UNIVERSITY OF CAMBRIDGE

HARVARD Kennedy Sch
JOHN F. KENNEDY SCHOOL OF GOVERNMENT

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Government funding and support for energy RD&D: what do we know about outcomes?

Session 4: Regulation and innovation for smarter and cleaner energy markets & networks
EPRG Spring Seminar, Howard Theatre, Downing College
University of Cambridge

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Overview

1. Motivation: government role in energy innovation
   - From how much to how?

2. Public energy R&D institutions in context

   - *US National Labs*

   - *Partnerships with cleantech startups and grants to SMEs*

   - *ARPA-E*

3. Key findings

4. Questions going forward

Government policy plays an important role
Calls for more funding for energy innovation since the mid-1990s

- Government R&D and its combination with other policies has played and continues to play a key role in energy
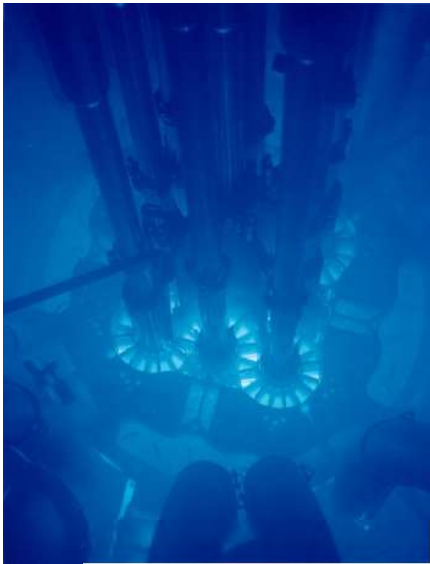
# [ASIDE: In spite of Trump´s proposals, US Congress is not going along with energy R&D cuts]

udget approved by
ongress last month
nored President Trump's
quest

- Different sides of the
  aisle could get behind
  different pieces of
  evidence advancing
  different goals

