Promoting Innovation on Low-carbon Technologies

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Introduction

- Meeting increasingly ambitious climate policy goals (e.g. net-zero carbon by 2050) replacing vast amounts of fossil fuel energy sources with alternative, carbon-free energy sources

- Innovation is needed to:
  - Reduce the cost of existing technologies
  - Develop new breakthrough technologies
  - Develop complementary technologies (e.g. grid management, energy storage) to better integrate intermittent renewables into transmission grids

- This talk highlights key lessons from research on policy and innovation, focusing on the role of private and public sector innovation

Introduction

- Clean energy innovation suffers from two market failures
  - *Environmental Externalities*
    - Pollution created in the production or use of a product are not normally included in the price of the product
      - Thus, neither firms nor consumers have incentive to reduce pollution on their own
    - This limits the market for technologies that reduce emissions, which in turn reduces the incentives to develop such technologies
    - Addressed by environmental policy (a/k/a *demand-pull* policies)

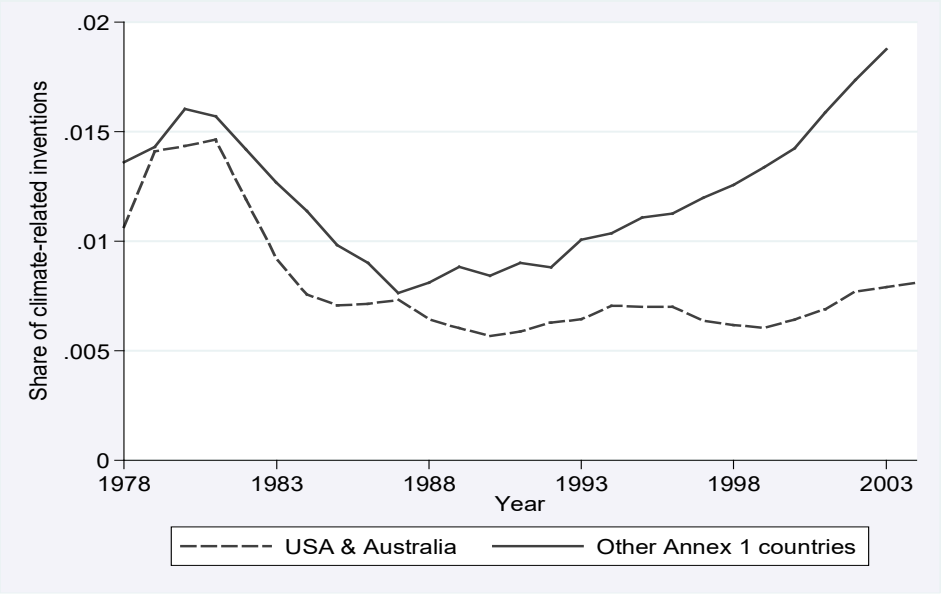
Introduction

- Clean energy innovation suffers from two market failures
  - *Environmental Externalities*: social benefits of clean energy associated with pollution reductions are not reflected in market prices without government intervention
    - Addressed by environmental policy (a/k/a *demand-pull* policies)
  - *Knowledge as a Public Good*: innovation leads to knowledge spillovers—additional innovations, or even to copies of the current innovations, that benefit the public as a whole, but not the original innovator
    - Addressed by science and technology policy (a/k/a *technology-push* policies)
      - May be general (IP) or specific (subsidies for renewable R&D)

The Role of Policy: Private Sector Innovation

- These two externalities could, in principle, be addressed separately
  - Use science policy to address knowledge market failures in *all* sectors of the economy
  - Use carbon pricing to "get the prices right"

- Using carbon pricing to "get the prices right" increases incentives for private sector innovation



Source: Dechezleprêtre *et al*. (2009)

The Role of Policy: Private Sector Innovation

- But…

- Broad-based policies that let the market "pick winners" focus research efforts on technologies closest to market (Johnstone *et al*., *ERE* 2010)
  - Renewable energy mandates => wind innovation
  - Guaranteed prices (e.g. feed-in tariffs in Germany) => solar innovation

