Research Institute of Economy, Trade and Industry (RIETI)

RIETI BBL Seminar Handout

"Technology Policy and Climate Change"

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http://www.rieti.go.jp/jp/index.html

Technology Policy and Climate Change

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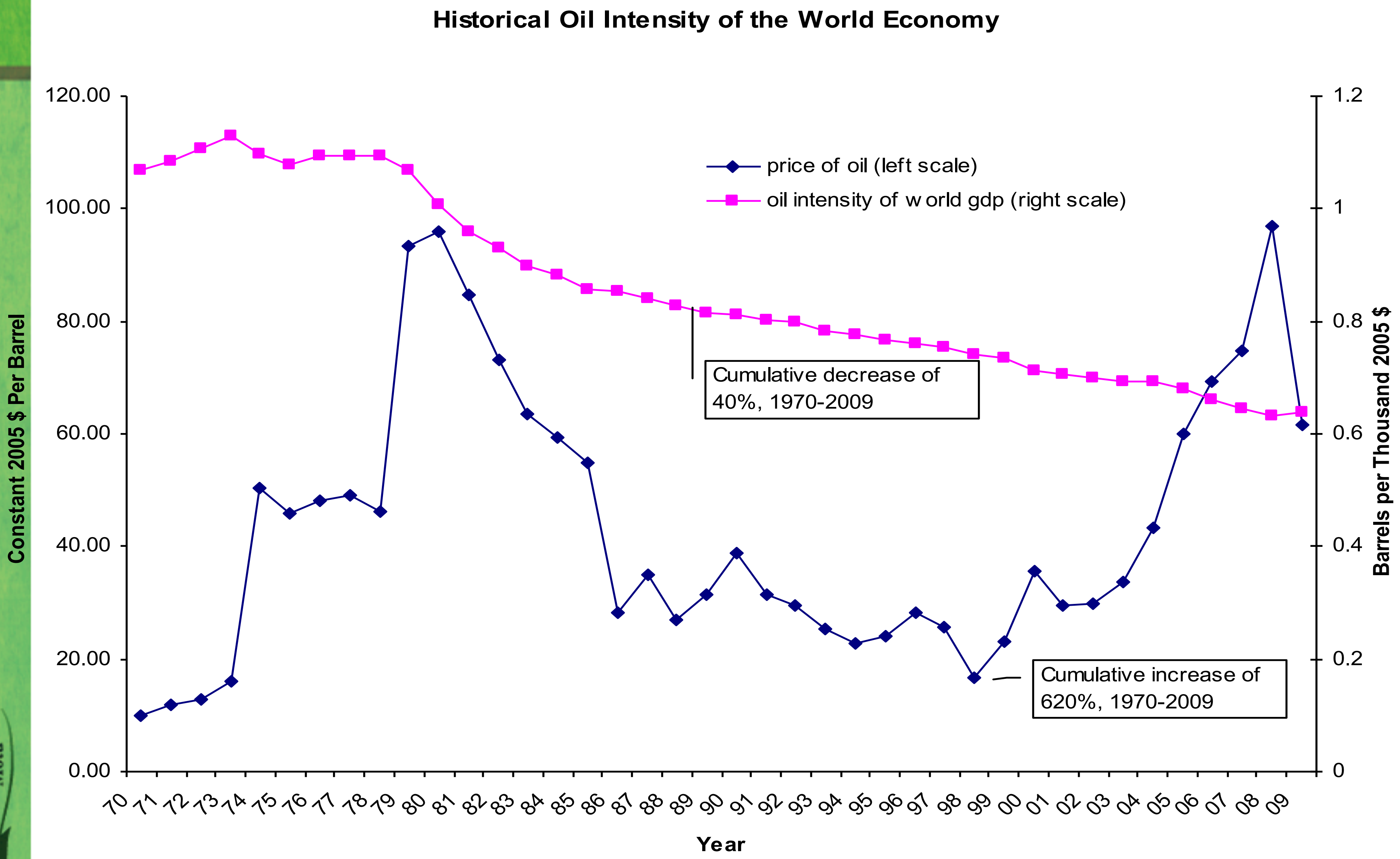
Overview

- Carbon policy is necessary but not sufficient
- Technology market failures
- Current state of public support for energy R&D
- Lessons from other technologies
- Speculative conclusions
- Research needs

Motivation

- Regardless of outcome of current debates about the timing, GHG emissions need to be stabilized and then reduced
- Assuming that we want world GDP to continue to grow, this means significant reductions in the world GHG/GDP ratio at some point this century
- Certainly at least 50%, probably more, by 2050

How hard will this be?

