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The role of domestic policy in energy innovation

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Outline

- Government policy and technological change in energy
- Some areas of new research insights relevant for the design of Mission Innovation and other energy innovation efforts
  - Energy R&D decision support
  - Public-private funding mechanisms for energy R&D
  - Public energy R&D institution management
  - The importance of the international dimension
- Concluding remarks

The linear model of innovation

- The ‘linear’ model, in which new technologies always stem from basic research, is still the mental model of many policymakers

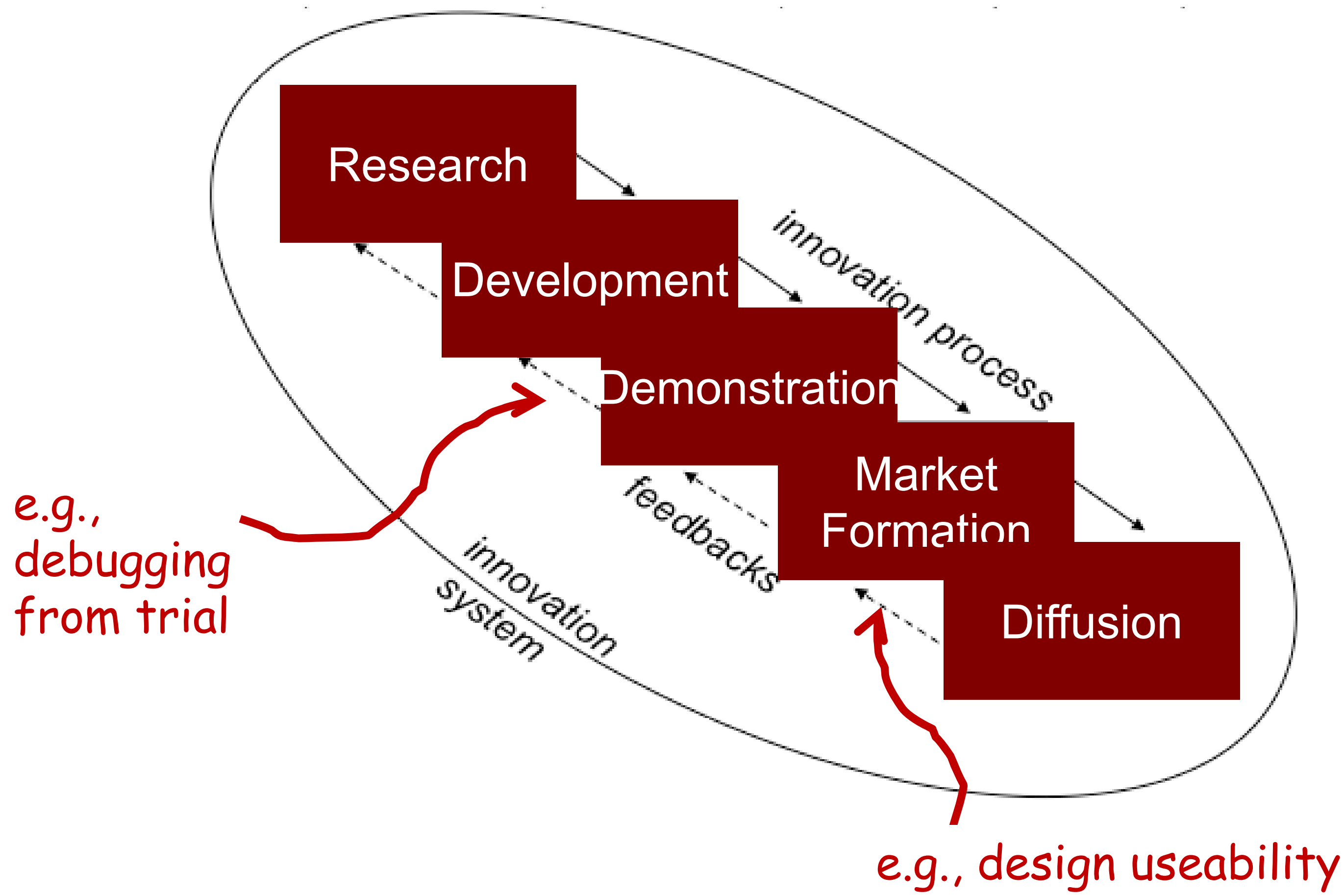
Research → Development → Demonstration → Diffusion

- In electrical equipment industries, theoretical and experimental physics preceded incandescent light, telephone, gramophone, radio, and TV
- But in other industries (tanning, dying, brewing), innovation came before science and engineering explained the processes
  - Early flying machines came before aerospace engineering
  - Transistors preceded the theory of holes an electrons in semiconductors

➔ Problems observed in industry don’t stay there, they are fed into research

Mowery & Rosenberg (1979); Arthur (2009); Gruebler *et al* (2013)

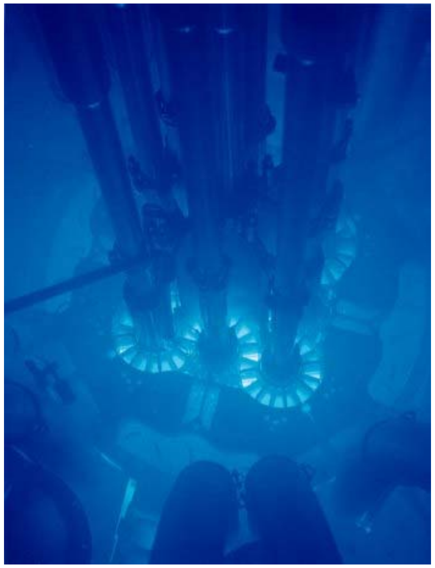
Innovation systems approach emphasizes interactions and information



