Climate Change, Innovation and Technology Policy

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Innovation in Kiwi-land

Overview

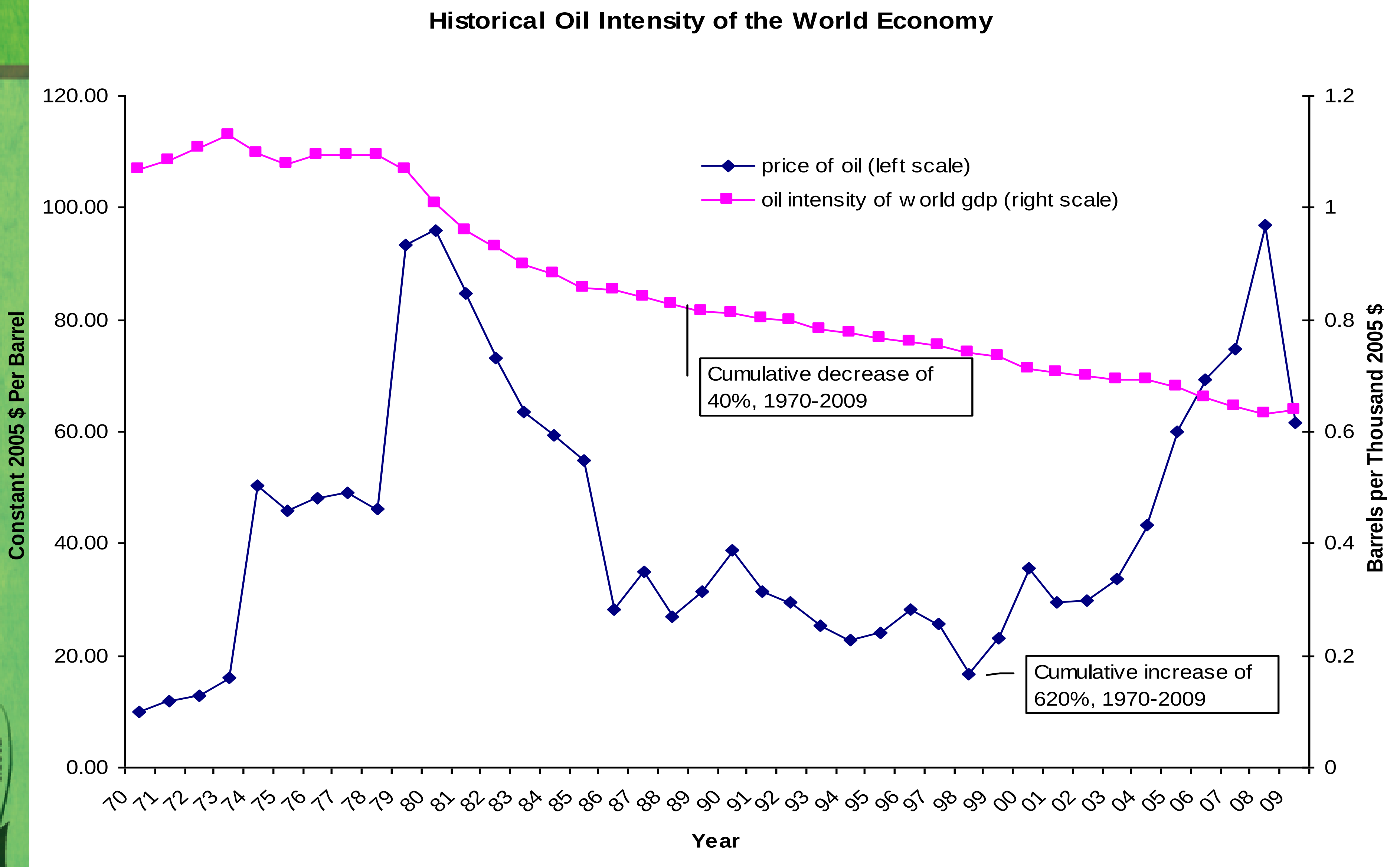
- The Challenge
- Lessons from history
- Policy levers
- Concluding thoughts

The Challenge

- There's controversy around the exact timetable, but general agreement that over approximately the next 4 decades, GHG emissions have to be drastically reduced
- We hope that world GDP will continue to grow over this period, so the GHG/GDP ratio needs to fall by even more than the needed absolute reduction in GHG emissions
- Back of the envelope: something like a 75-90% reduction in global GHG/GDP is needed by 2050

How hard will this be?