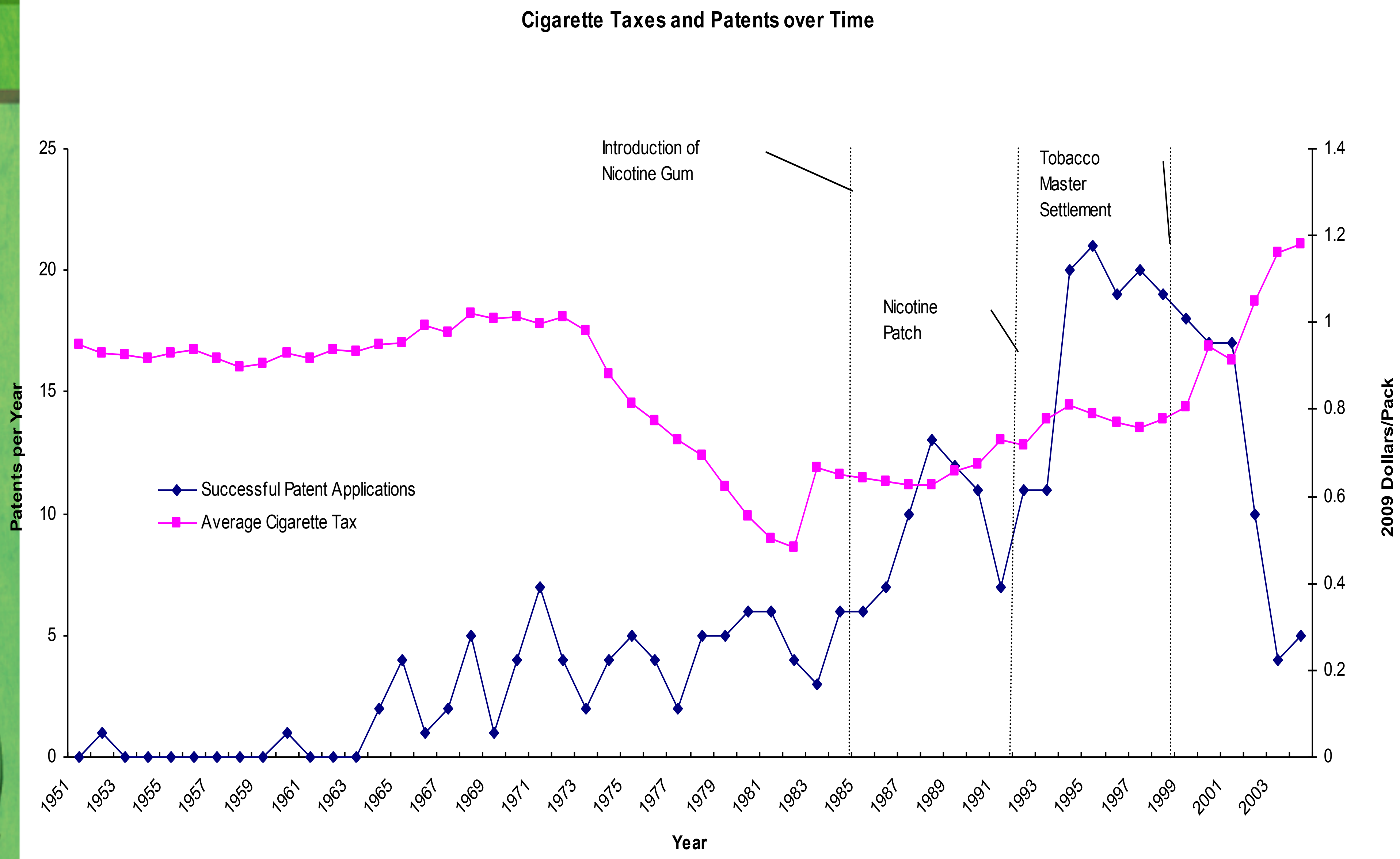


Historical Oil Intensity of the World Economy
Constant 2005 $ Per Barrel
Barrels per Thousand 2005 $
price of oil (left scale)
oil intensity of w orld gdp (right scale)
Cumulative decrease of 40%, 1970-2009
Cumulative increase of 620%, 1970-2009
Year

Do prices spur innovation?

- Old literature on induced innovation (Hicks, 1932)
- Theory suggests that high/rising carbon price should direct resources towards carbon-saving innovation
- Some evidence on changing menus (Newell, Jaffe and Stavins, 1999)
- No natural experiment confirming innovation impacts of the magnitude sought here

Motu



From Werfel and Jaffe, 2013

What does this mean for climate policy?

