - This includes support to R&D, and also policy and institutional measures to anticipate and confront barriers to scale-up and market launch.
- Innovation in renewable energy encompasses
  - Development of new technology
  - Implementation of existing technology, even if imported
  - Local manufacturing and installation of equipment and software

LEGACY SECTOR CHARACTISTICS

A ***Legacy sector*** is a part of the economy that is defended against disruptive innovation by a multidimensional paradigm that

- Has *technological, economic, political, social and cultural* elements that include but go beyond the ideas of 'technological lock-in,' 'socio-technical systems,' and 'social construction of technology'
- Creates barriers and market imperfections that
  - Favor existing technology
  - Share common features across diverse sectors
  - Provide incentives to producers that do not align with larger social objectives like environment, safety, health, security and inequality
  - Obstruct the development and market launch of disruptive innovations that do not fit existing business models
  - Affect the speed and direction of innovation
  - Are defended by powerful vested interests

Innovations <u>do</u> take place in Legacy Sectors

- Legacy Sectors accept incremental advances for existing technologies
- Innovations face no special obstacles ***IF*** they fit the Legacy Sector's paradigm
- *Paradigm-compatible innovations like fracking expand smoothly*

But innovations face high obstacles if They do *not* fit prevailing Legacy business models –

- Especially if they are driven by "*externalities*" like environment, health, safety or security, not by market forces
- So the obstacles to innovation in legacy 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:
  - Government often has essential role facilitating innovation
  - But government can get tied to Legacy Sectors
  - Sometimes it does need to just 'get out of the way'

Fossil Fuels Illustrate All the Features of a Legacy Sector:

Legacy Characteristics:

- Perverse prices that do not reflect externalities
  - (no carbon charge)
- Established infrastructure
- Public expectations of cheap energy
- Regulatory requirements place obstacles before wind and solar
- Limited R&D compared to revenue
- ***All defended by powerful vested interests***

Market Imperfections Hindering New Technologies & Renewables:

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

Other U.S. Legacy Sectors Include:

- Manufacturing
- The Electric Grid
- Transportation
- Higher Education
- Health Delivery
- Buildings
- Agriculture
- Defense

- These and similar legacy sectors constitute more than **half the US economy**
- **Their resistance to innovation drags down economic growth**, job creation and response to environment, safety, public health, and other **public goods**
- The obstacles facing renewable energy and other sustainable technologies are similar to those facing many other legacy sectors

UNDERSTANDING THE FIVE MODELS OF INNOVATION DYNAMICS

To create a context for innovation in legacy sectors, we need policy measures based on the

Five Models of the Dynamics of Innovation

- *1. Pipeline*: Support research; innovation will follow: Tech-Push
- *2. Induced*: Change prices (or policies);innovation follows: Market-Pull
- *3. Extended pipeline*: Government supports not only research, but also technology scale up and initial commercialization
- 4. *Manufacturing-led*: Design and initial production of a manufacturable, marketable product require creative engineering.
- *5. Innovation organization*: Research support, policy and institutional change needed to overcome an innovation context that poses obstacles to innovation scale-up.
- *Policy measures based on all four of these dynamics are needed to encourage innovation in a legacy sector.*

Five Models of Innovation Dynamics – 3 are new

1. The Pipeline:

- Technology-Push, Technology-Supply
  - Federally supported research pushes basic research
  - New technologies develop and push into markets
- The dominant model underlying US innovation policy
- This model describes the origins of nuclear energy, lasers, television, penicillin, helicopter, rockets, safety glass

2. Induced:

- Market-Pull, Demand-Pull. Most secondary innovations follow this model.
- Industry spots market niche
- Technology advances (often incremental) are pulled to meet demand
- Innovation can be induced by changes in markets or policy
  - Environment, safety, public health, gov't incentives, prizes
- Can work quickly if there are 'inducible' innovations

Models of Innovation Dynamics, Continued

3. The Extended Pipeline - ***NEW***

- Technology-Push
- But Government technology support at every stage
- Major example; Defense Department support to R, D, demonstration, testbed, and initial market creation for innovations related to service missions.
  - DoD has the advantage of political support and a large procurement budget
  - Successes from extended pipeline model: Airplanes, nuclear energy, Internet, satellites
  - Could this be applied to renewable energy?
- Other examples:
  - Agricultural research and extension (mainly for industrial agriculture)
  - NIH support to 'translational research'
  - Many Department of Energy programs