Global Energy Assessment (2011)

Government policy plays a unique role

- Government R&D and its combination with other policies has played and continues to play a key role in energy



Mazzucato, Stiglitz, Perez, and many others have challenged the ‘minimalistic’ view and argue that creating markets is an important role

Types of policies shaping energy innovation

Reducing cost of innovating:
Increasing the supply of knowledge

Technology-Push Policies

- RD&D policy:
  - Federal/state RD&D funding
  - Public-Private partnerships for demonstration projects
  - R&D tax credits
  - International cooperation in RD&D, etc.

- Education policy to improve and expand the labor force

Energy Technology Innovation

Increasing payoff to innovators:
Increasing the demand for innovation

Market-Pull Policies

- Price incentives
  - Direct spending (rebates)
  - Government procurement
  - Tax-related subsidies
  - Loan guarantees
  - Intellectual property, etc.

- Standard-based policies
  - Performance standards
  - Interconnection standards
  - Portfolio standards, etc.

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- Market-based policies
  - Cap and trade
  - Charge systems, etc.

Adapted from Mowery and Rosenberg (1979) and Anadon and Holdren (2009), *Brookings Press*

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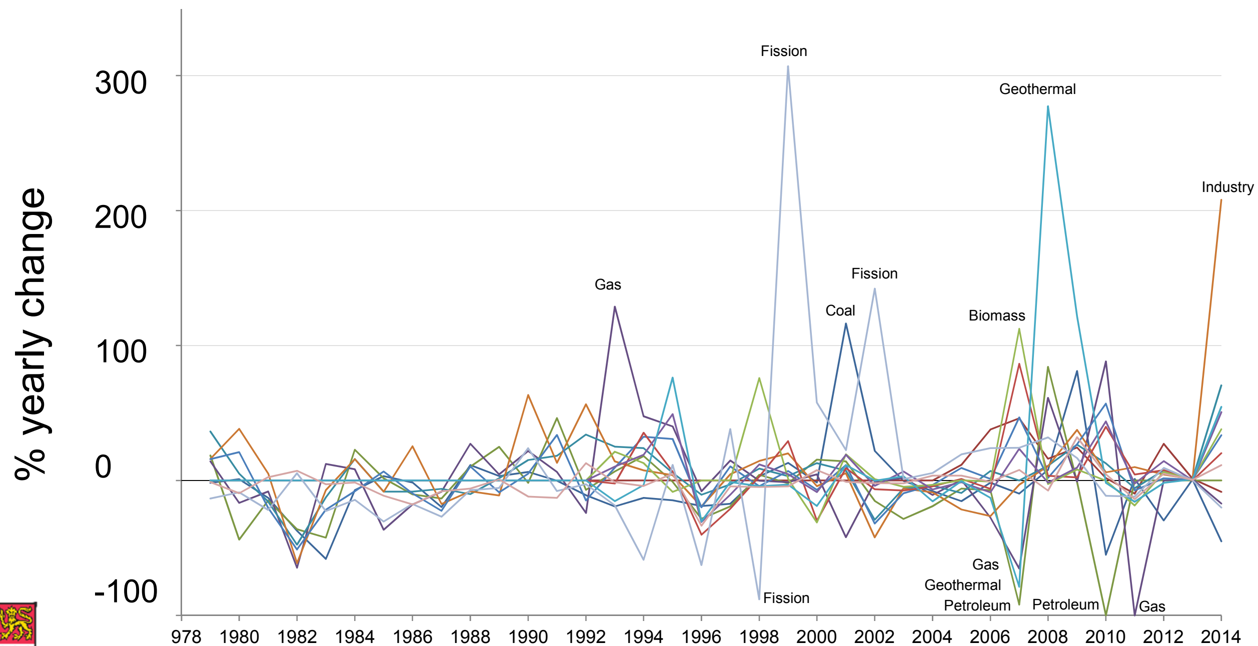
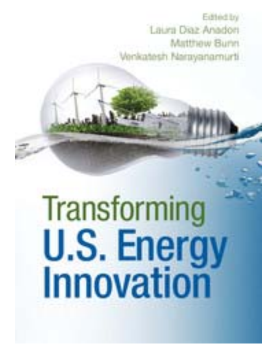
Supporting R&D decision-making

How public energy R&D decisions are made in the US

- US:$3bn, ~5% of non-defense R&D goes to Dept. of Energy
  - DOE proposes a budget and allocation with technical inputs from labs
  - OMB scrutinizes requests based on Presidential objectives
  - Congress allocates funds

