Creative Destruction and Under-Investment in R&D

Ted Temzelides

Rice University

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Questions

- R&D in renewable energy as an engine of GDP growth
- Is the energy sector under-investing in R&D?
- Why? Role for Policy?
- Most studies assume optimal size of R&D in renewable energy is 5 to 10 times the current level
- In early 80s energy companies were investing more in R&D than drug companies. By 2005 trend completely reversed
- Investments in energy R&D in US fell by 50% between 1991 and 2003
- As a percentage of total US R&D, Energy R&D has fallen from 10 percent in 1980 to 2 percent in 2005

Plan for this Presentation

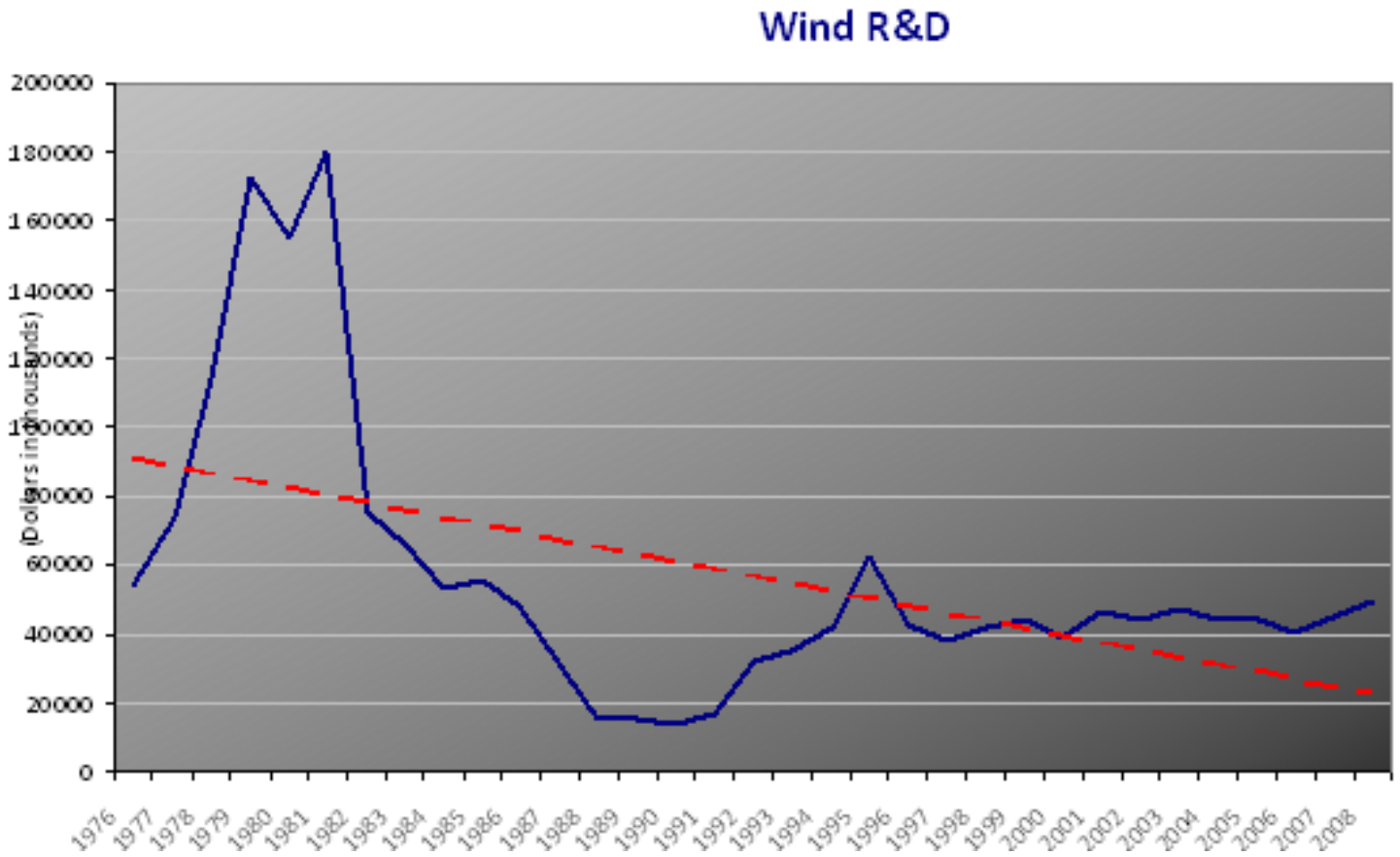
- Data on R&D and Innovation
- A theoretical argument suggesting under-investment in R&D:
- "*Creative Destruction*"
  - New innovation can make previous ones obsolete
  - Current resources devoted to R&D may depend negatively on expected future R&D
- Particularly relevant for the energy sector
  - Large fixed/capital costs, regulatory uncertainty
  - Evidence that R&D in fossil fuel and in renewable energy are substitutes
  - Invest profits on stock buy-backs and (capital-intensive) unconventional oil projects

Why is Innovation so Important?

