The America COMPETES Act: History, Overview, & Implementation

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Bruegel
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Overview: The story of an Act in many acts & the questions those acts raise

• Motivation
  – what is ACA & why study it?

• History, Overview, & Implementation
  – pre-history
  – ACA 2007 - content & implementation
  – ACRA 2010 - content & implementation
  – ACA 2015 - debate & content
  – taking stock: impact-to-date?

• Broader questions
  – S&T policy in world of constrained funding?
  – S&T policy in world with fewer constraints?
  – Questions for research going forward:
    • evaluating policies small & big

• Implications
  – politics = policy
  – consensus in USA = gone
  – policy evaluation = desirable & possible but requires partnership between researchers & policymakers
Who am I and what do I (usually) do?

- **Boston University, Questrom School of Business**
  - Associate Prof, Strategy & Innovation, 2001-present
  - Research Associate, NBER
  - PhD Management, MIT-Sloan

- **Research topics**
  - impact of location on productivity of R&D in the pharmaceutical industry
  - science & innovation policy
    - specific institutions, e.g., Biological Resource Centers
    - general institutions, e.g., system of scientific retractions
    - specific policies, e.g., Bush Administration hESC policy
    - broad policies, e.g., America COMPETES Act
What I typically do:
\[ \text{e.g., Assessing the Impact of the US hESC Policy} \]

  - conditional fixed effects negative binomial, stacked
  - incidence-Rate Ratios in brackets in top line; estimated coefficients in 2nd line
  - block bootstrapped SEs reported in parentheses
  - models include HESC*Year FEs, Stack-specific Year FEs, Stack FEs, Article Age FEs, & Article FEs

<table>
<thead>
<tr>
<th>Sample:</th>
<th>Core Sample (HESC &amp; RNAI)</th>
<th>HESC &amp; Nearest Neighbors</th>
<th>HESC &amp; Other Stem Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(4-1) DV = Cites with any US author (or No US author)</td>
<td>(4-2) DV = Cites with US RP Author (or Not US RP Author)</td>
<td>(4-3) DV = Cites with US RP Author (or Not US RP Author)</td>
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<td>HESC_2001</td>
<td>[1.250] 0.224 (0.212)</td>
<td>[1.594] 0.466 (0.115)</td>
<td>[0.999] -0.001 (0.205)</td>
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<tr>
<td>HESC_2002-2003</td>
<td>[1.078] 0.076 (0.292)</td>
<td>[1.918] 0.651 (0.163)</td>
<td>[0.853] -0.159 (0.239)</td>
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<tr>
<td>HESC_2004-2007</td>
<td>[1.333] 0.287 (0.351)</td>
<td>[2.579] 0.947 (0.213)</td>
<td>[0.898] -0.107 (0.272)</td>
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<td>HESC_2001_US</td>
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<td>[0.627] -0.467 (0.210)</td>
<td>[0.716] -0.335 (0.232)</td>
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<td>HESC_2002-2003_US</td>
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<td>[0.540] -0.616 (0.142)</td>
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<td>[1.050] 0.049 (0.107)</td>
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<tr>
<td>Article*Year Obs</td>
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<td>Number of articles</td>
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<td>569</td>
<td>108</td>
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<tr>
<td>Log Likelihood</td>
<td>-3187.15</td>
<td>-17938.24</td>
<td>-5644.91</td>
</tr>
</tbody>
</table>
What I typically do:
Regression analysis shows US falling behind & catching up

Based on Conditional FE negative binomial specification with Age and Year FE
Compared to non-US Citations to hESC articles, with RNAi root articles as controls
Why study the ACA:
Perceived importance for US competitiveness & welfare

• Technological innovation is a key engine of economic growth and, ultimately, social welfare. Discussions of innovation policy are thus justifiably prominent. Just this year, [Baumol, Litan, & Schramm] published an important book on the issue ...; presidential candidates held serious discussions about innovation; analysts debated patent reform; and Congress passed one of the best pieces of innovation legislation in years, the America COMPETES Act.