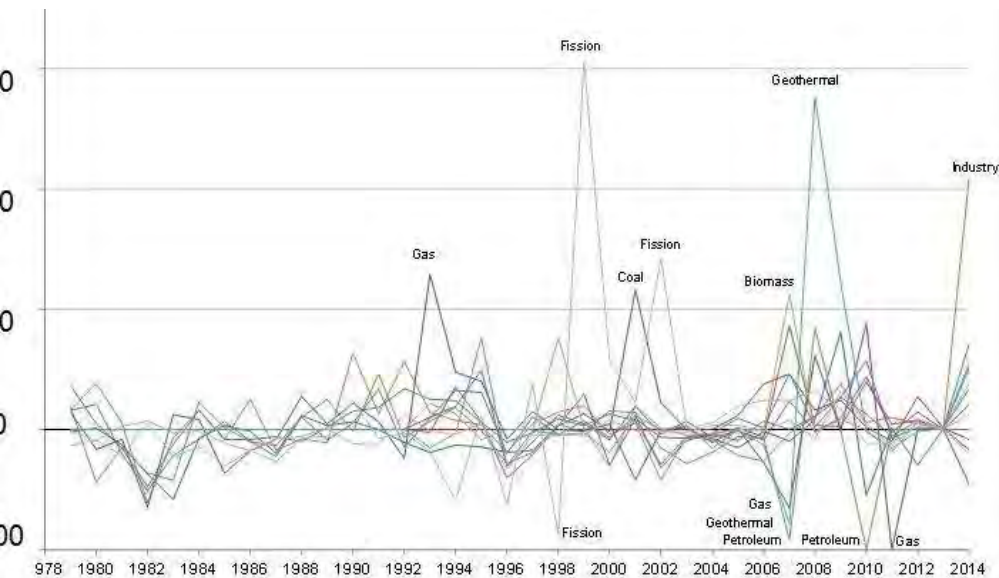Anadon, Gallagher, Holdren (2017). *Nature Energy*
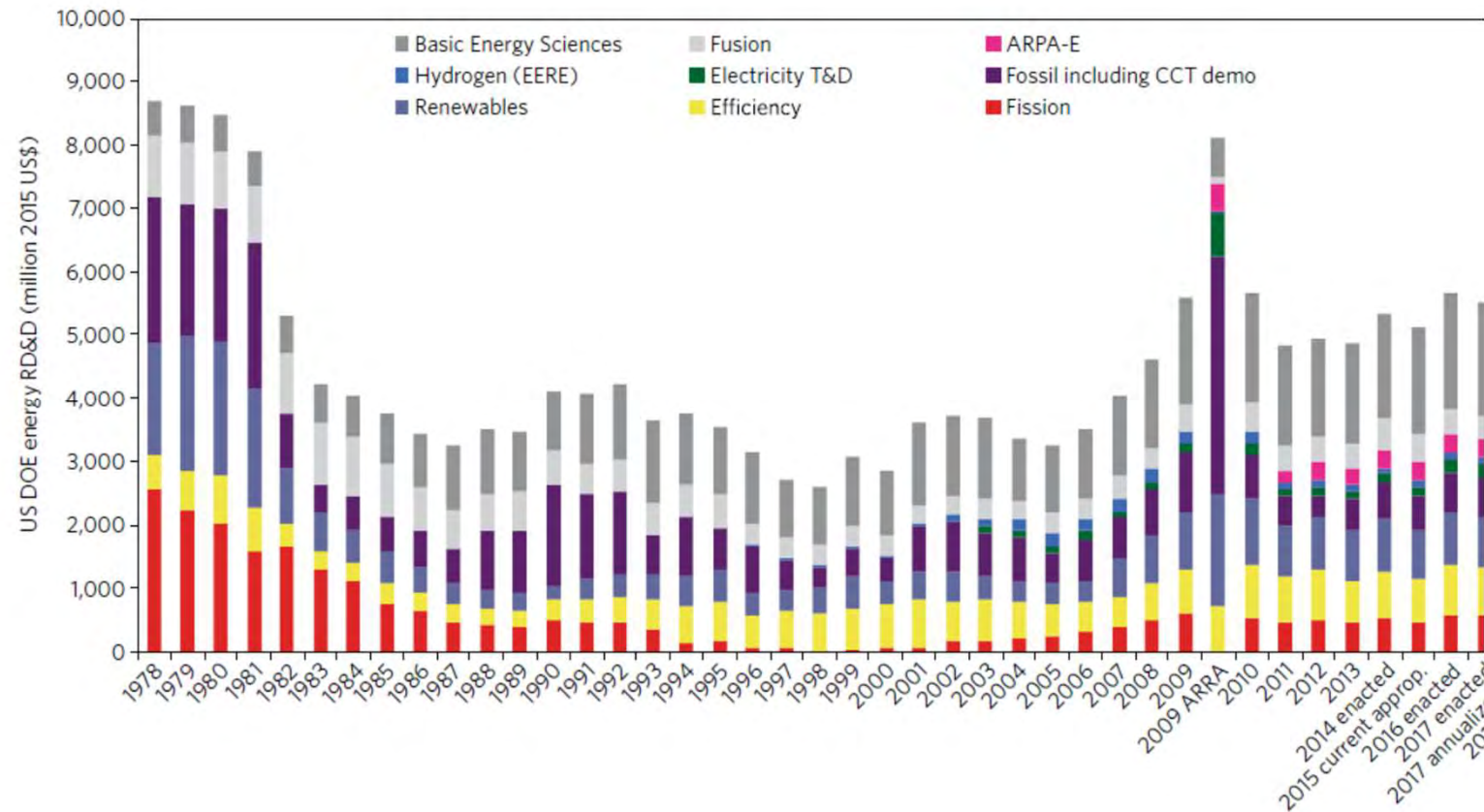
Work prioritizing R&D investments across technologies
Biggest returns on investments on storage and solar
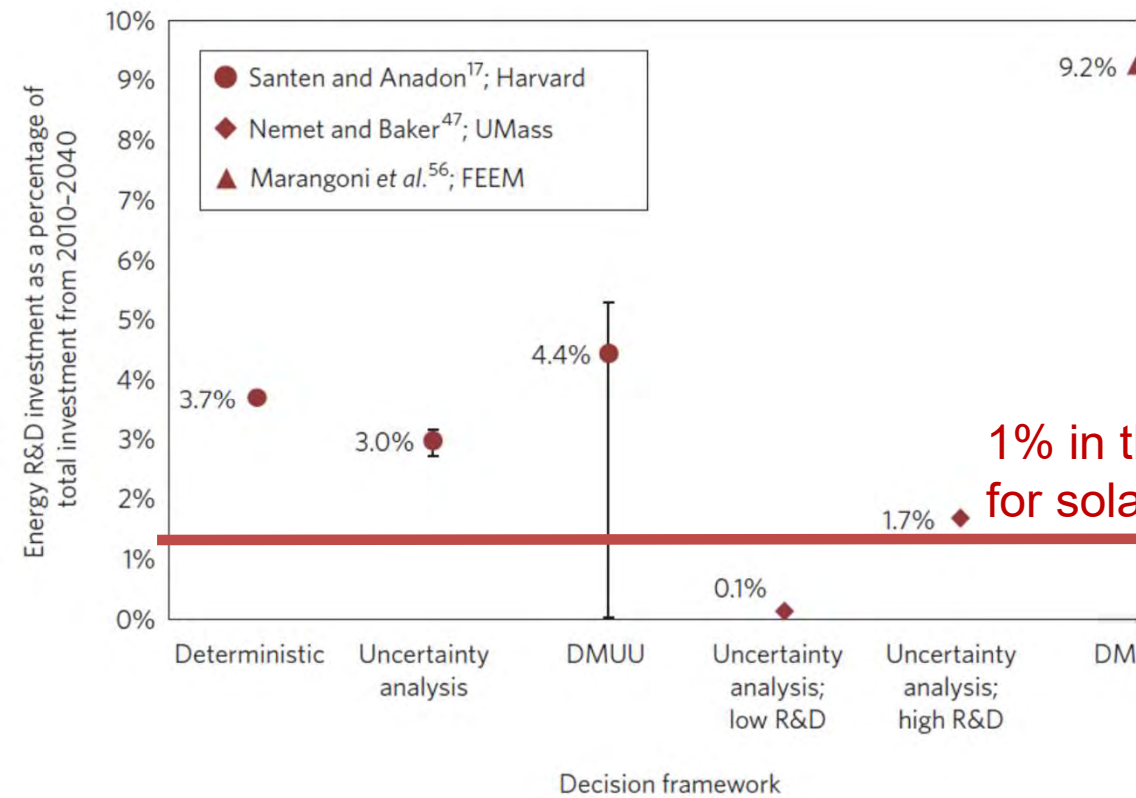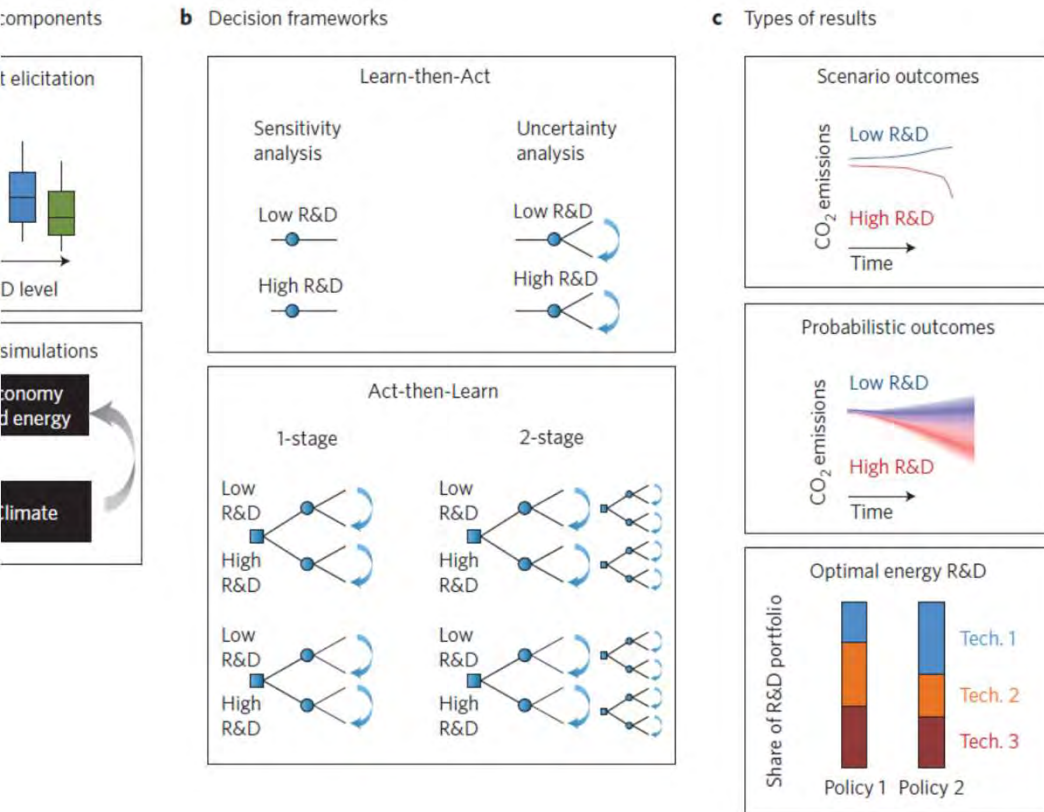
Anadon, Baker, Bosetti (2017), *Nature Energy;*
*Santen & Anadon (2016) Ren. & Sust. En. Rev.*

or some time we have pointed out the need for more funding tability

VOLATILE FUNDING

US Department of Energy budgets for the research, development and demonstration of different technologies fluctuate between years as government policies and priorities change. Unstable funding lowers the efficacy of such programmes.