- Percent of overall growth that stems from innovation in science and technology as high as 90%
- A Historical Example: *"The Great Horse-Manure crisis of 1894"*
  - Transport in 19th century was drawn by horses. London in 1900 had 11,000 cabs, several thousand buses (each using 12 horses), an estimated total of more than 50,000 horses
  - A horse produces between 15 and 35 pounds of manure per day
  - In New York in 1900, over 100,000 horses produced 2.5 million pounds of horse manure per day
  - The larger and richer that cities became, the more horses they needed to function. The more horses, the more manure.... *Times of London* (1894): "in 50 years every street in London would be buried under nine feet of manure."
  - Gottlieb Daimler and Henry Ford solved that problem through innovation...

Data on Innovation

- How to evaluate the output of R&D?
- Standard approach among economists (not without problems):
  - Use (cited) patents to evaluate effect of subsidies on innovation
  - Use productivity data to evaluate effect of patents on *GDP* growth
- Difficulties in locating private/VC R&D data
- Use Federal (DOE) R&D budget data (in 2008 dollars)
- Creating our own database on patents (thanks to Jane Kliakhandler and assistants)
  - Right now: wind, solar (P.V. and thermal), fuel cells


Wind R&D
(Dollars in thousands)
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
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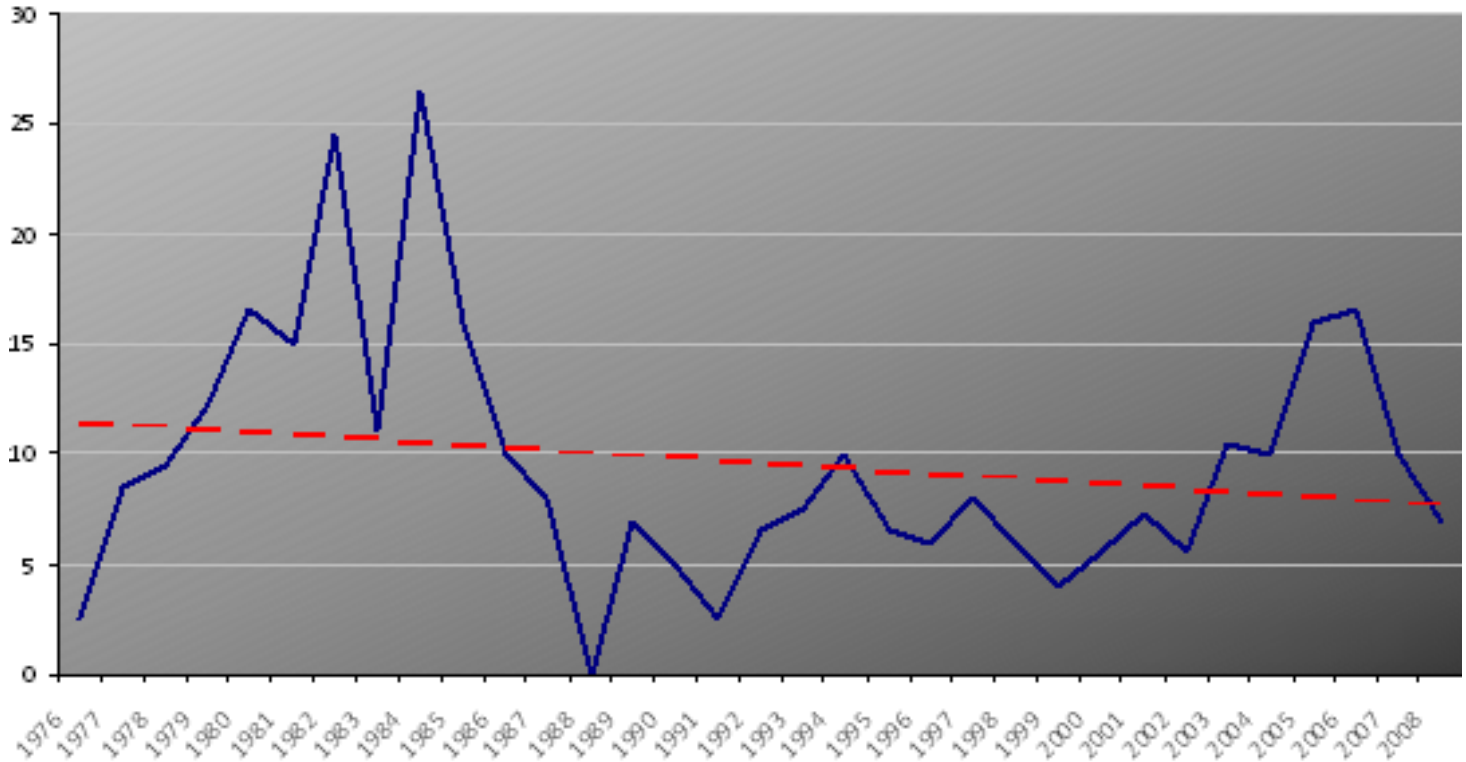
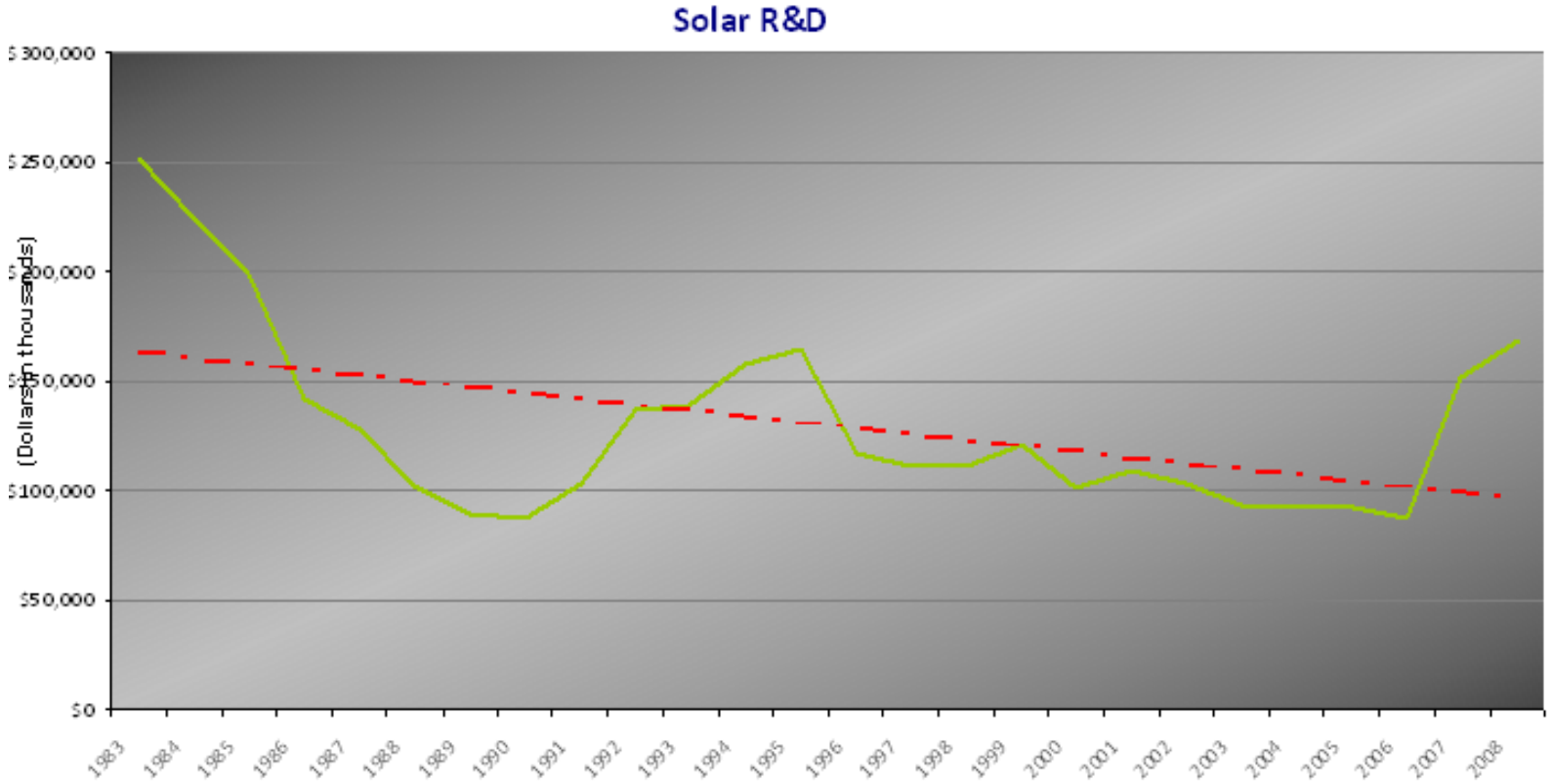
2008

