Economics of energy technological change: public policy considerations

ADAM B JAFFE
Motu Economic and Public Policy Research
Brandeis University
Queensland University of Technology

NAS PANEL ON EVALUATION OF SBIR AT DEPT OF ENERGY

MAY 22 2018

Overview

- Innovation market failures (review)
- Scale and scope of the climate/energy challenge
- Energy innovation market failures
- Implications
- Measurement
- Parting thoughts

Innovation market failures: the standard story

- Imperfect appropriability/spillovers
- Information failures and asymmetries
- Cognitive biases
  - Short-sightedness
  - Loss aversion/first-cost bias
- Networks and resulting coordination problems
- Path dependence

The patent system and innovation

- One mechanism for mitigating the appropriability problem is the patent system
- May be particularly important for small firms, who do not have access to other mechanisms for appropriation
- Current issues with the patent system
  - Patent quality
  - ‘Trolls’ and litigation
- Firms need innovation ‘maps’ to navigate the patent landscape
- Clear disclosure of patent ownership should be a condition for patent rights. No public policy purpose is served by obfuscation.

The role of technology transfer

- Global Bayh-Dole revolution has made 'technology transfer'—commercial development of inventions derived from public research—a key part of the innovation landscape
- But remember spillovers—the overall innovation benefits from public research likely greatly exceed those connected to patents flowing directly
- E.g. references in patents to universities' scientific papers greatly exceed their patents (Jefferson, et al '**Mapping the global influence of published research on industry and innovation',** NATURE BIOTECHNOLOGY VOLUME 36 NUMBER 1 JANUARY 2018)
- Success of public research projects in fostering innovation should NOT be judged solely or even mainly by their patents

The nature of the challenge

- Sometime this century, we need to get to (at worst) net zero global carbon additions to atmosphere
- There is no historical precedent for achieving changes in the global economy of the needed scale and scope in anything like this kind of time frame.
- Will require profound changes in the energy-economic system, not just in the use of individual technologies
- Will require the use of technologies that we do not/cannot foresee as of today.

Implications of this scale and scope

- Thought experiment: would hypothetical ideal global *climate* policy bring this about?
- I don't think so.
  - Relevant 'elasticities' are nowhere near big enough
  - Climate policy does not really operate at the level of the system
- If we are to have any hope of achieving carbon neutrality, we will need technology policy
- Historical precedent that is *closest* to what we are talking about is the ICT revolution of the last 5 decades.

  (In 1970, did you imagine today's phone?)

Lessons from the ICT revolution

(David Mowery, 2011. "Federal Policy and the Development of Semiconductors, Computer Hardware, and Computer Software: A Policy Model for Climate-Change R&D?" in Henderson and Newell, Accelerating Energy Innovation: Insights from Multiple Sectors, University of Chicago Press)

- Driven by or at least greatly facilitated by advances in basic science
- NOT driven by market-pull
- Government technology investments motivated by space and defense needs were crucial
- Many technologies' early development occurred in an environment where cost was either irrelevant or decidedly secondary consideration.
- Government activities fostered diffusion/adoption in addition to research/development

Energy innovation market failures: cognitive biases

- The “paradox” of under-adoption of energy-efficient technologies
- Actually, slow diffusion of superior new technologies is a widespread ‘paradox’
- BUT—it is true that energy technology adoption decisions are more sensitive to first cost than to the current price of energy
- Consistent with loss aversion generating a bias that over-weights initial investment cost relative to lifetime savings
- For any given technology, first-cost barrier is eventually overcome with time, but cumulative nature of innovation and importance of learning by doing means that the cumulative process is retarded

Energy innovation market failures: networks and coordination failure

- Networks are a key aspect of the energy system
- Transport is by its nature a networked market
  - E.g. gas stations versus charging stations
  - More generally: whatever mid-century transport energy sources turn out to be, they will have to be provided in a distributed network of ‘stations’
- At least as of now, it looks like electricity will be key to a carbon-neutral future
  - Perhaps local generation will eventually be so prevalent we don’t need a grid, but that seems unlikely

Energy innovation market failures: path dependence

- New technologies developed now will affect energy use in the next decade or so
- But they also affect the context in which the technologies of the following decades will be developed
  - Sunk investments
  - Infrastructure and networks
  - Production knowledge and learning curves
  - User knowledge and familiarity
  - Base of scientific/technical knowledge for new inventions
- So ‘building blocks’ and acceleration of learning curves may be the most important outcomes of near-term programs

Implications

- Government role is crucial.
- Adoption/diffusion are as important as research
- Let a thousand flowers bloom
  - Technologies
  - Market approaches
  - Policy/programmatic approaches

Implications II

- Usual tradeoff between 'big ideas' and 'feasibility' should be calibrated toward big ideas
- Small firms
  - More likely to think 'outside the box' in terms of technology and market paradigms
  - Network issues and path dependence create particular challenges
  - 'Success' may be hard to measure—pieces of the puzzle or contributions to others

Measuring research outputs

(Jaffe, Adam, 2015. ‘A Framework for Evaluating the Beneficial Impacts of Publicly Funded Research’, Motu Note No. 15, Motu Economic and Public Policy Research)

- Specify counterfactual: what is the ‘but for’ world against which research outcomes are to be compared
  - ‘good things happened’ is not informative. Need to know extent to which more good things happened than would otherwise have happened
- Specify ultimate public benefits that are desired—’outcomes’—e.g. understanding properties of materials; lower carbon emissions, higher gdp
  - Fundamentally multidimensional
  - No ‘bottom line’ or overall ROI

Measuring research outputs-II

- Look for:
  - Direct measures (e.g. reduced tons C per KWH)
  - Indicators (e.g. papers, citations, patents)
  - Intermediate outcomes (e.g. private investment dollars attracted)
  - Be clear on which are which
- Be creative (e.g. web scraping of catalogues looking for technology references)
- Be quantitative where feasible but do not rule out qualitative/subjective data (e.g. expert judgments)

Parting thoughts

- The future of humankind likely depends on our significantly accelerating energy innovation.
- The task is urgent but it is also long-term.
- Current programs and policies are most important not for what they contribute in terms of short-term outcomes, but in terms of their creation of building blocks for the next 3-4 decades of effort
  - Scientific/technical knowledge
  - Market knowledge and experience
  - Programmatic lessons

SYSTEMATIC PROGRAM TESTING AND EVAULATION!