Anadon, Chan & Lee (2014), CUP
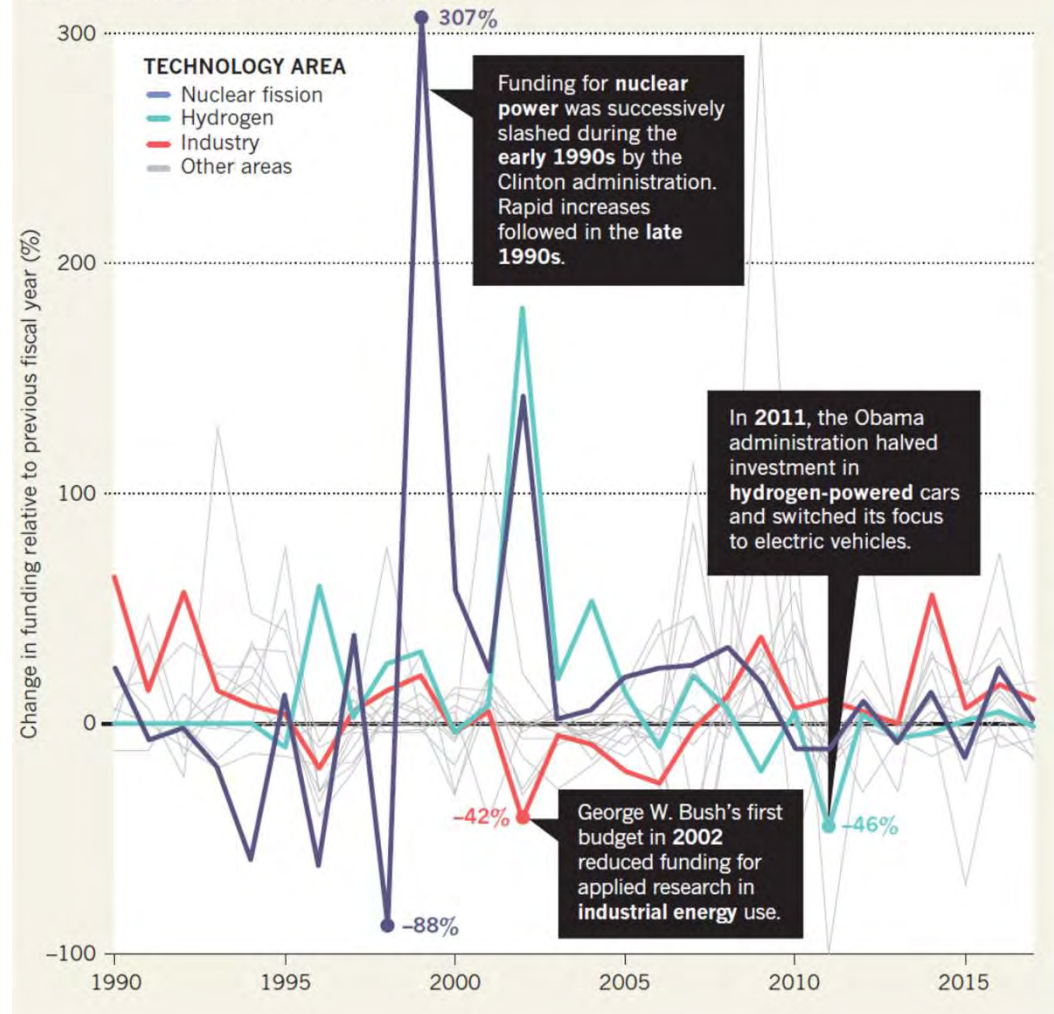
Chan, Bin-Nun, Goldstein, Anadon, Narayanamurti (2017) *Nature*

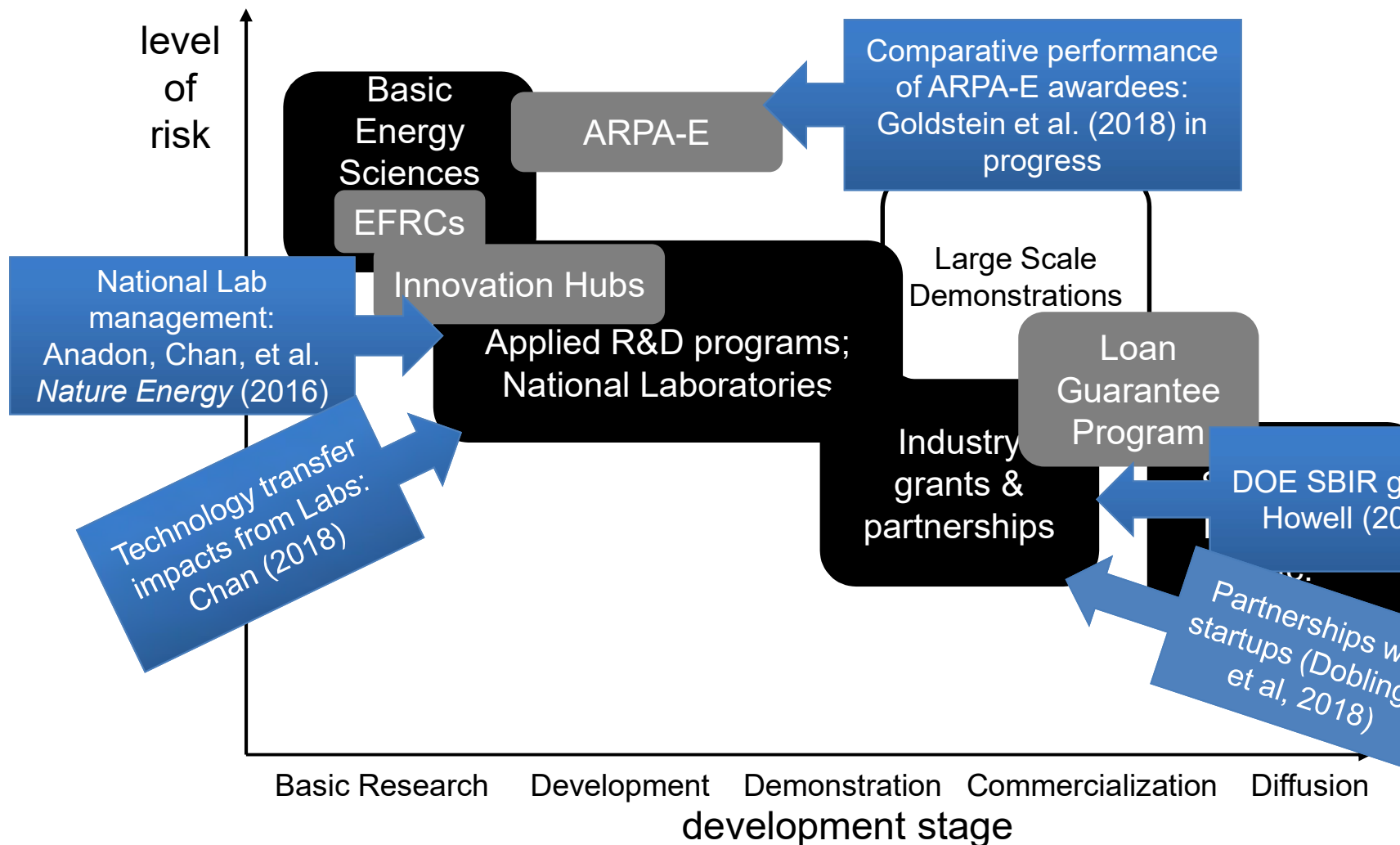# 2. Public energy innovation institutions