Models of Innovation Dynamics, Continued

4. Manufacturing-Led Innovation - ***NEW***

- Initial production can be highly innovative –
  - Design a product to fit a market, redo the science, highly creative engineering
  - Examples –
    - US Invention of mass production
    - Japan's creation of Quality Manufacturing: Toyota, Sony
    - China's innovations in scale-up; I-phones, cheap motorcycles
  - An important but underappreciated source of innovation

Models of Innovation Dynamics, Con't

5. Innovation Organization – ***NEW***

- Incorporates the four other models
- Goes beyond them to take account of broad context and structure into which innovation is to be introduced
- Efforts to encourage innovation in legacy sectors need to apply all models,
  - Neglecting any one of them puts too much pressure on the others. Specifically, failure to enact policy measures puts too much pressure on R&D and the innovation system
- *Change agents* orchestrate the full innovation environment and the actors within it to address new technology and broader policy and institutional issues

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

Defense Advanced Projects Agency (DARPA): The Innovation Organization Model in a Legacy Sector

- DARPA in Defense Department: translational research that links breakthrough ideas to practical application
- Accomplishments Include ARPA-Net, Stealth, drones, desktops
- Island/Bridge model –
  - Free of pressure to solve immediate problems,
  - Direct link to Secretary of Defense
  - Joint Chiefs must understand its mission
- Broad powers to link universities, research labs, and private companies with technologies with promising military applications
- Somewhat similar structures in private industry: Lockheed Skunkworks, IBM PC,
  - Though for engineering design and implementation, not technical breakthroughs

DARPA Management Principles

- “Connected” [right-left”] science and technology
- Technology visioning, not incremental progress
  - imagines a future and identifies technology to get there[
- Small, entrepreneurial staff
  - Program managers have autonomy and responsibility
- NO peer review – staff has initiative, responsibility
- Accepts risk and possibility of failure
- Free of bureaucratic constraints
- Creates research networks and “great groups” -- no laboratories of its own

Implications of these Models for Spurring Innovation in Legacy Sectors:

- Addressing Legacy Sectors requires *policy measures based on all the models of innovation dynamic*
- A *full-spectrum innovation policy* that fills system gaps
  - At the front end of the innovative Process: R&D, prototype
  - At the back end of the innovation process:
    - demonstration, testbed, manufacturing, market launch
- Active government role *Beyond the Pipeline Model:*
  - Support research to create disruptive technologies
  - Changes in policy to remove obstacles to market launch
  - Recognition of manufacturing as source of innovation and jobs
- NB: The most competitive parts of the US economy all benefit from government support to technological development: aerospace, defense, agriculture, fossil fuels, pharmaceutical, information and biotech

FRAMEWORK FOR LAUNCHING INNOVATION INTO LEGACY SECTORS

Launching Innovation into Legacy Sectors

A Five-Step Framework

Step 1: Strengthen the Front End of the Innovation System

- No innovation without innovations
- Form or strengthen 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: Identify the Launch Paths for Emerging Technologies

Step 3: Match Support Policies to Technology Launch Pathways

Step 4: Analyze and identify Gaps in the Innovation System

Step 5: Fill the Gaps in the Innovation System

- Examples: ARPA-E, Advanced Manufacturing Institutes

Launching Innovation in Legacy Sectors (3)

The Role of the Change Agent

- Innovation in legacy sectors requires *orchestration*:
  - 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 the way DOD effected the "Revolution in Military Affairs": drones, precision bombers, GPS
- Also the essential design behind Advanced Manufacturing initiatives and recent Clean Energy Initiatives

APPLYING THE FIVE-STEP MODEL TO RENEWABLE ENERGY

Taken from *Structuring an Energy Technology Revolution* (MIT Press, 2009)

To apply our analysis to renewable energy, We need to distinguish among

- Development of new U.S. technology (hardware and software)
  - Our main comparative advantage and focus of most U.S. innovation policy
- Implementation of imported technology
  - Helps mitigate global warming, wherever manufactured
  - Generates U.S. employment for sales, installation, maintenance, and repair, but not production
- Local production in the U.S.
  - Crates manufacturing and both upstream and downstream jobs
  - Helps mitigate inequality
- We shall consider local technology development and

Step 1: Building a Thinking Community (as of 2009)

- Many researchers exist but stovepiped by technology and concentrate in research on improved technology
- Need for major expansion in the R&D community and better links to the marketplace

Steps 2: Identify Launch Pathways (Varies with Technology) and Step 3: Match Policies and Programs to Foreseeable Obstacles to Scale-Up (2009 Recommendations)