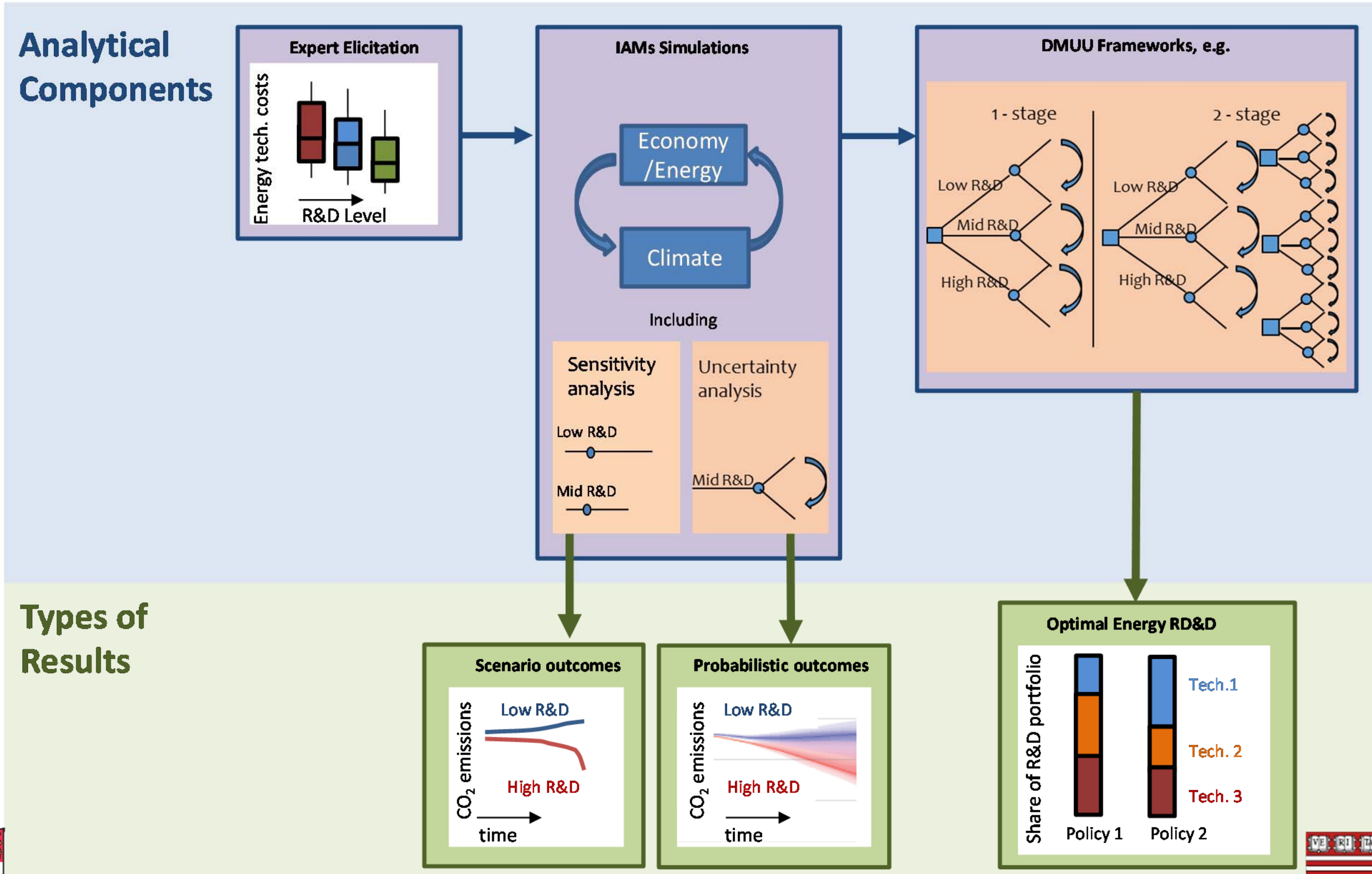
- Analysis and R&D allocation outcome do not consider market interactions, are volatile and lack legitimacy





Gallagher & Anadon (2016); Anadon, Chan & Lee (2014)

Accounting for technology uncertainty to provide new R&D policy insights (& increase legitimacy)



Anadon, Baker, Bosetti (2016), *under review*

Application of methods leads to insights about public US R&D investments

- R&D is not enough to meet climate goals (agrees with other work)

- Expected returns justify greater investments

- Allocation of R&D in the US not optimal (storage and solar underfunded)

Chan & Anadon (2016); Anadon, Chan & Lee (2014). *Cambridge University Press*

Combining insights of 9 studies using different methods, elicitations, and IAMs:

- Models and technology assumptions lead to different optimal R&D portfolios
- Only a limited number of technologies covered, but within these limitations:
  - The stricter the climate stabilization, the larger the share of CCS/nuclear/bioelectricity
  - The larger the R&D budget:
    - lower the share for vehicles
    - constant share of bienergy
    - solar decreases (driven by small budgets & intermittency assumptions)
    - increase in nuclear or CCS
  - For high R&D budgets, the ratio of optimal R&D/ (deployment + R&D) is between 1.5-4.4% (2013, excluding RPS and other subsidies, 4.6% for renewables) (15bn)

Anadon, Baker, Bosetti (2016), *under review*

From how much to how?