Wind Patents




Solar R&D
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0
(Dollars in thousands)
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
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2002
2003
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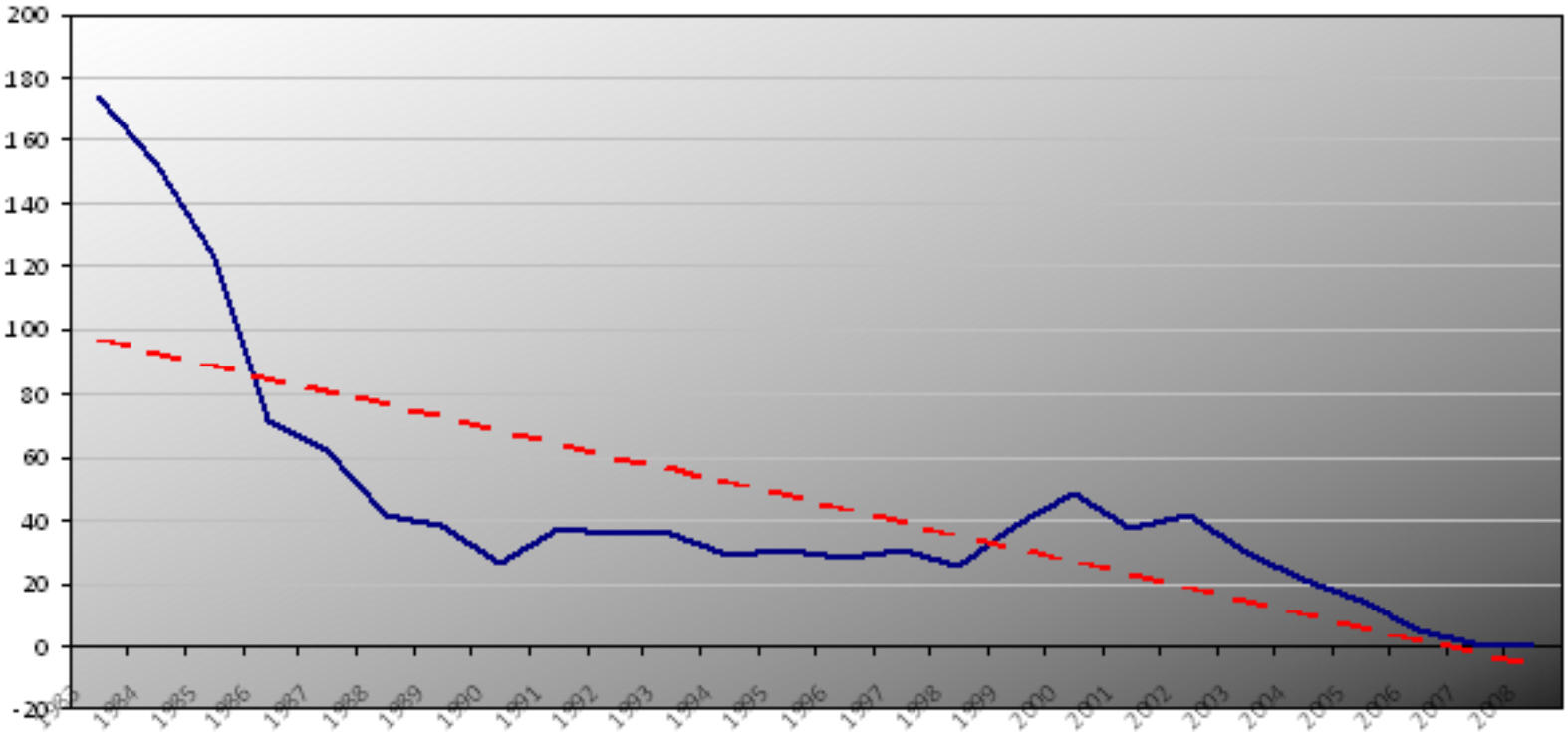
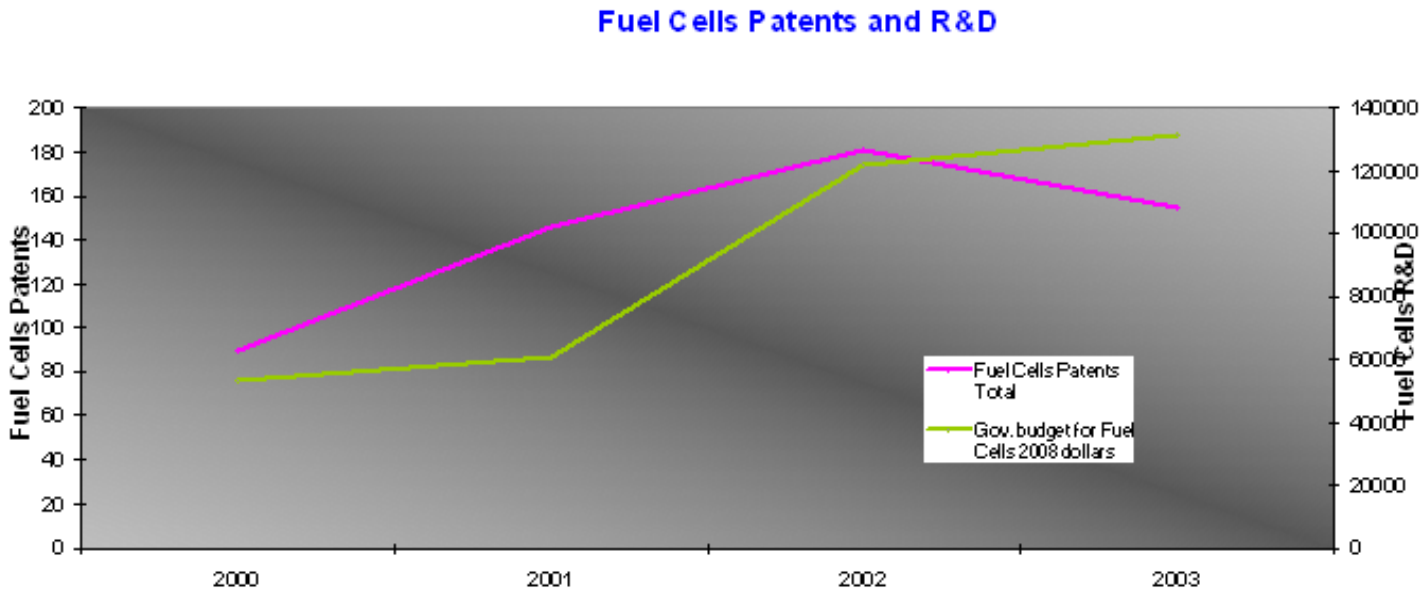
2008