- From 1970-2010, the global petroleum/GDP ratio fell by about 40%.


Historical Oil Intensity of the World Economy
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
Constant 2005 $ Per Barrel
Barrels per Thousand 2005 $
Year
120.00
100.00
80.00
60.00
40.00
20.00
0.00
1.2
1
0.8
0.6
0.4
0.2
0
70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09
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How hard will this be?

- From 1970-2010, the global petroleum/GDP ratio fell by about 40%.
- Over this time period, we saw an approximately 6-fold increase in the price of petroleum (prior to the most recent decline)
- Since petroleum is a subset of fossil fuels, it is inherently much more difficult to reduce overall fossil fuel use than to reduce petroleum use

We need a transformation in the energy/economy system that is qualitatively broader and deeper than anything that we've ever seen in this sector.

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

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
- 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)

Is there any historical analogue?

- The global IT/communication system has seen a transformation in performance over the last 4 decades that is qualitatively comparable to what we need in energy.
- Most of the key features of today's IT/communications system (the internet; smart mobile phones; gigabytes of memory on a keychain, etc.) were not even visualized as potential future products or markets as of 1970.
- We need a qualitatively comparable transformation of the energy/economy system.

Implications

- If we succeed, it is very likely that major components of the 2050 system will be technologies that we have not yet even conceived, let alone begun to develop
- The companies that will play large roles in the 2050 system probably do not exist today, and many of today's giants are likely to disappear, shrink, or be radically transformed.
- Major new technologies are likely to emerge and then fall by the wayside (think minicomputer, fax machine, CD ROM)
- Major contributions will be needed from both the public and private sectors

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

What can we learn from past attempts to push the technology frontier

- Manhattan/Apollo projects
- War on Cancer
- IT and Communications
- Synfuels

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

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

- Human capital is crucial
- Market demand (3^{rd} 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

Policy levers

- Scientific research
- Government procurement
- Intellectual Property rules

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Policy levers: scientific research

- Significantly increased fundamental science funding
  - Large private science efforts such as Bell Labs, IBM, Xerox were major drivers of early digital technology
  - These are mostly gone and do not seem likely to come back
- Capability building must be addressed along with research funding per se (think of NIH training grants)
- Entire energy science/technology system must be scaled up
- Again, need long-term commitment—ideally 5% real increase for decades, not a crash programme that creates large adjustment costs and then goes away