- Many analysts (including myself) had focused a lot effort on demonstrating that increasing energy R&D funding is needed

- This is very important, but given Mission Innovation pledges, the question is shifting to **how:**

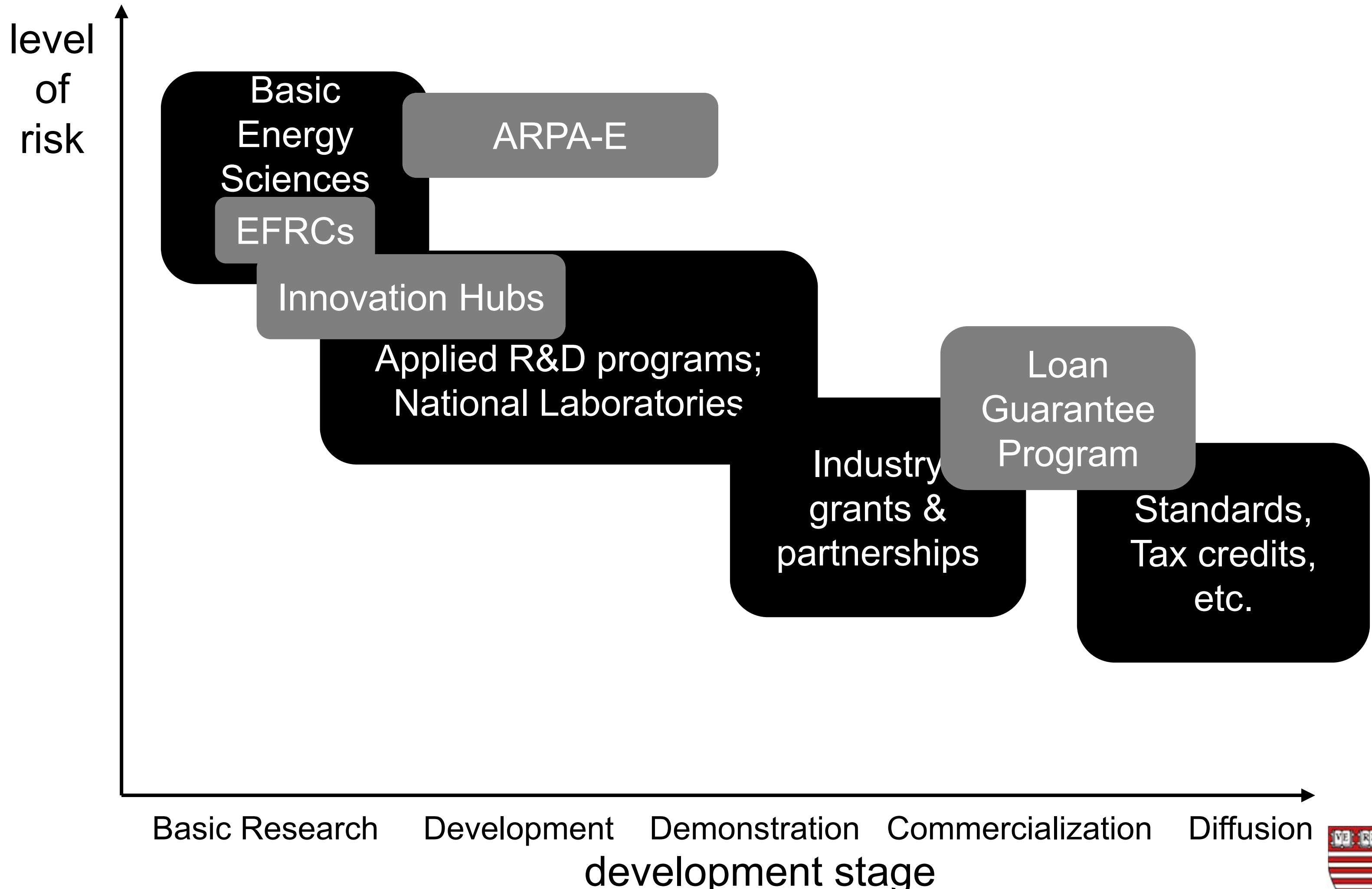
  - What types of collaborations with industry? Licensing, joint development, small procurement? And with what types of firms?

  - How much in national labs/universities? And how to manage them

  - And how to select demonstrations?