- Even significant increase in the effective price of carbon is unlikely, on its own, to yield needed emissions reductions.
- A *qualitative* socio-economic transformation will be required—comparable to IT/communications revolution
- Getting environmental policy "right" is surely *necessary*, it is unlikely to be *sufficient*
- Carbon base will be larger for a long time, so private incentives will continue to favor carbon innovation (Acemoglu, et al 2009)

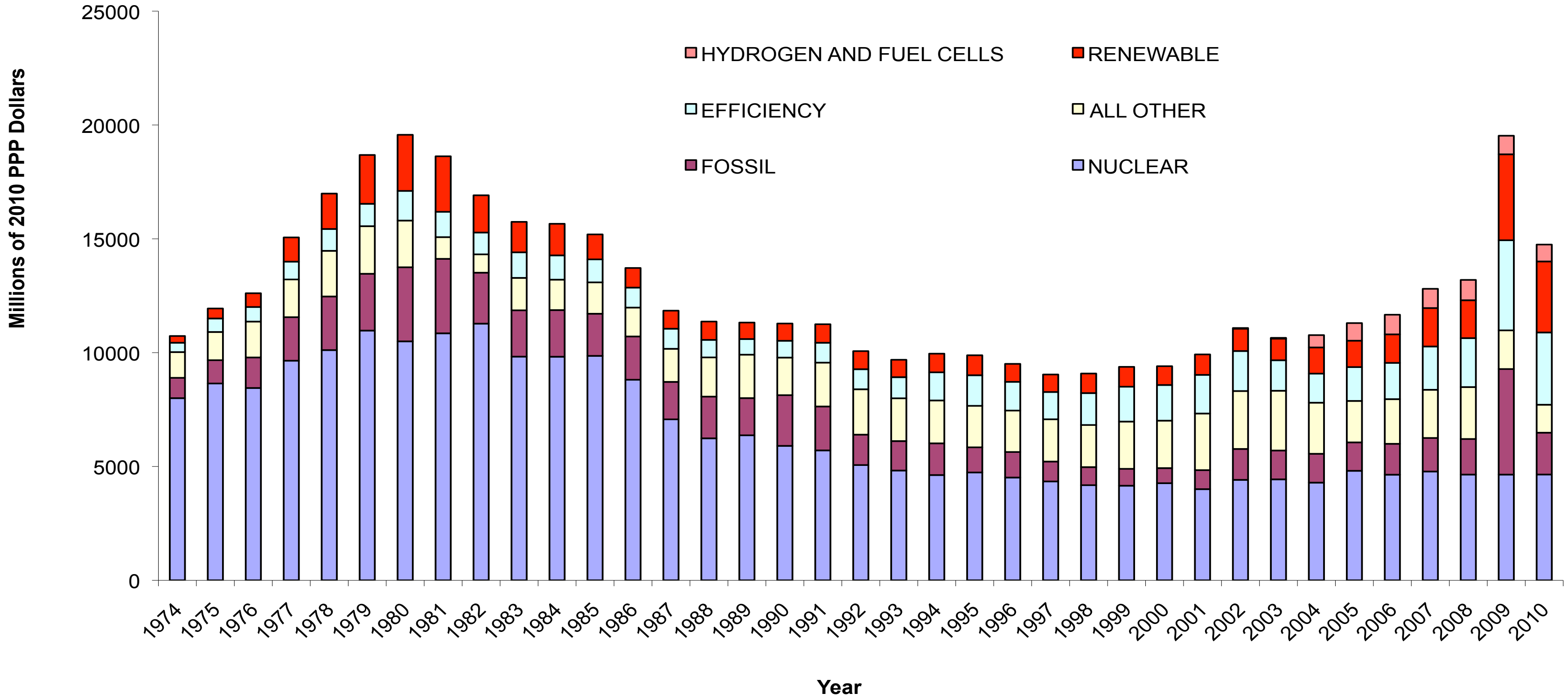
Technology Market Failures

- Imperfect appropriability of knowledge
  - Research spillovers (Jaffe, 1998)
  - Learning curve spillovers (Thompson, 2010)
  - User-driven technology improvement (von Hippel, 2010)
- Asymmetric information affecting capital market (Hall and Lerner, 2010)
- Path-dependence and potential importance of technology trajectories (Dosi and Nelson, 2010)

Important caveat: SR inelastic supply of specialized human capital

Figure Four

IEA Countries Energy R&D



Manhattan and Apollo projects (Willbanks, 2011)

- Manahttan project: $28B over 2-3 years
- Apollo $140B over 10 years
- Well-defined technical objectives with cost no object
- Maybe relevant to subgoals, e.g. carbon capture and storage

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War on Cancer/NIH budget doubling (Cockburn, et al, 2011)

- Human capital is crucial
- Market demand (3rd party payment, one way or another)
- NIH doubling
  - Adjustment costs
  - Importance of training in parallel with research expansion

Semiconductors, computers and communications (Mowery,2011)

- Design competitions for defense and space uses, with little or no regard to cost
- Transition to commercial markets later after cost fell
- Induced R&D through competition for technically specified products (Lichtenberg, 1988)

Synfuels
(Cohen and Noll, 1991)

- Government-built demonstration plants
- (contrast to previous case)
- Not cost-effective
- Crowded out private investment

Speculative Conclusions

- Long-term perspective
- The social rate of return to government technology investments is high.
- Increase in public support should be gradual.
- Building specific human capital is critical.
- Public purchases and/or purchase mandates will be needed.
- Government investment should be designed to be complementary to private investment.
- “Success” will almost surely require technologies not foreseen today.
- Nothing should be “off the table.”