- Experimental (long-range) technologies: support to basic research (defined as curiosity-motivated OR applied research that increases fundamental knowledge)
- Disruptive technologies launched in niche markets: Identify likely obstacles to market launch, e.g., distance from sun and wind resources to energy markets (from more recent experience)
- Component technologies: Incentives for adoption, support to manufacturing scale-up
- Technologies facing contested launch: Regulatory requirements
- Conservation and end-use efficiency requiring long-term investment: non-appropriability due to short time horizon of tenants and purchasers: Project financing mechanism for conservation
- Scale-up and improvement of manufacturing technology: Project financing mechanism

Step 4: Identify Gaps (as of 2009)

- Lack of translational research
- Insufficient demonstrations at full scale
- Manufacturing technology and processes, especially cost-cutting and production scale-up and related financing
- Need for Incentives and disincentives coherent with public objectives
  - Subsidies are disproportionately for fossil fuels and nuclear energy
- technological collaboration between government and industry
- "Roadmapping," jointly with industry
  - Defined as "an analysis that considers each technology element and its possible and preferred evolution pathways, and then ties each to the appropriate elements of **front-** and **back-end** support."
- Need for financing mechanisms for
  - small- and large-scale commercial engineering demonstration projects
  - manufacturing production scale-up for new energy technologies
  - new cost-cutting manufacturing processes and technologies
  - infrastructure needed for scale-up of innovative energy technology
  - conservation technologies for smaller commercial and residential users
- Measures to attract new people
- Prizes for best ideas and technologies

Step 5: Fill In Gaps (Obama Measures): Front-End
[Research, Development, Demonstration]

- ARPA-E: 'Partially extended pipeline,' or 'pipeline on steroids'" (New)
  - Competitive grants for breakthrough applied research
    - Enthusiastically received – agency flooded with proposals
  - "Tech-to-market team" joins researchers with small companies to facilitate commercialization
- SunShot (New): "Make solar energy cost-competitive"
  - "Funds cooperative research, development and deployment projects by private companies, universities, state and local government labs, non-profits, and national labs to drive down the cost of energy to $0.06/kilowatt-hour or $1/watt by 2020." This goal is said to be 70% achieved.
  - Supports concentrated solar power, photovoltaics, balance of system costs, systems integration
  - "Technology-to-market" teams link researchers to small companies to speed commercialization

Step 5: Fill In Gaps (Obama Measures): Front-End (continued)

- Advanced Manufacturing Program (New)
  - Technical assistance, shared facilities and partnership with private industry on translational research
  - Support to the Advanced Manufacturing Partnerships (to be discussed shortly)
  - Drives down production costs so that renewables can compete on price at market entry
- Technology Transition Office: new program to facilitate technology transfer from Department of Energy laboratories
- Roadmapping and Assessments (These tie Front- and Back-Ends)
  - Roadmapping program on solid-state lighting (new program, industry closely involved)
  - Quadrennial Technology Reviews (broad strategies for research, development, demonstration and deployment, in consultation with industry)

STEP 5: Fill in Back-End Gaps
[Manufacture and Deployment]

- Department of Energy loan guarantees
  - Accelerates deployment and scale-up of innovative, ‘clean’ energy technology
  - Supports manufacture of fuel-efficient, advanced-technology vehicles and vehicle components
  - Expansion of an older program that saved Tesla from bankruptcy
- ASSESSMENT of measures to date:
  - Almost all our recommended policy instruments (or rough equivalents) are being implemented for some technology, but not across the board. Gaps remain:
  - Coherent policies have not yet been achieved, though the Paris commitments would have been a start

APPLYING THE FIVE-STEP MODEL TO MANUFACTURING

Manufacturing and "Full-Spectrum Innovation"

- Both a key *legacy sector* and a key *source of innovation*
- *A revolution in manufacturing is underway*
- Nevertheless, U.S. thinks of R&D as the main source of innovation, and has thought that offshoring of manufacturing to be natural and inevitable
- Germany, Japan, Korea, Taiwan and China all organize their innovation systems around manufacturing – "manufacturing-led"
- In contrast, U.S. hasn't recognized that manufacturing is a highly creative stage of the innovation process.

