Modeling Innovation and Technology Diffusion: Implications for Policy Action

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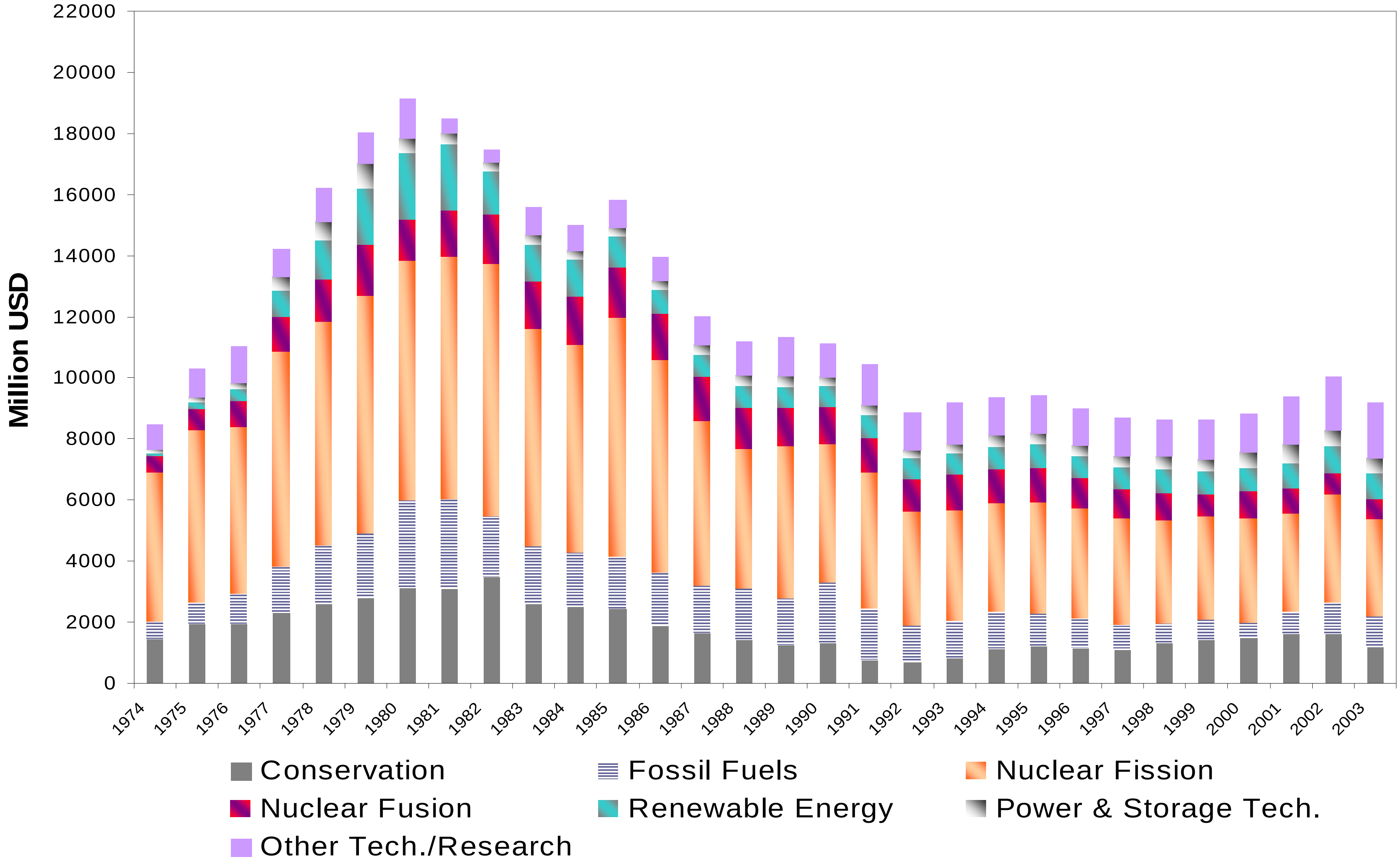
LCS-RNet First Annual Meeting

CMCC

Bologna, 12-13 October 2009

Energy R&D Expenditure 1974-2003



Mitigation Policy and Technological Innovation

- In order to meet climate change mitigation targets, significant changes in technological portfolio are needed.
- Low or zero carbon technologies currently have limited range of application.
- Significant investment in:
  - R&D of carbon free energy technologies;
  - R&D to increase energy efficiency.
- Policy question: how to induce and manage a rapid increase in energy related R&D? Do we need R&D policies coupled to mitigation policy?