The Role of Policy: Private Sector Innovation

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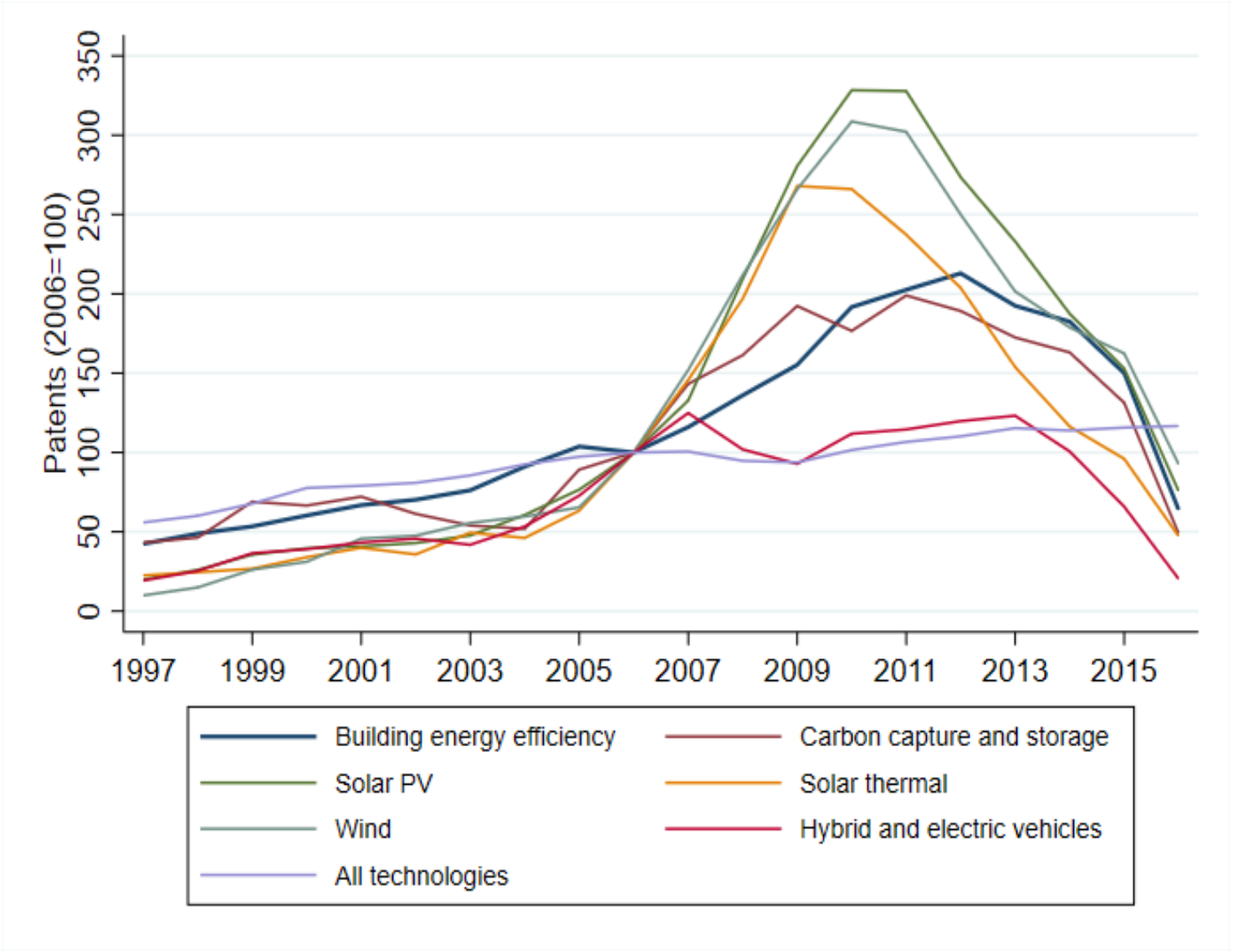
- Solutions?
  - Combine broad-based policies with targeted subsidies for technologies furthest from market (Fischer *et al*., *JAERE* 2017)
    - Most effective if target other market failures
  - Use government R&D to support long-term research needs (Acemoglu et al. *JPE* 2016)

Which technologies to target?