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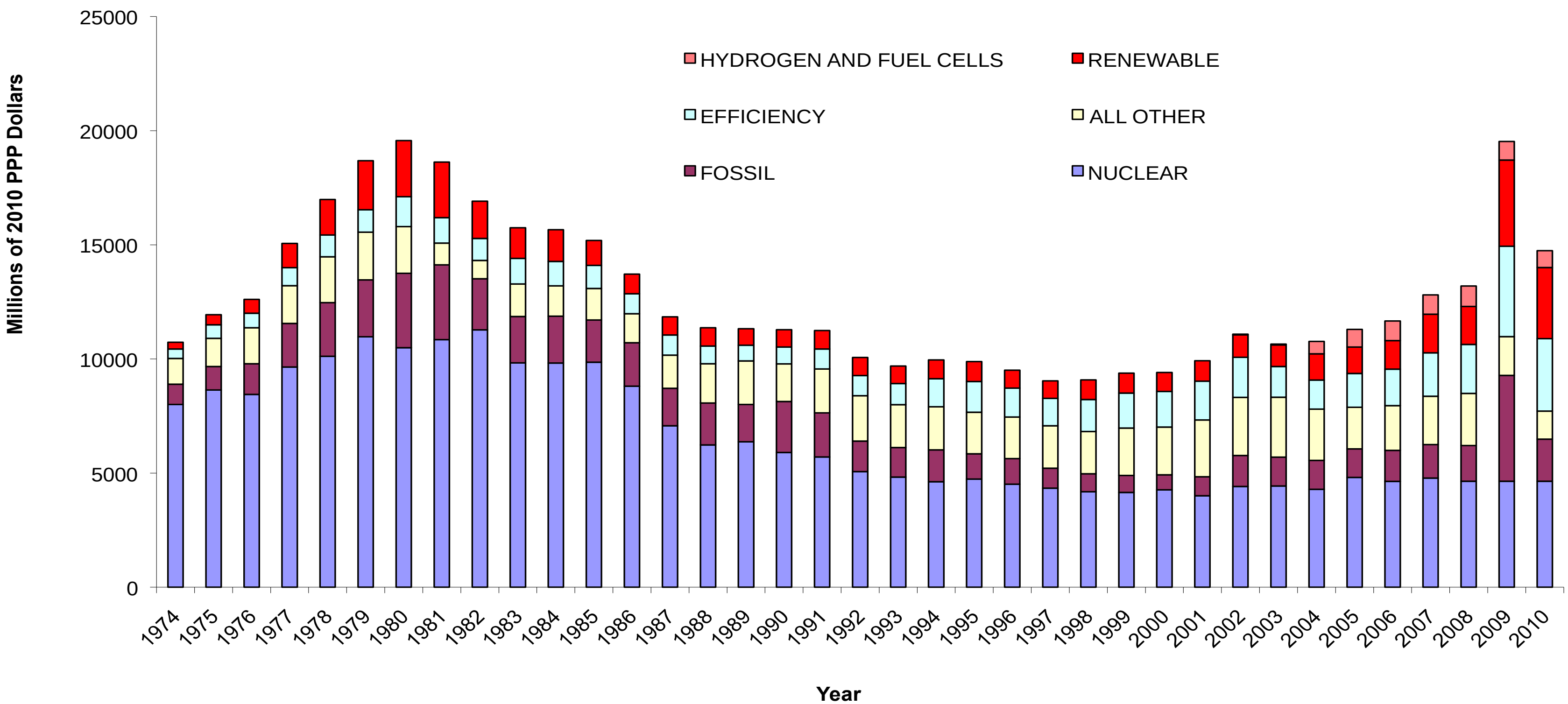
Figure Four

IEA Countries Energy R&D



Government procurement

- Large-scale specific goals, such as the atomic bomb or landing on the moon.
  - Scientific/technological advances emerge as by-product of the need to solve the particular challenges of the project.
    - Not clear if this is a cost-effective way of improving technology
    - May be valuable as political/popular focusing mechanism
- Design competitions for ongoing purchases (think military aircraft)
- Mandates on quasi-public or regulated entities, such as renewable energy portfolio rules

Policy Levers: Intellectual Property Rules

- IP protection theoretically supports investment in innovation by providing protection for development expenditures.
- Empirical evidence in support of their efficacy is limited.
- “Strong” IP protection also inhibits the diffusion of new technologies. This is problematic for two reasons:
    - GHG-reducing benefit is less than it could be
    - Feedback from deployment to innovation is also inhibited, so new technologies may not improve as fast as they might.
- LDCs are not fooled by the claim that enforcing strong IP is in their own economic interest.

Systematic Evaluation

- It's embarrassing how little we know about the effectiveness of different policy instruments
- Agencies are allowed to get away with success stories rather than true evaluation
- Need to measure the "treatment effect" of a policy intervention just as we do for drugs
  - Randomized control trials
  - Natural experiments
- Over the next decade, we could learn a lot about what works best, which could then be implemented as we continue to ramp up

Speculative Conclusions

- “Carbon” policy and “innovation” policy are not substitutes—they are complements and we need both
- The social rate of return to government technology investments is high.
- Increase in public support should be gradual.
- Building specific human capital is critical.
- Time scale is decades, which allows time to build capabilities efficiently, but also requires credible long-term commitments
- Public purchases and/or purchase mandates will be needed.
- Government investment should be designed to be complementary to private investment.
- Look for opportunities for global “win-win”: e.g. pair strong global IP enforcement with significant financial assistance for poor countries to implement new GHG-reducing technologies
- “Success” will almost surely require technologies not foreseen today.
- Should be embarking on systematic programme evaluation
- Nothing should be “off the table.”