Recent institutional innovation in energy R&D

Updated and adapted from Anadon (2012) in *Research Policy* & Chan et al. (2017) in *Nature*:

$: provision of funds

circles: direct private sector involvement in decision-making;

house: creation of new entity during the funding;

person: provision of expertise in the form of business or technical advice.

| Country	Selection of new institutions funding and enabling energy innovation	Use-inspired basic research	Applied R&D	Demonstration	Market formation and deployment
United Kingdom	UK Carbon Trust (2001-)				👤 $
	UK Energy Research Center (2004-)	Non-technology, social science research			
	Energy Technologies Institute (2007-)		$ ⊚		
	Env. Transf. Fund/International Climate Fund (2008/2011-)				$ 👤
	Technology Strategy Board/Innovate UK (2008/2014)[1]		$ ⊚		
	Catapults[2] (2011-)		$ 🏠 ⊚ 👤		
United States	Energy Frontier Research Centers (2008-)	$ 🏠			
	ARPA-E (2009-)	$ 👤			
	Energy Innovation Hubs[3] (2009-)	$ 🏠			
	Cyclotron Road (2015-)	$ 👤			

2017: Faraday Institute

Growing evidence on the impact of different federal energy innovation institutions/policies in the US

Data is starting to become available to learn more about the impacts (short term) of different initiatives

level of risk

Basic Energy Sciences

ARPA-E

Comparative performance of ARPA-E awardees: Goldstein et al. (2018) in progress

EFRCs

Innovation Hubs

National Lab management: Anadon, Chan, et al. *Nature Energy* (2016)

Applied R&D programs; National Laboratories

Large Scale Demonstrations

Loan Guarantee Program

Technology transfer impacts from Labs: Chan (2018)

Industry grants & partnerships

DOE SBIR g Howell (20

Partnerships w startups (Dobling et al, 2018)

Basic Research   Development   Demonstration   Commercialization   Diffusion

development stage

Anadon, Bunn, Narayanamurti (2014). *Cambridge University Press.*

US National Labs

- Particularly timely in the UK since labs were mostly privatized in the 1980s and the Faraday Institution is trying to create a 'virtual lab'
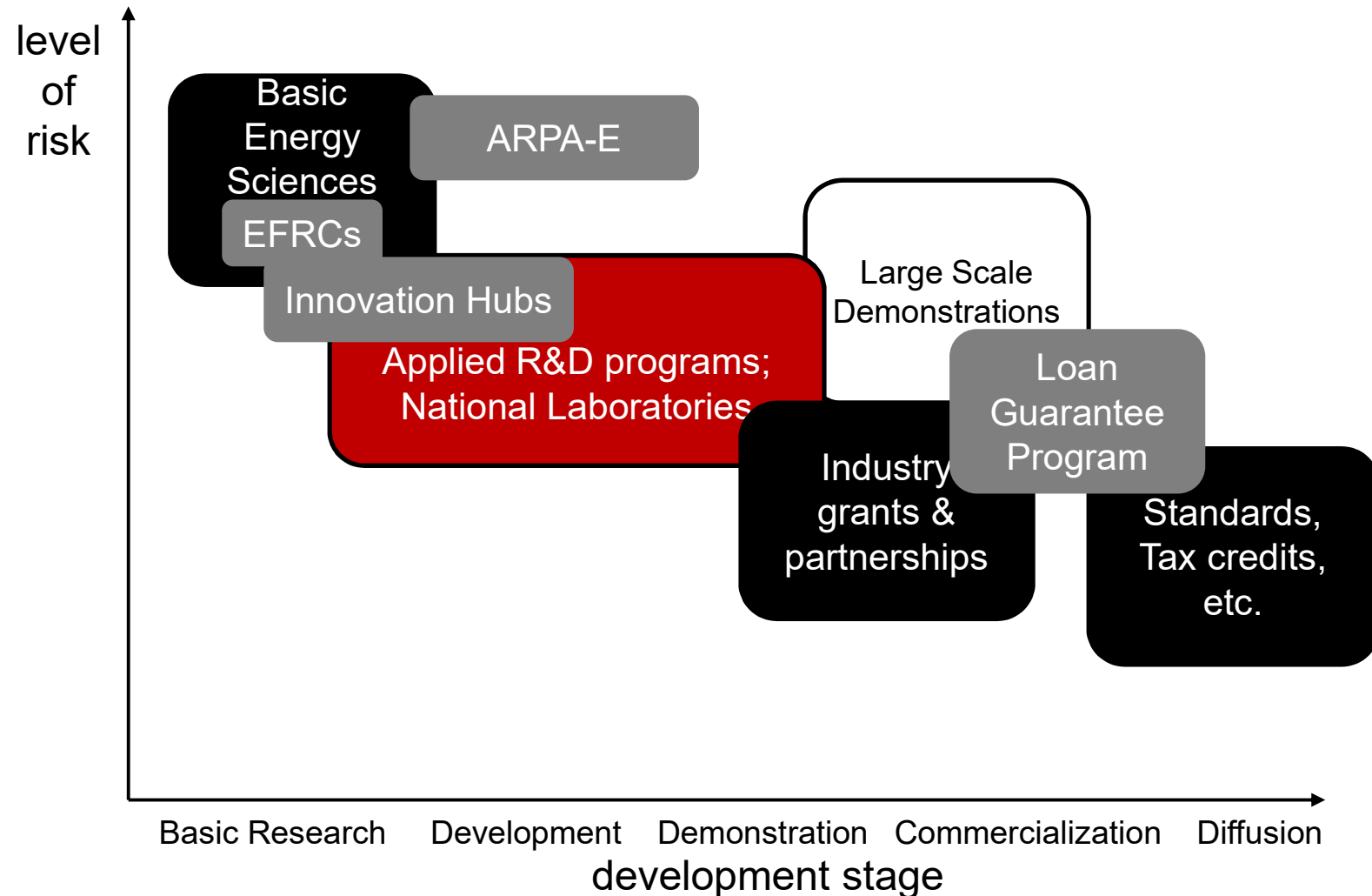
Anadon, Bunn, Narayanamurti (2014). *Cambridge University Press.*