- Targeted energy innovation policies should focus on technologies underserved by broad-based policies

Global Energy Patents: Clean Energy



Source: Popp *et al*. (*NBER WP*#27145, 2020)

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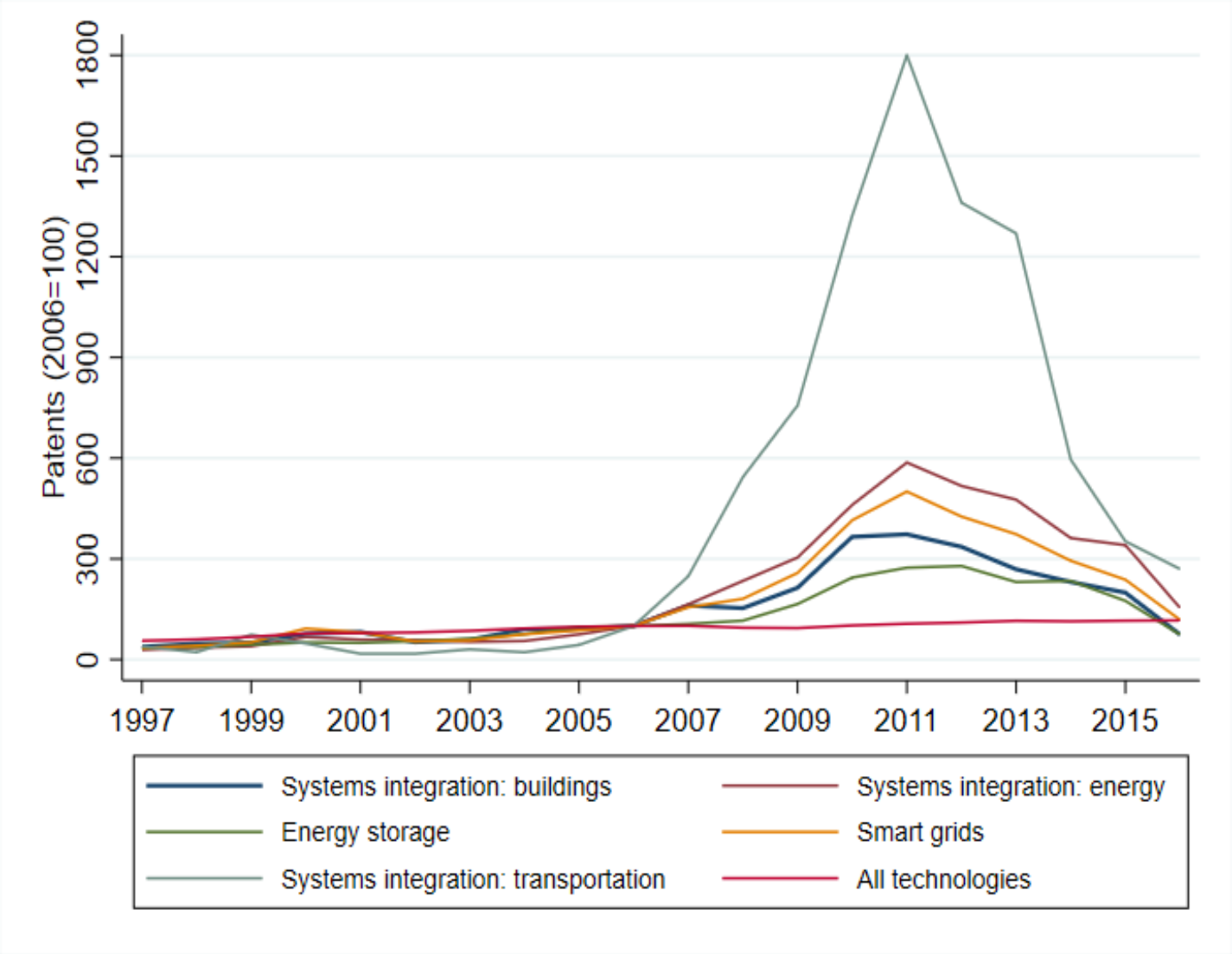
Which technologies to target?