  – Stuart Benjamin and Arti Rai
  – Science Progress
  – Tuesday, November 6th, 2007
Sadly, I could not analyze the ACA as I did hESC: Perception ≠ reality

• Despite the initial hype and hope...

1. Much of the 2007 America COMPETES Act was never implemented

2. Much of the 2007 Act that was implemented was funded at levels below those allocated by the ACA

3. The 2010 Act further lowered funding expectations

4. And actual funding was below that allocated under the 2010 Act

5. Nonetheless, the package did include some elements (e.g., ARPA-E) that were eventually funded and whose impact could be analyzed in future projects

• In the rest of the presentation, I focus on the history and context of the ACA 2007 and the ACRA 2010
What is the America COMPETES Act? Both a simple & a complicated question

• Simple answer
  – set of acts designed to boost American innovativeness & competitiveness via Federal funding of S&T research & education
  – America COMPETES Act - 2007 (ACA-2007)
  – America COMPETES Reauthorization Act - 2010 (ACA-2010)
  – America COMPETES Reauthorization Act - 2015 (ACA-2015)

• More complicated answer
  – Economic evaluation: more straightforward to evaluate specific programs implemented at a single point in time
  – Content
    • acts contained numerous programs, some new, some old [how to parse?]
    • more straightforward to examine specific provisions of Acts
  – ACA = Authorization Acts
    • much of the authorized funding never appropriated/implemented
    • some implemented in fits & starts (ARPA-E)
    • implementation not always straightforward from budget documents
Background:
Origins of US Federal S&T Funding

• 1700s
  – Constitution: providing incentives to authors & inventors
  – IP systems (patents, copyright, ...)

• 1800s
  – Morrill Act (1862, 1890)
  – National Academy of Science (1863)

• 1900s
  – National Bureau of Standards (1901)
  – Public Health Service (1912)
  – Naval Consulting Board (1915)
  – National Research Council (1916)

• World War II & the legacy of Vannevar Bush
  – federal S&T activities expanded dramatically during WW2
    • direct involvement with war
    • e.g., Manhattan Project
  – Vannevar Bush – Science: The Endless Frontier
    • scientific enterprise = key to economic growth
    • science = public good, i.e., social returns > private returns
    • thus, if society wants benefits of scientific and technical progress, federal funding is necessary
    • vision results in National Science Foundation (1950)
Background:
US S&T funding & international competitiveness

• 1950s & 1960s
  – U.S. at world’s scientific & technical frontier
  – EU & Japan devastated by war but reinvesting

• 1970s & 1980s
  – U.S. firms lose market share in innovative sectors (e.g., auto & consumer electronics) to former laggard countries (esp. Germany & Japan)
  – fears of alternative models of capitalism (e.g., state-supported MITI in Japan & cooperative model of Germany)

• 1990s
  – Cold War Ends; Japan’s lost decade; West Germany absorbs former East
  – Internet, dot.com surge, and overall economic growth in US quiet competitiveness fears

• 2000s
  – globalization of R&D, b/c of historical investments by former laggard countries, raises new fears of competitiveness in U.S.

• 2010s
  – political polarization regarding science funding & research priorities limits increases in public investments in science; Chinese S&E investments surge
Setting the stage:
International comparison of R&D Funding, 1990s-2000s

Background: 

• Economic successes of 1990s and early 2000s increased awareness of S&T globalization
  – successes of large & small high-tech firms based in South Korea, Finland, Israel, Taiwan, Singapore, China, India, ...
  – questions about future of US innovation leadership

• National Academies of Science study S&T globalization
  – yielded extraordinary report, completed in a few weeks
  – “Rising Above the Gathering Storm: Energizing & Employing America for a Brighter Economic Future”