Lab- (as opposed to HQ-) controlled funds are more productive at the margin in tech transfer terms
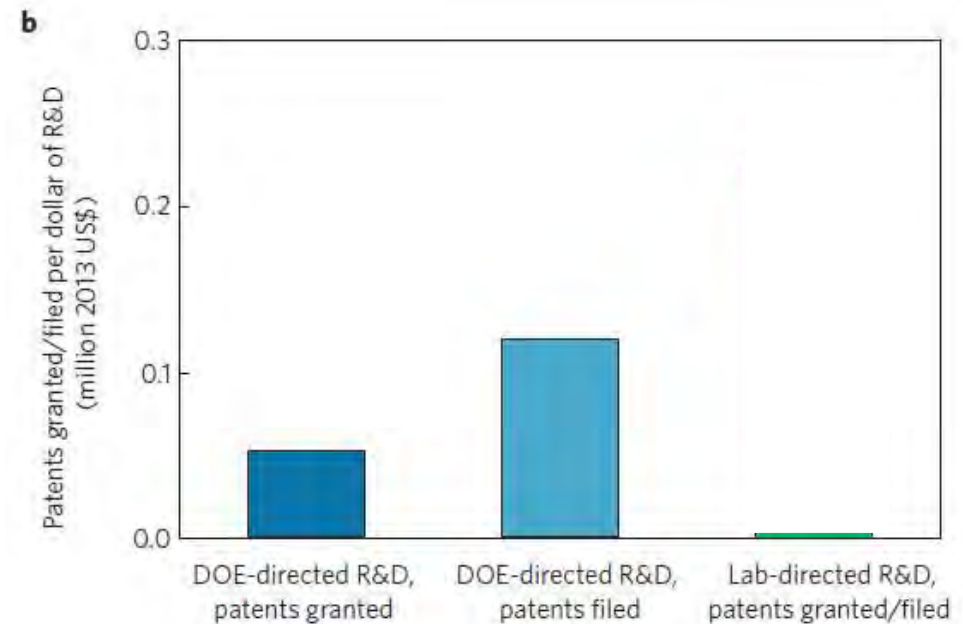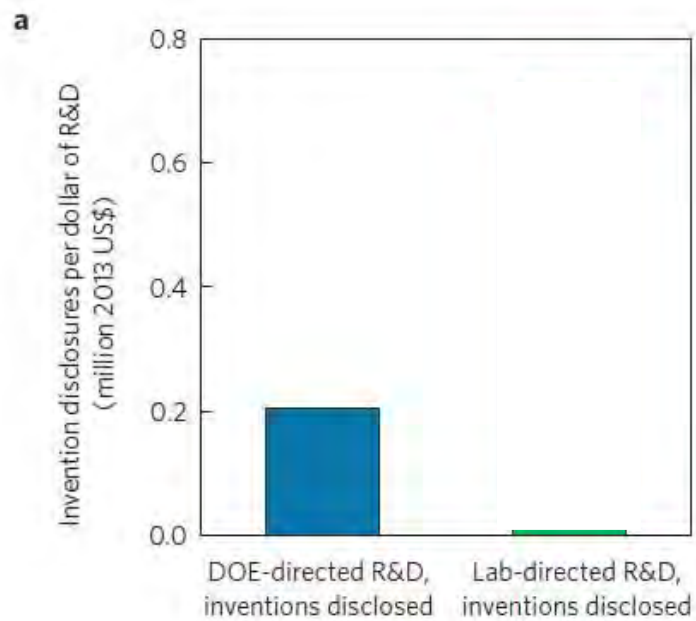
Anadon, Chan, Bin-Nun, Narayanamurti (2016), *Nature Energy; See also
Chan et al. (2017) Nature "Six guiding principles for energy innovation"*

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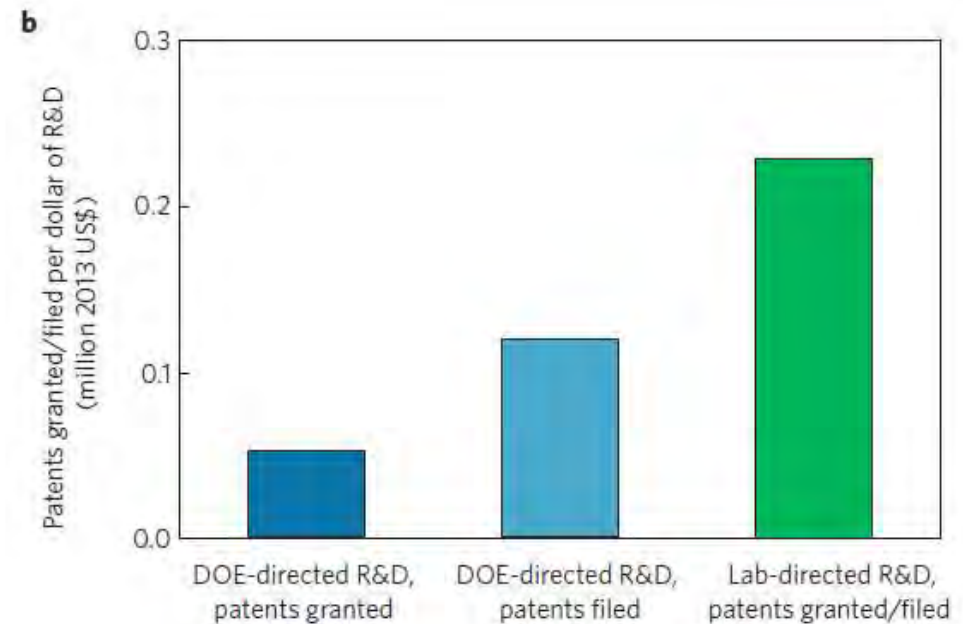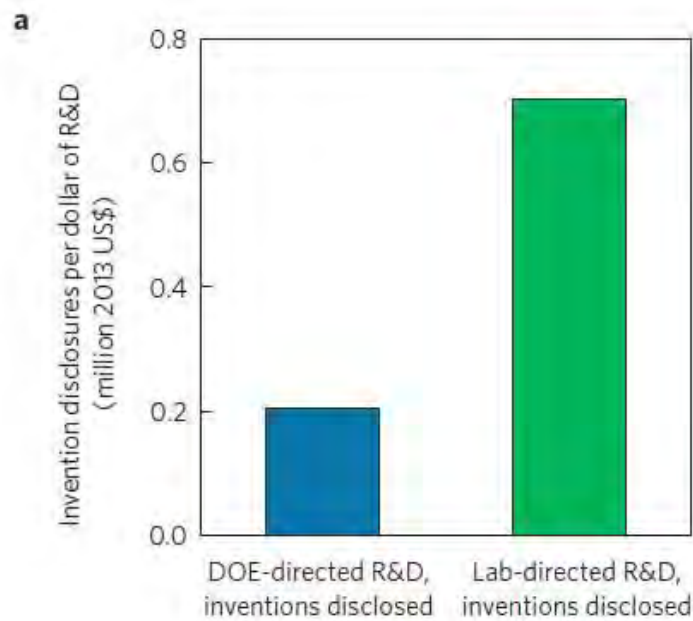
- Lab directed funds have decreased twice recently but are the most productive ➔ increase laboratory directed funds (LDRD) at the margin, further facilitate private sector interaction, and new contracting approaches