- Why has energy innovation fallen? Possible explanations include (Popp *et al., NBER WP*#27145, 2020):
  - Lower energy prices in US ("fracking")
    - But decline is worldwide
  - Weaker than expected regulations
  - Innovation worked
    - By 2017 solar PV costs had fallen below what experts had earlier predicted for the year 2030 (Nemet, 2019)

- But…

Global Energy Patents: Enabling Technologies



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- These enabling technologies need more government support

Which policy tools to use?

- The presence of other market failures inform policy choice
  - Capital market failures
    - Energy innovations take longer to get to market (Popp, *Res. Policy*, 2017)
    - Often have large fixed costs
    - Government support helps overcome funding hurdles
    - Policy examples:
      - DOE Loan Guarantee Program
      - US Dept. of Energy SBIR grants
        - » Recipients 2X as likely to receive subsequent venture capital, produce more patents, & earn more revenue (Howell, *AER* 2017)

Which policy tools to use?

- The presence of other market failures inform policy choice
  - Capital market failures
  - Path dependency
    - Developing charging infrastructure is necessary before consumers will purchase electric vehicles
    - The private sector won't develop charging infrastructure until there are enough electric vehicles on the road to make investment profitable

      => early adopters of electric vehicles provide external benefits through network effects, justifying subsidies

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- The presence of other market failures inform policy choice
  - Capital market failures
  - Path dependency
  - Learning-by-doing
    - Justifies additional deployment policies (e.g. tax credits)
    - But LBD effects are small (Nemet, *JPAM* 2012; Tang, *Energy Policy* 2018)
      - Fischer *et al*. (*JAERE*, 2017): R&D market failures more important than LBD, so R&D spending more effective than targeted deployment policies
        - » But current U.S. policies favor deployment

Which policy tools to use?

- The presence of other market failures inform policy choice
  - Capital market failures
  - Path dependency
  - Learning-by-doing
  - Knowledge spillovers: are they different for energy?
    - Clean patents generate larger knowledge spillovers than the dirty technologies they replace (Dechezleprêtre et al., working paper 2017)
    - Justifies increased government funding for clean energy R&D

Public Sector Energy R&D

- Which technologies to support?
  - To avoid duplicating, and potentially crowding-out, private research efforts, government R&D support should focus on:
    - basic research
    - technologies not yet close to market
    - specialized technology with small markets (e.g. industrial energy efficiency)
    - applied research whose benefits are difficult to capture through market activity
      - E.g. improved electricity transmission, energy storage
  - Common theme: high-risk/high-reward projects

Guidance for Government Energy R&D Policy

- The DOE's Advanced Research Projects Agency-Energy (ARPA-E) is an example of a government agency that has successfully promoted and managed high-risk, high-reward innovation
  - Requires research teams to set clear, measurable goals through various stages of research
  - Gives program directors the ability to terminate or redirect projects not achieving these predetermined milestones
    - Takes the decision to end funding out of the hands of politicians, making it easier to support more high-risk/high-reward projects

Summary

- Targeted policies that address the market failures noted earlier are needed *even if* broad-based carbon pricing becomes a reality

- R&D is not a substitute for energy and environmental policies that create demand for clean energy, but rather complements demand-side policies

- Other targeted policies may build support for future broad-based policies (Meckling *et al*., *Science* 2015)

Thank You!