New evidence about public-private collaborations in the US

Insights on public-private interaction design from the U.S. experience



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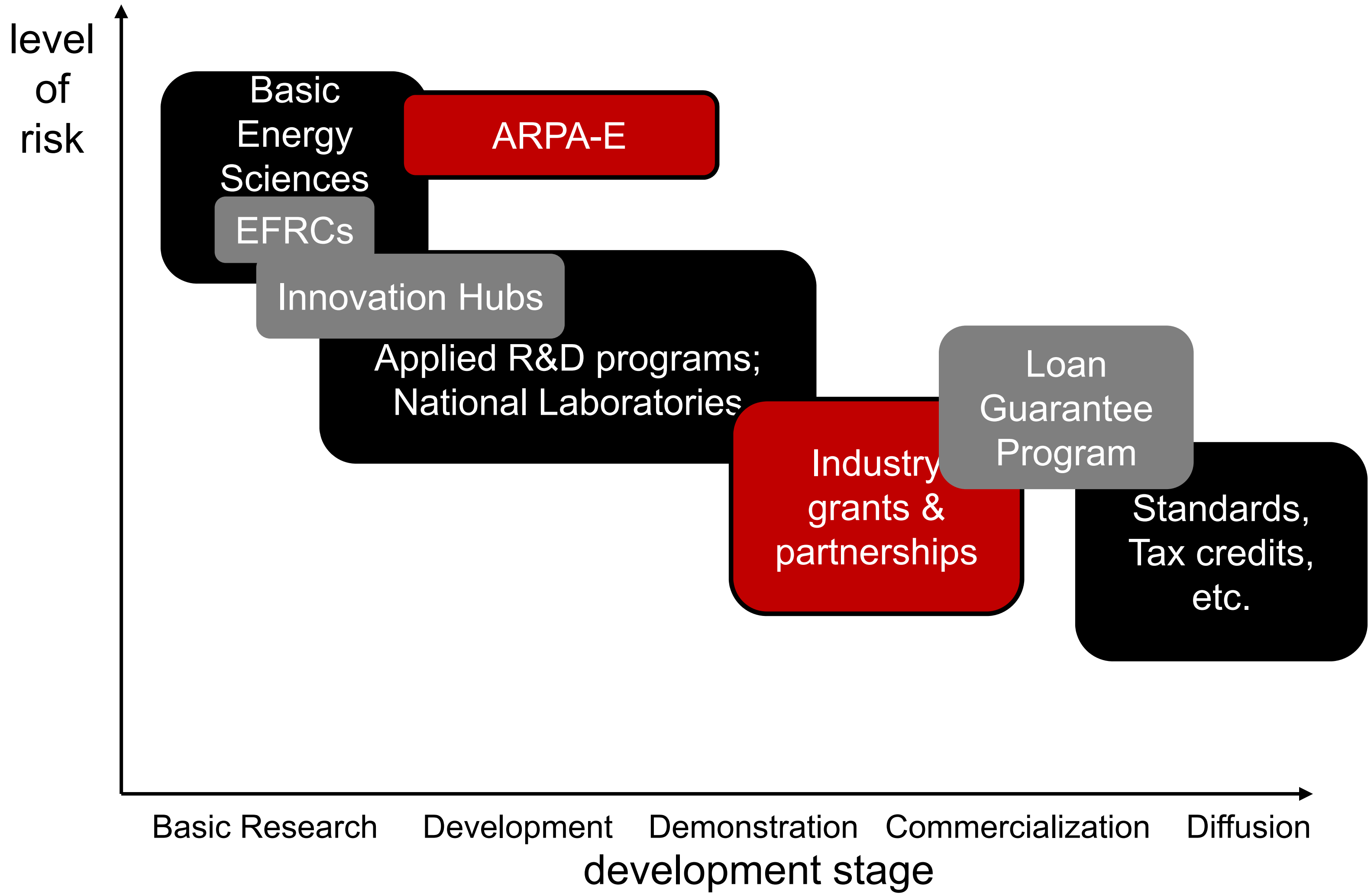

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Impact of collaborations on short term outcomes for US cleantech startup firms

Collaboration Type	
Technology-based collaboration	joint technology development
	licensee
Market-based collaboration	procurement or customer
Additional forms of collaboration	licensor
	project development

- Evaluated relationship between different partnerships and partner types on patents and financing deals:
  - Controlling for network aspects, size, location, age, sector, etc

Doblinger, Surana & Anadon (2016)

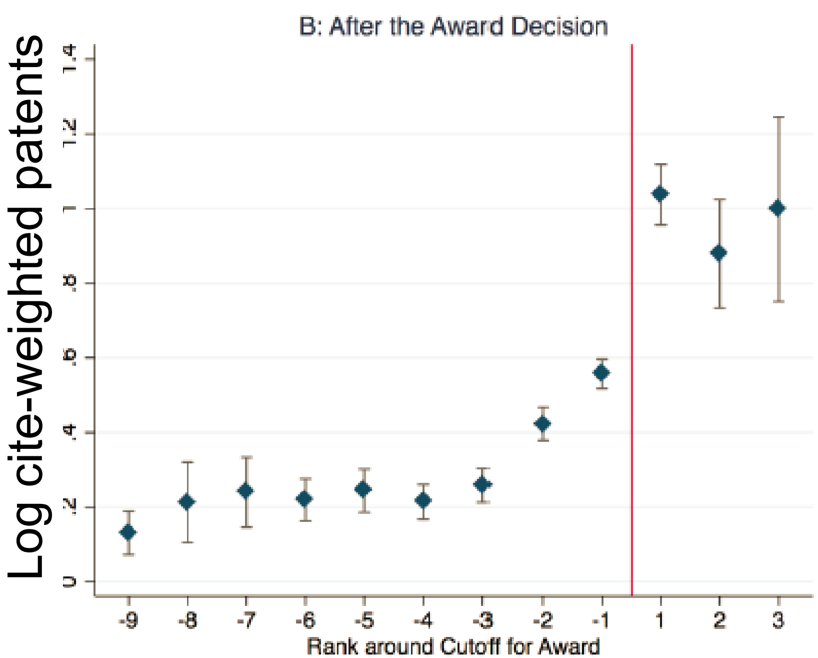
Results relevant for public-private partnership design