• Recommendations
  1. Doubling Path: double federal investment in basic R&D in 7 years
  2. STEM funding: substantial increases in STEM education esp. for science & math teaching and student recruiting
  3. STEM workforce: scholarships for U.S. citizens & visas for int’l grad students
  4. ARPA-E: Advanced Research Projects Agency - Energy based on DARPA
  5. IP & tax: enhance IP protection & pro-innovation tax incentives
  6. Broadband: ensuring broadband internet access for largest possible pop

• Other initiatives
  – Innovate America (Council on Competitiveness, 2005)
  – American Competitiveness Initiative (Bush Administration, 2006)

- **Sponsor** = Bart Gordon (D-TN)
  - received bipartisan support in House & Senate (15 Dem. + 6 Rep. co-sponsors)
  - Passed by overwhelming majority in House & via unanimous consent in Senate

- **Signed by GW-Bush** (Aug 2007)
  - expressed concern, “that legislation includes excessive authorizations and new duplicative programs”

- **Greeted with substantial optimism by high tech firms & scientific societies**

- **Act broad in scope but focused in aims:**
  1. increase Federal investment in (physical) sciences...
  2. increase investment in STEM education...
     ➢ in order to further American innovativeness & competitiveness

- **Act authorizes $33.6B in federal spending for FY2008-FY2010**
  - authorized programs & provisions principally for: OSTP, NASA, DOC/NIST, NOAA, DOE, D-Ed, NSF
  - **authorization ≠ appropriation**
  - FY2008 appropriations process already begun!
Contents: Key provisions of the America COMPETES Act (2007)

1. “Doubling Path”
   - authorized Fed S&T funding of 10% per year for FY08-FY10
   - doubling within 7 years (relative to FY06 base)
   - concentrated in DOC (NIST), D-Ed, DOE-OS, NSF

2. ARPA-E
   - created agency dedicated to translational research in energy projects that private sector finds too risky
   - modeled on DARPA – lean org structure with entrepreneurial, expert program managers
   - $300 million in FY08, “such sums as necessary,” (FY09/10)

3. STEM Education
   - varied programs, esp. DOE, D-Ed, NSF
   - goals:
     - increasing # & quality of STEM teachers & primary/secondary STEM students
     - attracting more US-students into STEM
     - Increasing funding for US grad students
     - increasing STEM education for women, minorities, high-need schools

4. NIST reforms & funding
   - expand Hollings Mfg Extension Prog.
   - replace ATP with TIP (both matching programs, TIP → SMEs)
   - NIST fellowships + expanded funding

5. Support high-risk, high-reward projects

6. Coordination of S&T investments

7. Obligations for other agencies
   • Did not include clear mechanisms for enabling evaluation, although it supported the idea
The next steps: ACA 2007 implementation
A tale of limited funding, FY2008-FY2010

PROGRAMS NOT FUNDED IN FY2009

• Department of Energy
  – Pilot Program of Grants to Specialty Schools for Science and Mathematics
  – Experiential Based Learning Opportunities
  – Summer Institutes
  – National Energy Education Development
  – Nuclear Science Talent Expansion Program
  – Hydrocarbon Systems Science Talent Expansion Program
  – Early Career Awards for Science, Engineering, and Mathematics Researchers
  – Discovery Sci & Eng. Innovation Institutes
  – Protecting America’s Competitive Edge Graduate Fellowship Program
  – Distinguished Scientist Program

• Department of Education
  – Advanced Placement & Int ’l BA Program
  – Math Now
  – Summer Term Education Program
  – Math Skills for Secondary Skill Students
  – Advancing America Through Foreign Language Partnership Program
  – Math & Science Partnership Bonus Grants

• National Science Foundation
  – Laboratory Science Pilot Program

PROGRAMS FUNDED AT AUTHORIZED LEVELS IN FY2009

• Department of Energy
  – Office of Science

• National Science Foundation
  – Research & Related Activities
  – Major Research Instrumentation
  – Professional Science Master’s Degree Program
  – Robert Noyce Teacher Scholarship Program
  – Graduate Research Fellowship Program
  – Major Research Equipment and Facilities Construction