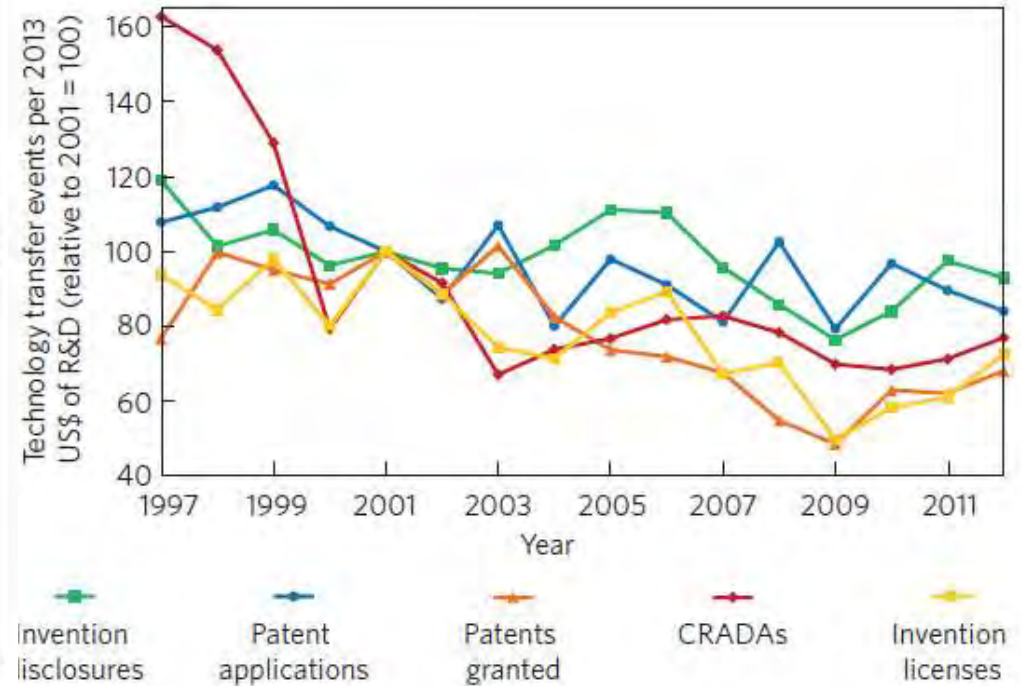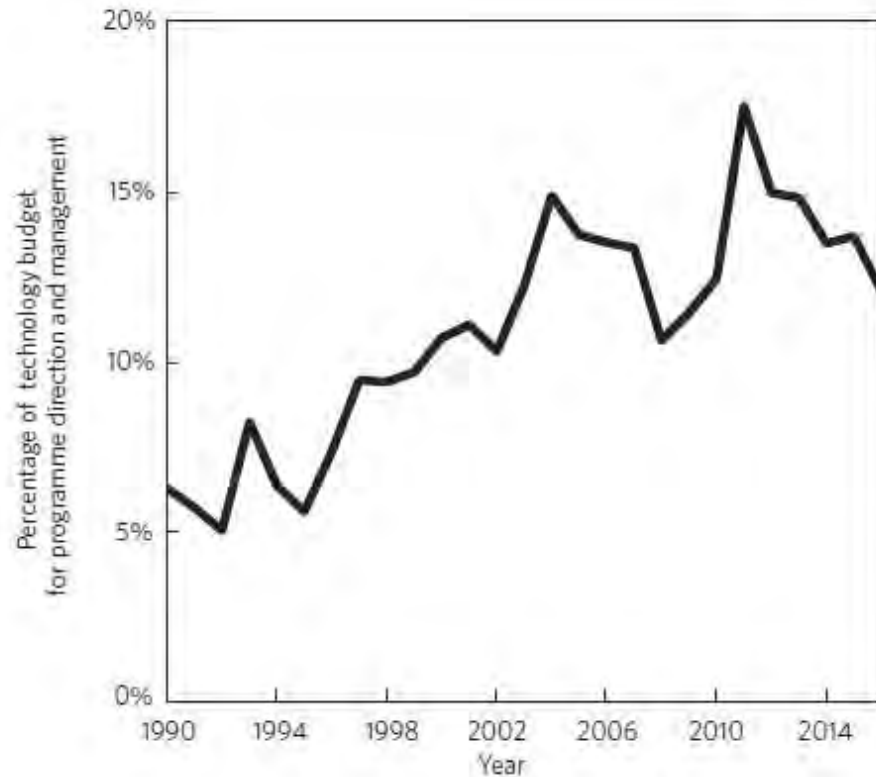Anadon, Chan, Bin-Nun, Narayanamurti (2016), *Nature Energy; See also Chan et al. (2017) Nature "Six guiding principles for energy innovation"*