Manufacturing and the Loss of Full-Spectrum Innovation (2)

- After World War II:
  "Innovate here, produce here"
  - U.S. once had *"Full-Spectrum Innovation"* and gained from every stage from R&D to initial production
- Now: *"Innovate here, produce there"*
  - U.S. split innovation and production – it "Distributed production"
  - MNCs and start-ups sent even initial production offshore
  - Small and Medium Enterprises lost the "industrial ecosystem" of suppliers, researchers, consultants, skilled workforce. This limited their ability to expand.
  - Result: Losses in manufacturing employment, speed of economic recovery, and innovative capacity

Manufacturing and Full-Spectrum Innovation (3)

- So: Risk of "*Produce there, innovate there*"
  - *Jobless innovation* risk in many sectors where manufacturing and innovation are linked (aerospace, capital goods, bio-pharma, energy technologies, etc.)
- ***The five-step model helps to find measures to restore the lost ecosystem and regain manufacturing employment and "green jobs" without new tariffs:***
  - Smooth the way for new launch paths for advanced manufacturing technologies and processes
  - Identify and fill system gaps through a network of Manufacturing Institutes acting as *Change Agents*
  - Government-industry partnerships based on German model
  - Bipartisan support in previous Congress

Advanced Manufacturing Institutes (4):

- ***9 Now in Place:***
- 3D Printing/additive mfg.
- Lightweight metals
- Advanced composites
- Power electronics
- Digital manufacturing
- Flexible hybrid electronics
- Photonics
- Advanced fibers and textiles
- "Smart" manufacturing

- ***6 Planned in FY 2017 Budget:***
- Bioengineering for tissue and regenerative medicine
- Assistive and soft robotics
- Modular chemical processing
- Sustainable manufacturing – recycling and remanufacturing
- Two open topics from NIST – industry to propose

What does innovation-driven Advanced Manufacturing Mean for the Creation of Manufacturing Jobs? (5)

- Loss of Jobs – can it be affected by Advanced Mfg.?
  - U.S. lost 1/3 of manufacturing jobs in 2000-2010 – still haven't come close to recovering
  - Although software led to new firms (Uber, eBay, etc.) manufacturing jobs are still the highest job multipliers
  - Manufacturing is the way the economy scales via innovation-based growth, not services (slower scaling)
- Advanced manufacturing technology can maintain
  - U.S. comparative innovation advantage
  - U.S. jobs in supply chain and downstream services
  - 'Hourglass model' of employment structure –
    - jobs from advanced mfg. will be in the "hourglass" value chain of firms, not simply in production stage

Wrap-Up

- *Legacy sectors* – most parts of the economy, including fossil-fuel-based energy
  - Resist innovation unless it fits their *technological/economic/political/social paradigm*
  - Many have important implications for *jobs and environment*
- Legacy sectors share in common a series of *barriers and market imperfections*

Wrap-Up (2)

- For innovation to enter a legacy sector like energy, need to understand *the 5 Models for Innovation Dynamic* –
  - pipeline, induced, extended pipeline, manufacturing-led, innovation organization
  - Legacy sectors require the "innovation organization" model, *which*
    - Requires attention to the whole innovation system, both R&D and policy
    - Involves active collaboration between government and industry
    - Technology is pushing a very big rock uphill in the absence of policy measures to address externalities and other barriers to scale-up
- *Manufacturing - a legacy sector, a model for innovation AND A DRIVER OF JOBS*
  - Needs to be seen as part of the innovation process for renewable energy
- *Framework for bringing innovation into energy and other legacy sectors*
  - Strengthen early stage innovation,
  - Understand innovation launch pathways and tie policies to them,
  - Identify the gaps in the sector's innovation system and fill them
  - Change agents require enablers and political or management support

For More Info: Bonvillian & Weiss – Fall 2015

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RESERVE SLIDES

The Economic Context:
"Secular Stagnation" – Decline in Productivity and Growth

- **Larry Summers – "secular stagnation" 2013 speech to IMF**
  - Term from Alvin Hanson in1938 describing lasting effects of the Great Depression
  - Summers – it's more than the lasting effects of Great Recession
  - Krugman – part is slowing growth in working age populations in developed world
  - GDP growth stuck in the 2% level vs. historic 3% range of U.S.; middle income in decline
  - Productivity: 3+% in the IT revolution, now in the 1% range
- **Robert Gordon – *The Rise and Fall of American Growth* (2015)**
  - The IT innovation wave is less significant than the 1870-1970 waves (internal combustion engine, modern communications, electricity, chemicals, pharmaceuticals, urban sanitation)
  - Productivity gains lower, real growth lower
  - Stagnating living standards ahead
- **U.S. Limits technological innovation to "Frontier" sectors**
  - IT sector: still only 4.6% of the U.S. economy
  - Legacy sectors: some 80% of the U.S. economy
- **"Technological and related innovation" is the dominant causative factor in growth**
- **Would bringing innovation to Legacy sectors help growth?**