• NIST
  – Scientific & Technical Research and Services
  – Construction & Maintenance

Funding for ACA2007 programs, FY2008 – FY2010

<table>
<thead>
<tr>
<th>Programs with Specific Authorized Budgets in the 2007 America COMPETES Act</th>
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<tbody>
<tr>
<td>---------------------------------</td>
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<tr>
<td>Department of Energy</td>
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<tr>
<td>Office of Science</td>
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<tr>
<td>Advanced Res Projects Agency— Energy*</td>
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<tr>
<td>Department of Education</td>
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<tr>
<td>Teachers for a Competitive Tomorrow: BA*</td>
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<tr>
<td>Teachers for a Competitive Tomorrow: MA*</td>
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<tr>
<td>Department of Commerce</td>
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<tr>
<td>NIST</td>
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<tr>
<td>Scientific &amp; Technical Research &amp; Services</td>
</tr>
<tr>
<td>Construction &amp; Maintenance</td>
</tr>
<tr>
<td>Technology Innovation Partnership (TIP)*</td>
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<tr>
<td>Manufacturing Extension Partnership (MEF)</td>
</tr>
<tr>
<td>National Science Foundation</td>
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<tr>
<td>Research and Related Activities (R&amp;RA)</td>
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<tr>
<td>Major Research Instrumentation (MRI)</td>
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<tr>
<td>Exp Prog to Stimulate Comp Res</td>
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<tr>
<td>Education and Human Resources (EHR)</td>
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<tr>
<td>Math &amp; Sci Ed Partnership (MSP)</td>
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<tr>
<td>Robert Noyce Teacher Scholarship Program</td>
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<tr>
<td>Graduate Research Fellowship/EHR (GRF)</td>
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<tr>
<td>Major Res Equip &amp; Facilities Construction</td>
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<tr>
<td>Agency Operations and Award Management</td>
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<tr>
<td>National Science Board</td>
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<tr>
<td>Inspector General</td>
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</table>

**Takeaways**

- **Doubling Path**
  - $\rightarrow 7$ year trend
- **ARPA-E funded**
  - $\rightarrow$ $15m$ in FY09
  - real start in ARRA, $\rightarrow$ $300m$ 
  - 1st awards = Oct-09
- **STEM Education**
  - limited $\Delta$ funding
- **NIST funded**
- **High-risk projects**
  - GAO: limited
- **Coordination**
  - not $b$ savings
ACRA 2010: Onwards to Reauthorization?

• Congressman Bart Gordon, the outgoing Democratic chairman of the House Science and Technology Committee, told Nature he would dearly like to see the reauthorization bill pass. Even if signed into law by President Barack Obama, funds will still need to be found in the 2011 budget to support the bill. While it will be a challenge to persuade Congress to increase funding for basic science during a time of budget austerity, Gordon says, “it’s a challenge we have to take on.”
  – Nature
  – 17 Dec 2010, Ivan Semeniuk (link)
ACRA 2010: tough road to passage; implementation tougher

- Financial crisis & recession
  - Lehman collapse Fall 2008
  - Great Recession follows
  - stimulus, ARRA FY2009
  - partisanship & shadow of budget austerity, 2009

- Difficult road for ACRA 2010
  - failed 2x in House
  - passed on 3rd try in May 10
  - Senate passed amended bill in Dec 2010
    - period reduced from 5 to 3 years
    - funding decreased, $85.6b → $45b
    - approved via unanimous consent
  - House approved on final day of 111th Congress
    - bipartisan support for bill, 228-130

- Passed with fanfare...
  - more than 750 endorsing organizations, including Chamber of Commerce, American Chem Society, BIO, Ass of Public & Land Grant Unis (link)