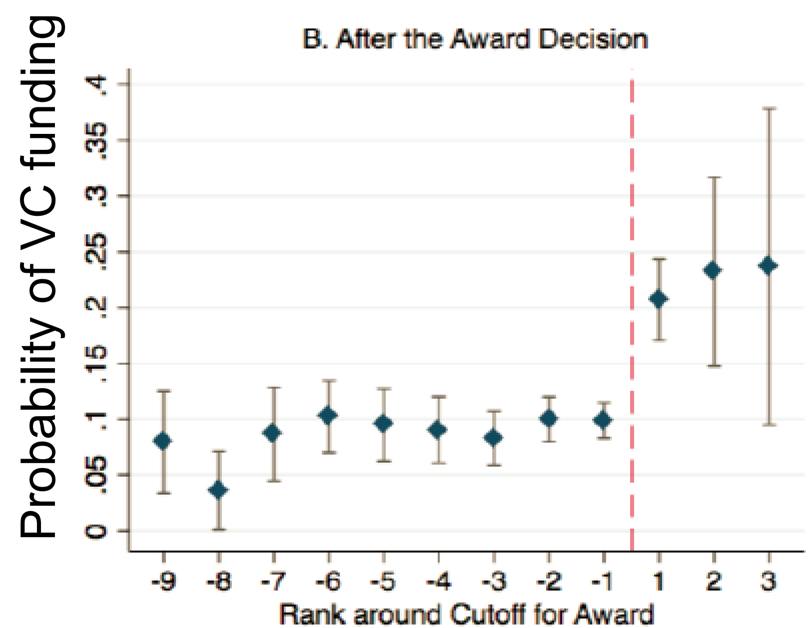
- Technology and licensing partnerships with network central organizations enables increased innovative activities—regardless of geographical proximity
  - Relationships with other firms have no correlations, with universities smaller
  - Partnerships with public R&D organizations more important for unconnected startups
  - Co-location in technology hotspots might be more important for startups operating in sectors that are characterized by frequent changes, high-turnover rates, and smaller capital requirements
- Public procurement not associated with better startup outcomes
- Public licenses associated with improved follow-on investment outcomes

Doblinger, Surana & Anadon (2016)

DOE R&D grants to small businesses

- Regression discontinuity design on U.S. DOE Small Business Innovation Research (SBIR) grant recipients:
  - Award doubles probability that a firm receives subsequent VC and has large, positive impacts on patenting and commercialization





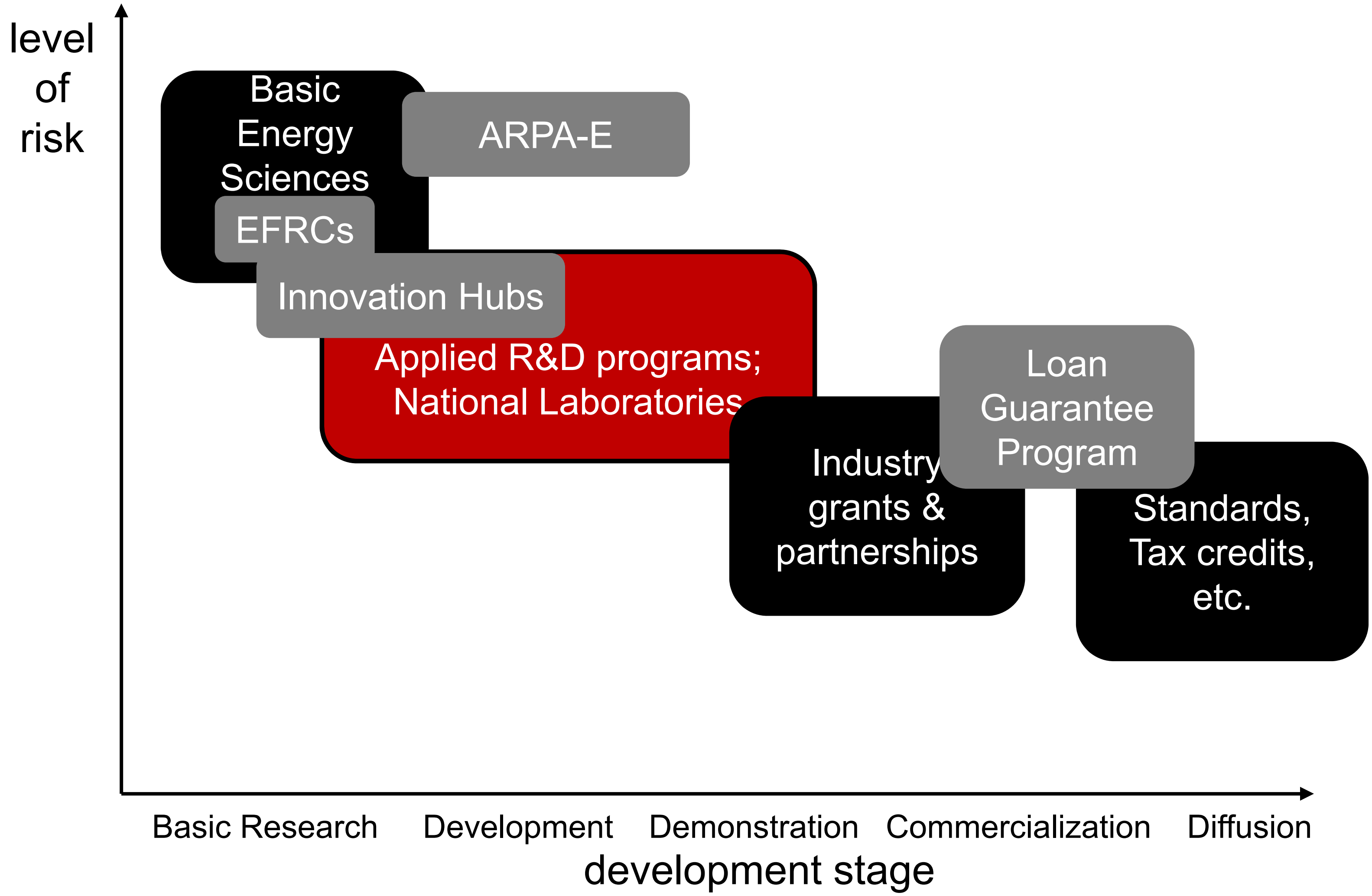
Howell (2016)