Increased demands for short term 'results' (less tolerance to uncertainty) can lead to a vicious circle
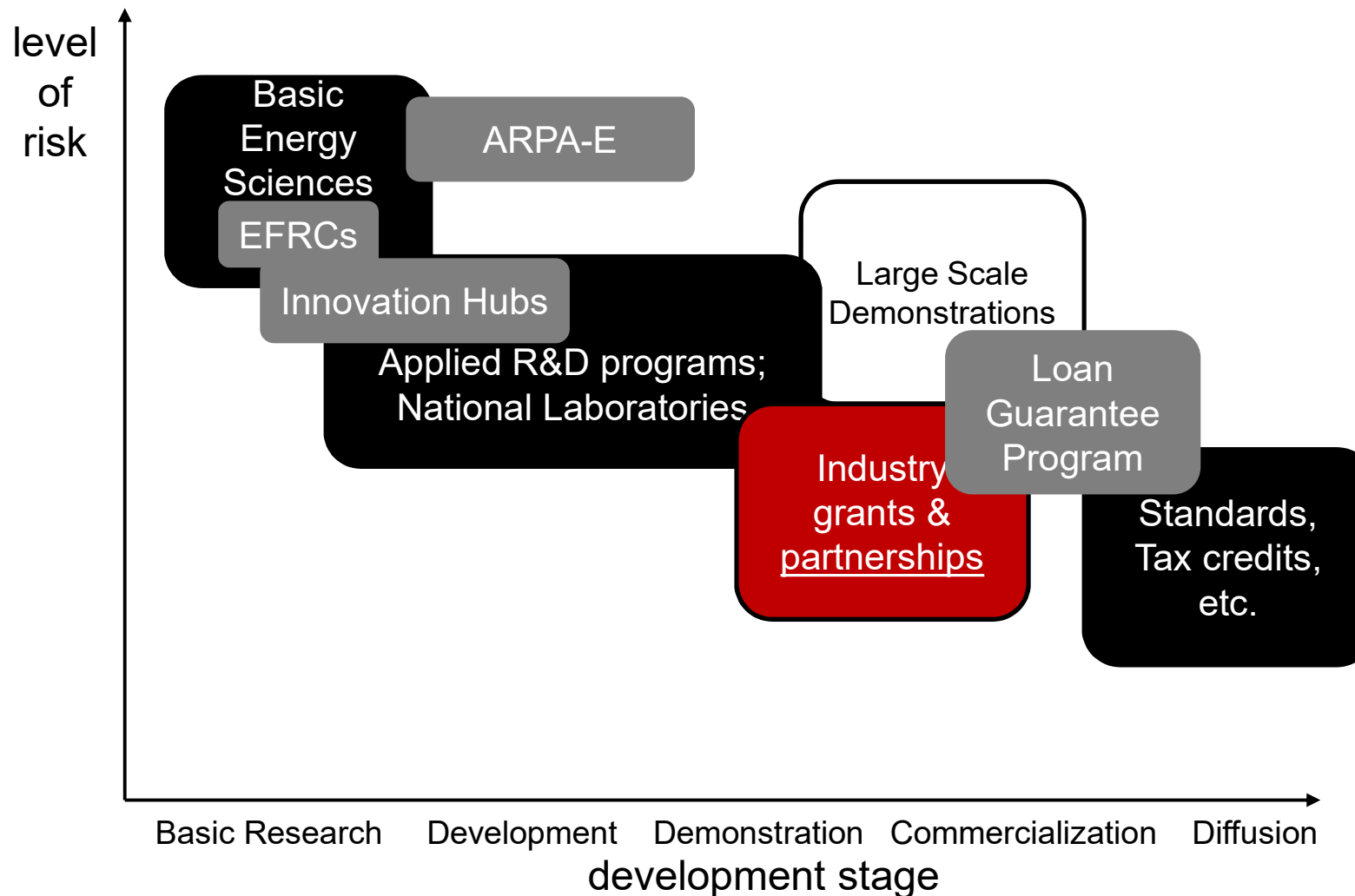

- From interviews and data analysis we found that there is a vicious circle of congressional demands for short-term results, increased admin, less risk taking, less results, which leads to more demands for results…

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

Alliances (joint development, licensing, procurement) between public institutions (e.g., labs) and cleantch startups

Recommendation from the (mainly qualitative) literature to date was (approximately): collaborate as much with as many diverse partners as possible or "Don't Go At It Alone" Baum et al., (2000, p. 267)

But startups cannot collaborate with everyone: Who holds critical technological resources for cleantech innovation?

level of risk

Basic Energy Sciences

ARPA-E

EFRCs

Innovation Hubs

Applied R&D programs; National Laboratories

Large Scale Demonstrations

Loan Guarantee Program

Industry grants & partnerships

Standards, Tax credits, etc.

Basic Research   Development   Demonstration   Commercialization   Diffusion

development stage

Results relevant for public-private partnership design

Patenting activity: increases with every additional governmental technology alliance when compared to those startups that did not engage in such alliances

- Different expertise, tacit knowledge, facilities, less risk of leakage

Private financing deals: increase for every additional license from a governmental agency (quality signals)

- Quality signals, information asymmetry, correlated with firm openness

Public procurement not associated with better startup outcomes

Doblinger, Surana and Anadon (2018)

DOE R&D grants to small businesses

Regression discontinuity design on U.S. DOE Small Business Innovation Research (SBIR) grant recipients (over 20 years, thousands of awards:

- Award doubles probability that a firm receives subsequent VC and has large, positive impacts on patenting and commercialization