- But tempered expectations
  - 112th Congress = Republican majority in House of Representatives
    - dedication to limiting Federal expenditures
  - again, bill passed after associated FY11 appropriations
  - turnover in key positions in House Committee on Science, Space, and Tech
    - Bart Gordon (D-TN, Chair) & Vernon Ehlers (R-MI, Ranking Member)
Contents: Key provisions of the America COMPETES Reauthorization Act (2010)

- **“Doubling Path”**
  - embraced 10 year doubling (relative to FY06 base)
  - focused on NIST, DOE-OS, NSF
  - NIST ~15% ↑ from smaller base; DOE/NSF few % ↑

- **STEM Education**
  - requested coordination, substantially via National Science & Technology Council
  - emphasis on STEM programs for underrepresented populations
  - programs mainly at NSF

- **ARPA-E**
  - authorized approx $300m, FY11-FY12

- **Prizes**
  - authorized each federal agency to award innovation prizes based on competitive process
  - enabled but did not require matching from private sector

**Other programs**
- fewer, more modest than in ACA 2007
- Technology Innovation Program = eliminated
- DOC – federal loan guarantees for SMEs
- DOC – Regional Innovation Program, loan guarantees for science parks
- NIST GREEN JOBS Act of 2010
### Funding for ACA2010 programs, FY2011 – FY2013

<table>
<thead>
<tr>
<th>Programs with Specific Authorized Budgets in the 2010 Act</th>
<th>FY2011 Appropriated</th>
<th>FY2012 Estimated</th>
<th>FY2012 Authorized</th>
<th>FY2013 Authorized</th>
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<tr>
<td><strong>Department of Energy</strong></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Office of Science</td>
<td>4,842.70</td>
<td>4,873.60</td>
<td>5,614.00</td>
<td>6,000.70</td>
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<td>Advanced Research Projects Agency - Energy</td>
<td>179.60</td>
<td>275.00</td>
<td>306.00</td>
<td>312.00</td>
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<td><strong>Department of Education</strong></td>
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<td>Teachers for a Competitive Tomorrow – BA</td>
<td>^</td>
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<td>2.00</td>
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<tr>
<td>Teachers for a Competitive Tomorrow – MA</td>
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<td>2.00</td>
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<tr>
<td><strong>Department of Commerce</strong></td>
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<tr>
<td>NIST</td>
<td>878.60</td>
<td>750.8</td>
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<td>Scientific &amp; Technical Research &amp; Services</td>
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<td>567.00</td>
<td>661.10</td>
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<tr>
<td>Construction of Research Facilities</td>
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<td>55.40</td>
<td>84.90</td>
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<tr>
<td>Industrial Technology Services</td>
<td>173.30</td>
<td>224.80</td>
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<tr>
<td>Technology Innovation Partnership (TIP)*</td>
<td></td>
<td>eliminated</td>
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<tr>
<td>Manufacturing Extension Partnership (MEP)</td>
<td>128.40</td>
<td>128.40</td>
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<td>165.10</td>
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<td><strong>NIST Green Jobs Act of 2010</strong></td>
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<td>7.00</td>
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<tr>
<td>Dept of Commerce (other than NIST)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Loan Guarantees for Innov Tech in Mfg*</td>
<td>5.00</td>
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<tr>
<td>Loan Guarantees for Science Park Infrastructure*</td>
<td>5.00</td>
<td></td>
<td>7.00</td>
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<tr>
<td>Regional Innovation Program*</td>
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<td><strong>National Science Foundation</strong></td>
<td>6,859.90</td>
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<td>Research &amp; Related Activities</td>
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<td>Major Research Equip &amp; Facilities Construction</td>
<td>117.10</td>
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<td>Office of the Inspector General</td>
<td>14.00</td>
<td>14.70</td>
<td>14.70</td>
<td>15.00</td>
</tr>
</tbody>
</table>

* = new program

\(^\) = program noted as not included in authorization or appropriation acts; blank if not mentioned in funding docs


### Takeaways
- Doubling Path – 15+ year trend?
- ARPA-E funded – $180m in FY11, $275m in FY12
- STEM Education – embedded in NSF funding
- DOC authorized programs get limited funding
- NIST funding ↑
- Prizes funded internally – challenge.gov
Overall: The Doubling Path - has the ACA shifted funding for federal S&T investment? No!