Ongoing work on ARPA-E and licenses

- ARPA-E awardees doing better (DID & matching) than non-awardees and other firms on follow on funding (Goldstein, Doblinger, Anadon 2016, ongoing)
- Chan (2016) used matching on patents from U.S. national labs:
  - Licensing increases spillover benefits to other firms
  - Whether or not not-patenting would result in better outcomes is a longstanding question

Insights on public R&D institution management

Insights on public R&D organization management

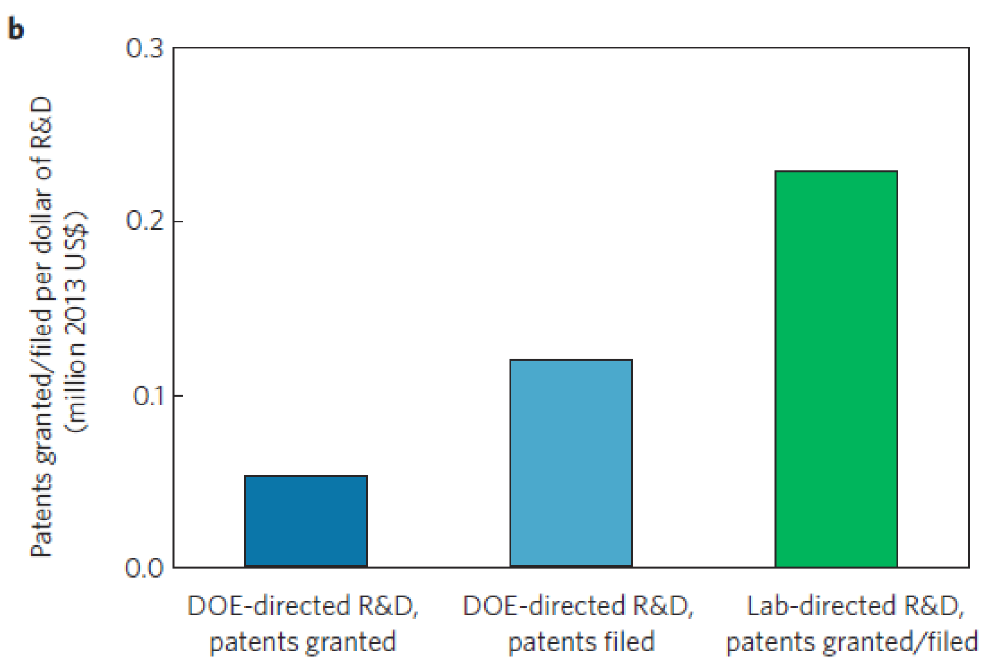


- Over 68 countries have at least 30% of all R&D done by govmn'ts…

Anadon, Bunn, Narayanamurti (2014). *Cambridge University Press;* Anadon et al (2016) *Nature Energy*

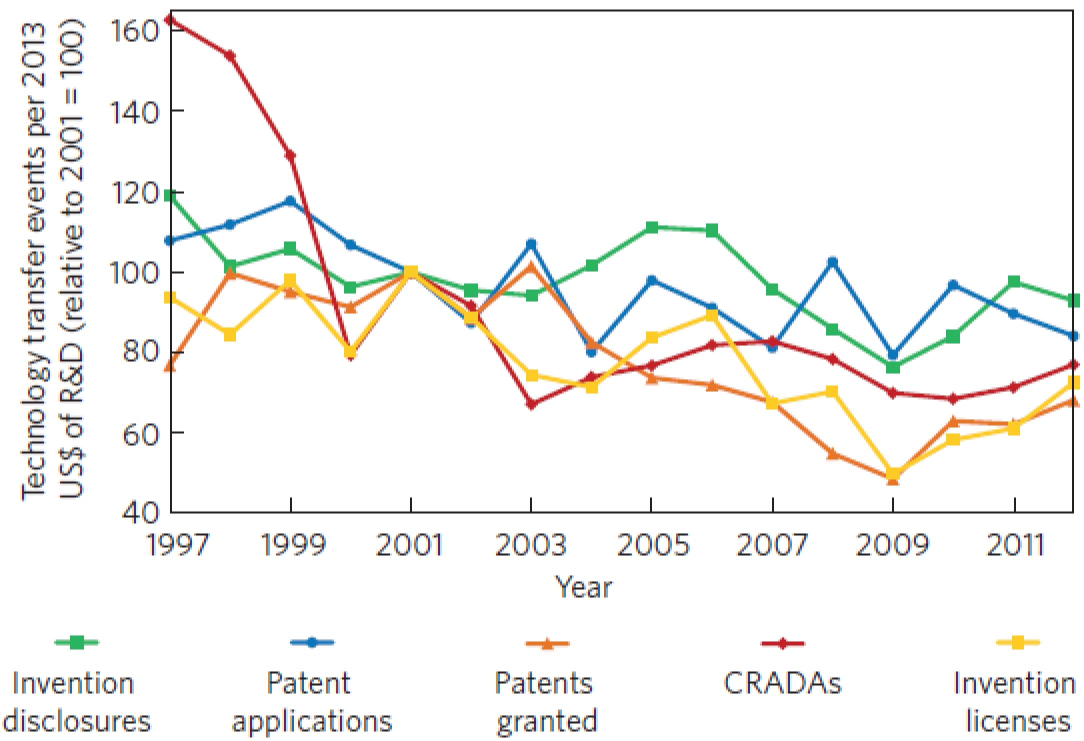
Lab controlled funds are productive in tech transfer terms