Howell (2017) *American Economic Review*
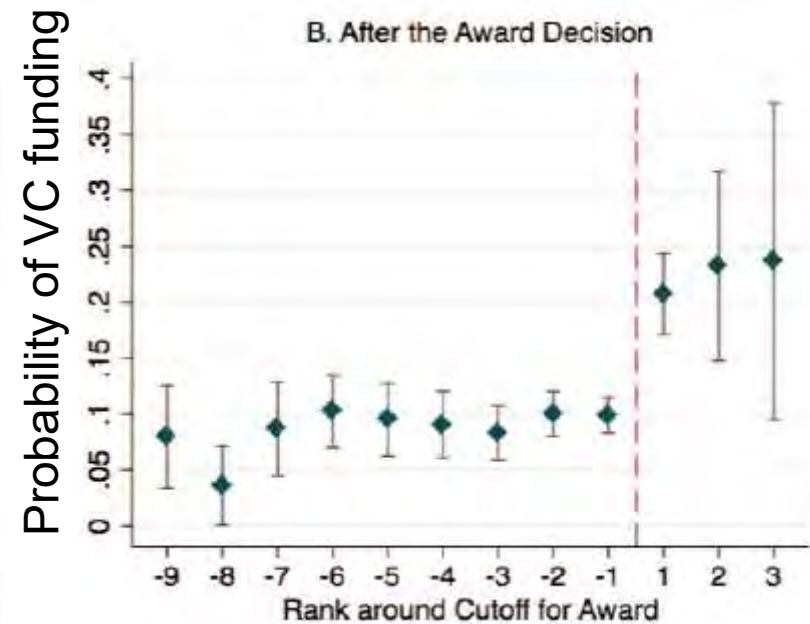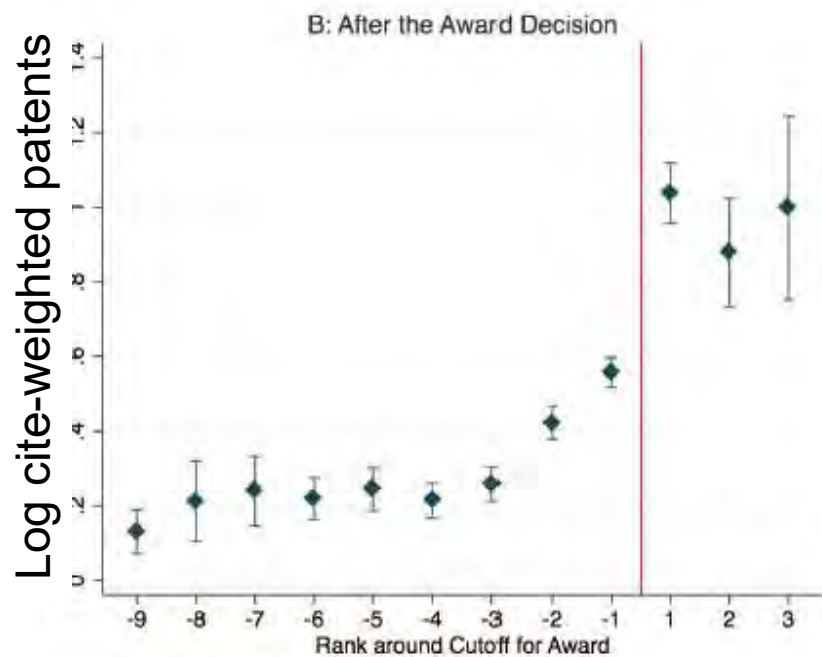
Actively managed R&D funding organizations
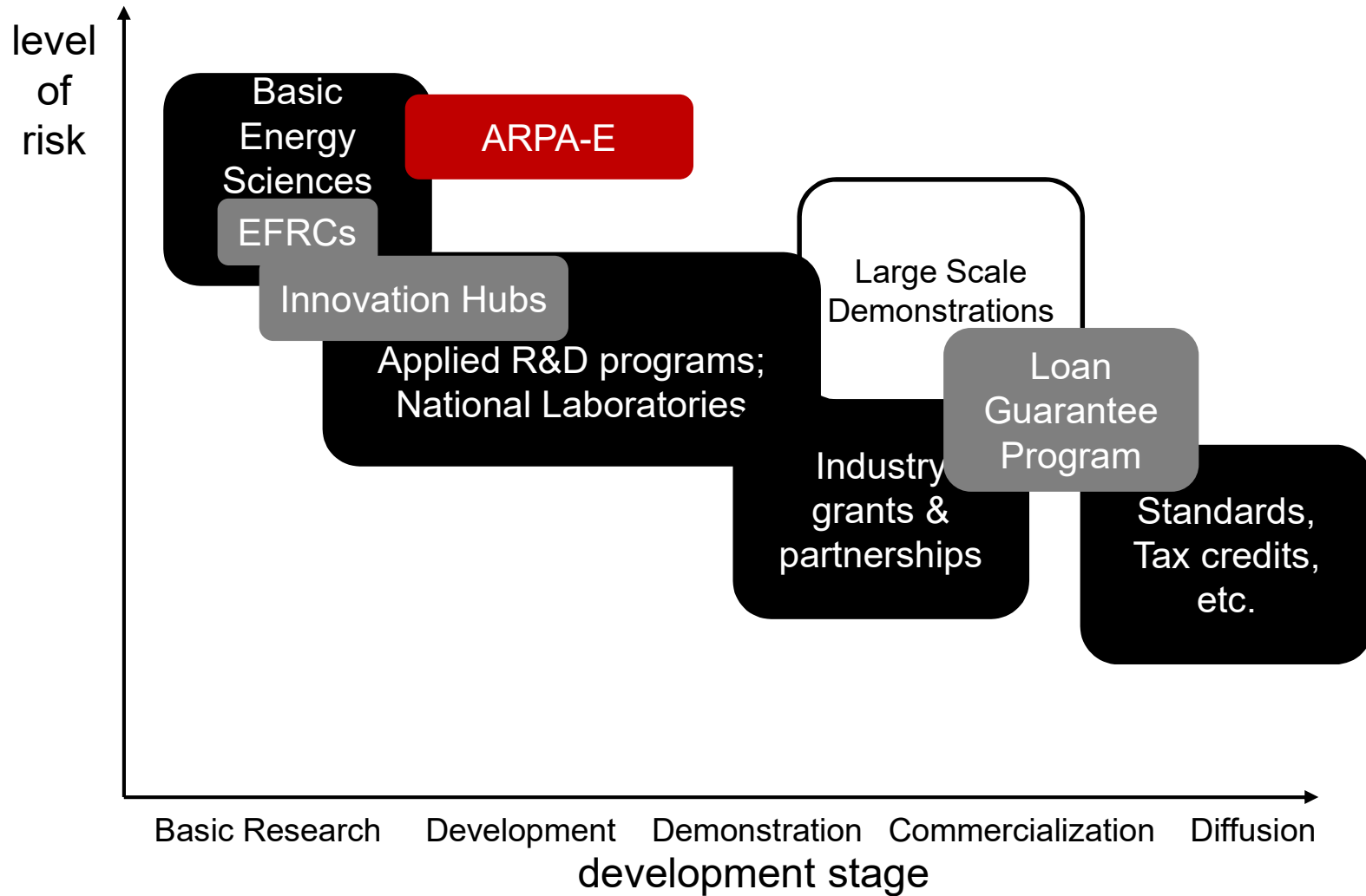
Ongoing work on ARPA-E and licenses

Over 400 projects, across 39 states, with over $1 billion in funding

Over 20 focused programs and 3 open solicitations

Recipients:

- 32% led by small business
- 42% by universities
- 14% by large business
- 8% by FFRDCs
- 4% by non-profits

- ARPA-E awardees doing better than awardees and other firms on follow on fur (Goldstein, Doblinger, Anadon 2018, ongoing)

- Compared to other similar awards from DOE ARPA-E has:
    - Excelled broadly in producing patents
    - Excelled in publications relative to EERE
    - Matched the output of publications from Offic Science (Goldstein & Narayanamurti, 2018, under revie

- Chan (2016) used matching on patents from national labs:
    - Licensing increases spillover benefits to firms (whether or not not-patenting would res better outcomes is a longstanding question)

3. Key findings

Broad guiding principles from cross national experiences

1. **Giving researchers and technical experts autonomy and influence over funding decisions** (e.g., labs, ARPA-E)

2. **Incorporating technology transfer in research organizations** (labs, transfer, joint development, and researcher mobility)

3. **Focusing demonstration projects on learning** (decades of projects)

4. **Incentivizing international collaboration**

5. **Adopting an adaptive learning strategy**

6. **[Keep funding stable and predictable]**

Chan, Goldstein, Bin-Nun, Anadon, Narayanamurti (2017), *Nature (Six principles for guiding energy innovation)*

4. Questions going forward

Important questions going forward

- How to think through the balance
  - Portfolio across actors, technologies, and stage of development?
  - Insights from TIS?

- How to measure success beyond patents, licenses, papers, spinoffs, follow-on funding?
  - Incentives to report failures, changes in direction (ARPA-E has revised milestones)
  - GETTING DATA FROM PUBLIC ENTITIES

- What gaps exist in the landscape to attract different actors and other needed types of innovation?
  - Demonstration
    - How to incentivize partnering while sharing learning
  - Use of facilities for actors not yet at a company stage?
  - Attracting large firms?

- How to translate the U.S. insights to other countries with different funding and risk taking environments?

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Thank you for your attention!

Dr. Anna Goldstein   Dr. Kavita Surana   Prof. Claudia Doblinger   Prof. Gabriel Chan   Prof. Venky Narayanamurti