Figure tracks potential doubling of federal funding for science and technology, including funding for the NSF, DOE Office of Science, and NIST Core Research and Construction relative to FY2006 appropriations levels.

Source: Sargent (2016) Congressional Research Service, Report #7-5700
Overall: The Doubling Path - has the ACA shifted funding for federal S&T investment? No!
Overall: The Doubling Path - has the ACA shifted funding for federal S&T investment? No!

Comparing Federal Defense & Nondefense R&D
Composition of US Nondefense R&D Spending

Trends in Nondefense R&D by Function, FY 1953-2013
outlays for the conduct of R&D, billions of constant FY 2012 dollars

Source: AAAS, based on OMB Historical Tables in Budget of the United States Government FY 2013 Constant dollar conversions based on GDP deflators. FY 2013 is the President's request.
Note: Some Energy programs shifted to General Science beginning in FY 1998.
International Comparison in national R&D investments, the continuing trend

Recent history: International comparison of R&D Funding; globalization at work

Source: NSF (2016), National Science & Engineering Indicators
Recent history: International comparison of R&D Funding; globalization at work

Source: NSF (2016), National Science & Engineering Indicators
ACA 2007 & ACRA 2010 Impact on: ARPA-E, STEM, NIST, Prizes

- **ARPA-E**
  - it is too soon to tell what impact of funding will be on commercial outcomes
  - invites research on program structure and productivity (see Erika Fuchs on DARPA)
  - <$1 billion dispersed
  - US Fed energy R&D $5b/yr
    - less than many other countries
    - ~ 0.03% of GDP
    - ~ 0.08% in Japan
    - ~ 0.04% in China

- **STEM Education**
  - funding changes unlikely to have significant impact on amount or quality of STEM teachers

- **NIST**
  - significant funding increases for general research fund
  - but base in hundreds of millions of dollars, not $Bs

- **Prizes**
  - good idea, but <$b
America COMPETES 2015?

• ACRA 2010
  – most provisions expired in 2013
• America COMPETES 2015
  – passed HoR on party line vote 215-207
    • no Democrats voted in favor of bill
    • limits funding growth
    • imposes restrictions on ability of NSF to fund priorities across directorates
  – “This bill does absolutely nothing” to preserve U.S. research excellence,” Eddie Bernice Johnson (D–TX)
  – “House spending panel does its best to hide large cut to NSF social and geosciences research” (Science, 2015)
  – no companion Bill in Senate
    • bill focused on subset of funding for DOE; not yet passed
Conclusions & Implications

• America COMPETES Act 2007
  – introduced with broad support of industry, scientific community, & both US political parties
  – authorized funding increases for physical sciences & engineering; 7-year “doubling path” for key agencies
  – most investments did not materialize

• America COMPETES Reauthorization Act 2010
  – scaled back scope of investments; agreed to longer doubling path
  – weaker bipartisan support
  – limited appropriations

• Implications for US R&D & GDP
  – not clear for a number of reasons
  – historical consensus that national S&T leadership → superior economic growth & welfare
    • consistent with theory & casual empiricism
    • but limited basis in large scale analysis
  – can USA concede leadership in some fields and maintain economic growth?

• To have an impact, scholars studying science & innovation
  – must provide more convincing analyses
  – partnership with policymakers would be helpful; ideally, analysis can be incorporated into policymaking process
    • access to administrative data?
    • experiments?
    • focus on program features