- Lab directed funds have decreased twice recently but are found to be productive in terms of patents and disclosures
- Icrease LDRD at the margin, further facilitate private sector interaction, and new contracting approaches



Anadon, Chan, Bin-Nun, Narayanamurti (2016), *Nature Energy*

Increased demands for ‘results’ in technology (less tolerance to uncertainty) can result in vicious circle



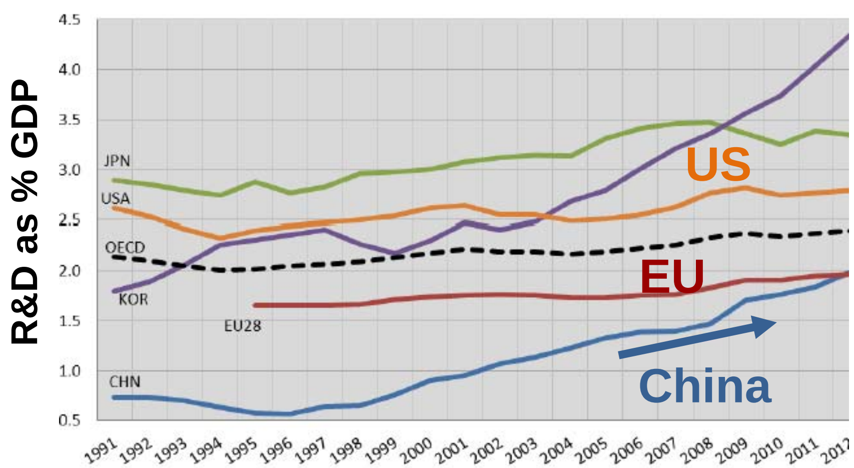
- From interviews and data analysis we posit that there is a vicious circle of congressional demands for short-term results, increased admin, less risk taking, less results, which leads to more demands for results…
- There is a need to enable more fluid interaction of researchers with private sector and a review of contracting methods

Anadon, Chan, Bin-Nun, Narayanamurti (2016), *Nature Energy*

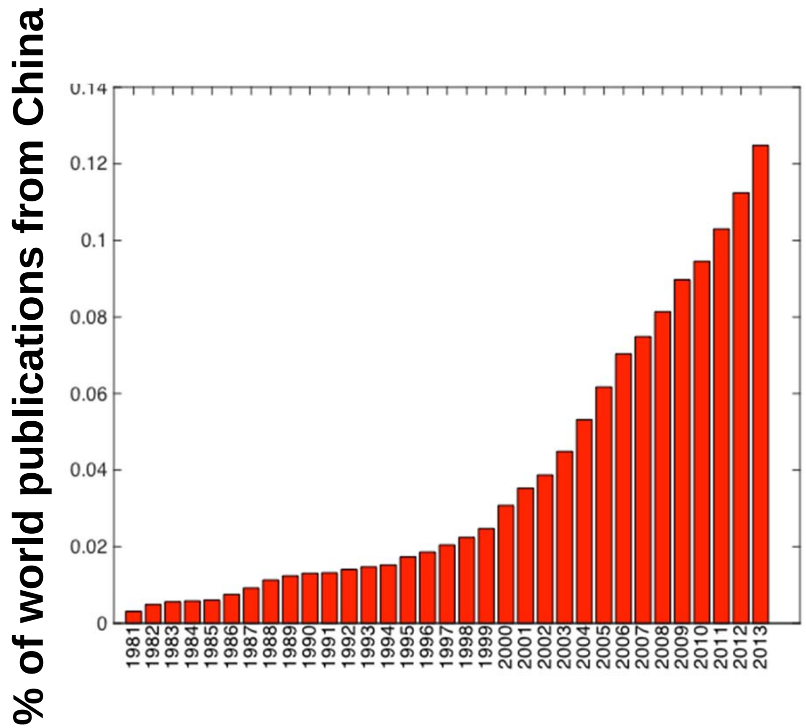
What is shaping the debate on the role of government internationally?

Non-OECD countries are becoming important in innovation

China example



OECD (2014)



Siddiqi et al. (2016); Binz et al. (2015)

Unlike the wind development story in India and China, solar PV in China was fast and not directed by govmn’t

- Surana & Anadon (2015) in *Global Environmental Change* documented the deliberate government actions developing wind in China and India

- In Binz & Anadon (2016) we found that the emergence of the PV manufacturing industry in China was not directed by the central government and relied to a large extent on a set of international resources and generic domestic absorptive capacity

Binz & Anadon (2016). *Under review*

Concluding remarks

- R&D portfolio analysis can help hedge against risks, we have a better handle on energy expert elicitations
- Some evidence of some types of public-private partnerships having positive impacts on patenting and follow on financing (growth)
- National R&D organizations important for cleantech startups but some changes could improve effectiveness on energy innovation mission
- International competition is growing, and the extent to which it can be organic may depend on the technology area

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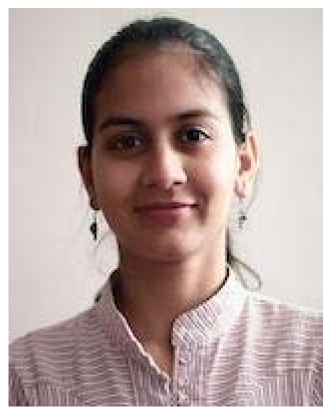

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