Other U.S. Legacy Sectors Display Many of the Same Obstacles to Disruptive Innovation

- The 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

- UNDERSTANDING THE NATIONAL INNOVATION ENVIRONMENT: consists of: 1) innovation system, plus
  2) innovation context

The ***Innovation System***: A Familiar Subject of Innovation Research

- ***Consists of the firms, institutions and policies --***
  - ***that carry out, encourage, facilitate, and support --***
    - ***research, development, innovation,***
    - ***and development of technical capacity***

The *Innovation Context* – A Neglected Dimension of the **Innovation *Environment***

- **Cultural attitudes toward**
  - Risk, novelty, individualism, competition, cooperation, university-industry cooperation
  - Acceptance of social mobility, promotion on merit, failure, gender/sexual preference, ethnic origin
  - Importance of family, class, alumni connections, religion
- **Economic**
  - Macroeconomic environment, exchange rates, business climate, trade policy, tax system, stability
  - Access to finance
  - Physical infrastructure and connectivity
  - Income distribution
  - Incentives – subsidies, prizes, tax provisions – that favor certain kinds of innovation over others
- **Political**
  - Stable, relatively free of corruption and overregulation
- **Legal**
  - Labor, commercial, IP, commercial transactions, immigration, bankruptcy, pension, property
  - Functioning and reasonably honest court system
- ***As important as the innovation system in determining***
  - Whether innovation does or does not take place
  - Whether innovations improve environment, safety, or health
  - Innovation environment = innovation system + innovation context

U.S. Innovation Owes a Great Deal to its Favorable National Innovation *Context*

Positives

- Economic
  - Huge, relatively unregulated internal market
  - Flexible, mobile labor market
  - Stable macroeconomics, favorable business climate
  - Portable pensions
- Social and Cultural
  - Welcomes novelty and disruption
  - Proud of individualism & entrepeneurship
  - Accepts risk of failure
  - Rewards merit, relatively indifferent to social origin, religion, gender, education
  - Expects university-industry collaboration
- Legal
  - Basic legal structure: IP, commercial and property protections, bankruptcy flexibility

Despite . . .

- Spotty educational systems
- Weak safety net for those hurt by offshoring or disruptive innovation
- innovation or Neglect of physical infrastructure
- Neglect of legacy sectors, especially manufacturing
- Neglect of environmental externalities, especially climate
- Lack of understanding of role of government in the innovative process intensifies opposition to
  - "corporate welfare"
  - government investment in later stages of innovation
  - Any failure by a government backed firm

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 **– *especially in Legacy Sectors***
  - For *encouraging* innovation
  - For *guiding* innovation to address externality issues of environment, safety, security, health, inequality, public goods

- In a ***dis*abling innovation environment**, efforts to stimulate innovation are "**pushing on a string**"

- A national innovation context can create both strengths and weaknesses
  - ➢ Note: we can learn lessons 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
  - Locally owned 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
  - Strong unions
  - 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 <u>context</u>,
  - In addition to an improved innovation system

The Chinese Innovation Environment: Strong on Manufacturing, Weak at the Cutting Edge

Innovation System

- Major investments in research, education and "strategic industries"
  - Research management capability and tradition of research integrity are still being built
  - Mastery and improvement of European technology, followed by but over-expansion in solar and wind
  - Semi-official industrial espionage
- "Scale-Up Nation":
  - Creative re-engineering for low-cost, reduced quality products for developing country markets
  - For quick up-scaling of the manufacture of state-of-the-art products (like i-Phones)
  - Has attracted US "industrial ecosystem"

Innovation Context

- Huge population and expanding market attract foreign investment, enable pressure on investors for local partners, procurement, research
- New infrastructure, high productivity, low but increasing wages, bad environmental performance and periodic quality scandals
- But difficult business climate, theft of intellectual property
- Official corruption, combined with incentives for economic performance
- History of undervalued exchange rate to encourage exports
- Traditionally high savings rate controls on capital exports but the resulting cheap credit is funneled to state-owned enterprises and politically connected private firms
- Cutting-edge entrepreneurs face mixed policy messages
  - Tradition of risk aversion affects financing ,recruitment and project choice
  - Encouragement to innovation but ambiguous and fluctuating policies