Research Needs

- Systematic program evaluation.
- Which means:
  - Modeling of “but for” world so that incremental impact of policy can be estimated
  - Which means:
    - Evaluation has to be built into program design and funding up front, so that data on initial evaluations, rejected proposals and baseline attributes of funded entities are collected and maintained.

References

BP Statistical Review of World Energy 2010, http://www.bp.com/productlanding.do?categoryId=6929&contentId=7044622

Cohen, Linda R. and Roger G. Noll, 1991. The Technology Pork Barrel, Brookings Press

Cockburn, Iain, Scott Stern and Jack Zausner, 2011. "Finding the Endless Frontier: Lessons from the Life Sciences Innovation System for Energy R&D," in Henderson and Newell, *op cit*

Dosi, Giovanni and Richard R. Nelson, 2010. "Technological change and industrial dynamics as evolutionary processes," in Hall and Rosenberg, *op cit*

Goolsbee, Austin, 1998. "Does government R&D policy mainly benefit scientists and engineers?", *American Economic Review*

Goulder, Lawrence H. and Stephen H. Schneider, 1999. "Induced technological change and the attractiveness of CO2 abatement policies," *Resource and Energy Economics* 21 pp. 211-253.

Grimaud, Andre and Gilles Lafforgue, 2008. "Climate change mitigation policies: Are R&D subsidies preferable to a carbon tax?" *Revue d Economie Politique* 118:6 pp. 915-940 .

Griliches, Zvi, 1992. "The search for R&D spillovers," *The Scandinavian Journal of Economics*

Hall, Bronwyn H. and Josh Lerner, "The financing of R&D and innovation," in Hall and Rosenberg, *op cit*

Hall, Bronwyn H. and Nathan Rosenberg, eds., Handbook of the Economics of Innovation, North Holland

Henderson, Rebecca and Richard Newell, eds., 2011. Accelerating Energy Innovation: Insights from Multiple Sectors, University of Chicago Press

Hicks, John R., 1932. The Theory of Wages, London: Macmillan

Jaffe, Adam B., 1998. "The Importance of 'Spillovers' in the Policy Mission of the Advanced Technology Program," *Journal of Technology Transfer***,** Summer

Jaffe, Adam B., 2002. "Building Programme Evaluation into the Design of Public Research-Support Programmes," *Oxford Review of Economic Policy*

Lichtenberg, Frank, 1988. "The Private R and D Investment Response to Federal Design and Technical Competitions," *American Economic Review* 78:3, pp 550-559.

Mansfield, E., J.Rapoport, A.Romeo, S.Wagner and C.Beardsley, 1977. "Social and Private Rates of Return from Industrial Innovations," *Quarterly Journal of Economics* 77:221-240

Mowery, David C., 2011. “Federal Policy and the Development of Semiconductors, Computer Hardware, and Computer Software: A Policy Model for Climate-Change R&D?” in Henderson and Newell, *op cit*

Popp, David, 2006. "Comparison of climate policies in the ENTICE-BR model," *Energy Journal* Special Issue 1, pp. 163-174.

Popp, David, Richard Newell and Adam Jaffe, 2010. “Energy, the environment, and technological change,” in Hall and Rosenberg, *op cit*

Thompson, Peter, 2010. “Learning by doing,” in Hall and Rosenberg

US Dept of Agriculture, World GDP Historical Data, http://www.ers.usda.gov/Data/Macroeconomics/Data/HistoricalRealGDPValues.xls

U.S. National Science Foundation, “Federal obligations for total research and development, by major agency and performer”, Multiple tables: 1951-2002; 2001-2003; 2004-2006; 2007-2009.” Science and Engineering Statistics, Federal Funds for R&D, http://www.nsf.gov/statistics/fedfunds/

Von Hippel, Eric, 2010. “Democratizing innovation: The evolving phenomenon of user innovation,” in Hall and Rosenberg, *op cit*

Werfel, Seth and Adam Jaffe, 2013. “Induced Innovation and Technology Trajectory: Evidence from Smoking Cessation Products” ***Research Policy***

Wilbanks, Thomas J, 2011. “Inducing Transformational Energy Technological Change”, *Energy Economics* 33:4