Solar Patents



- Investment and innovation in fuel cells has grown



Economic Modeling of the Innovation Process

- Economy produces goods/services (e.g., consumption, transportation, etc.)
- Production uses energy resources (e.g., oil, gas, solar, etc.)
- Exhaustible energy $= R_t F(\text{fossil fuel,capital})$
- Renewable energy $= A_t f(\text{capital})$
- Research produces a *random* sequence of innovations: $A_t \longrightarrow A_{t+1} \longrightarrow A_{t+2} \ldots$
  - *"Climbing the "Innovation ladder"*

- *Random (Poisson)* arrival rate of innovations at any point
- Higher level of resources in R&D $ increase the innovation arrival rate
- Innovation rewarded with patent resulting in short-run monopoly profits
- *Profit maximization*: Choose resources devoted to R&D to equate the marginal expected future **private** benefit from innovation to the marginal current private cost

Profit maximizing versus Socially Optimal R&D Levels

- Equilibrium R&D can be less than socially optimal even if firms are "forward-looking"
- Why? Social benefits of R&D exceed private ones
- Reasons:
  - *Spillovers,* "*Creative Destruction*" effects
  - New innovations build on old ones
  - At the same time, new innovation can make previous ones obsolete
  - Current resources devoted to R&D may depend **negatively** on expected future R&D

An Alternative Explanation: Decreasing Returns to R&D

- Main factors affecting R&D in energy:
  - Demand for energy (prices)
  - Productivity (patent/R&D ratio)
- Some evidence that patents begin to decline prior to R&D budget drop
- **Diminishing Returns** to R&D (patents/R&D declines)

Summary

- Creative destruction: a theoretical argument for under-investment in R&D
- Adoption of renewable technologies slower than optimal
- Subsidizing R&D might be beneficial
- **Caveat 1:** substantial cost reductions may come through innovations **not** reflected in efficiency/patents (recent PV cost reduction appears to be due to **less** conversion-efficient modules that resulted in 15-20% price reduction)
- **Caveat 2:** Policies that subsidize R&D must also take into account decreasing returns/effects on other sectors
- More research needed to determine socially optimal subsidy levels

Sources

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