Modeling Technological Innovation: Policy Implications

- Use the IAM WITCH (World Induced Technical Change Hybrid)...
  - Bosetti, V., C. Carraro, M. Galeotti, E. Massetti and M. Tavoni, EJ 2006
  - Bosetti, V., E. Massetti and M. Tavoni, 2007
  - www.feem-web.it/witch

A World Induced Technical Change Hybrid Model

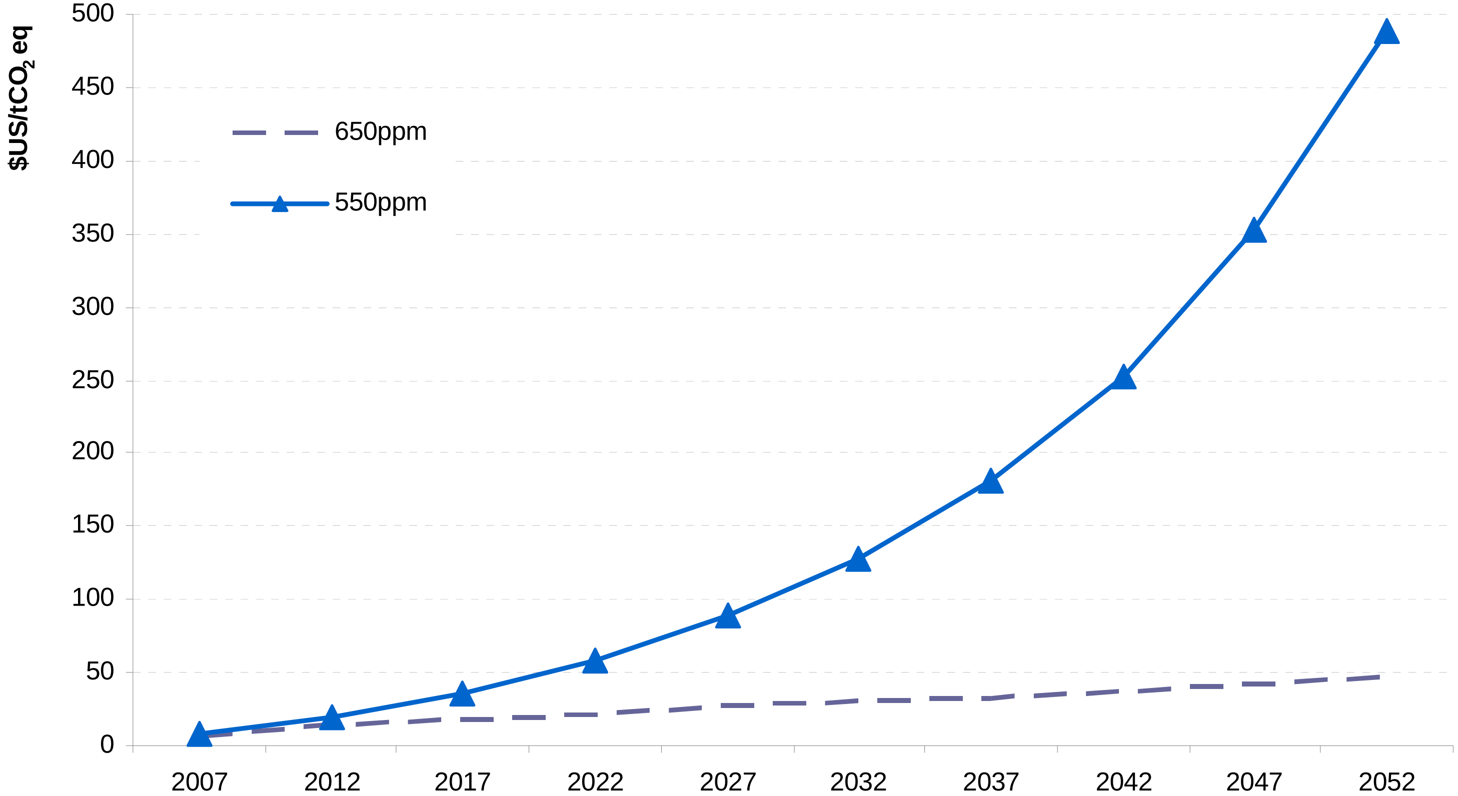
- ... to explore the implications of different modeling assumptions on policy prescriptions:

1. The role of carbon price signals: a benchmark;
2. Modeling R&D for breakthrough technologies;
3. Energy and Non-Energy R&D: crowding-out effects and the true macroeconomic cost of energy R&D;
4. Climate policy in a second-best world: domestic and international R&D spillovers;
5. Technological innovation as a “stand alone” policy.

1. The Role of Carbon Price Signals: A Benchmark

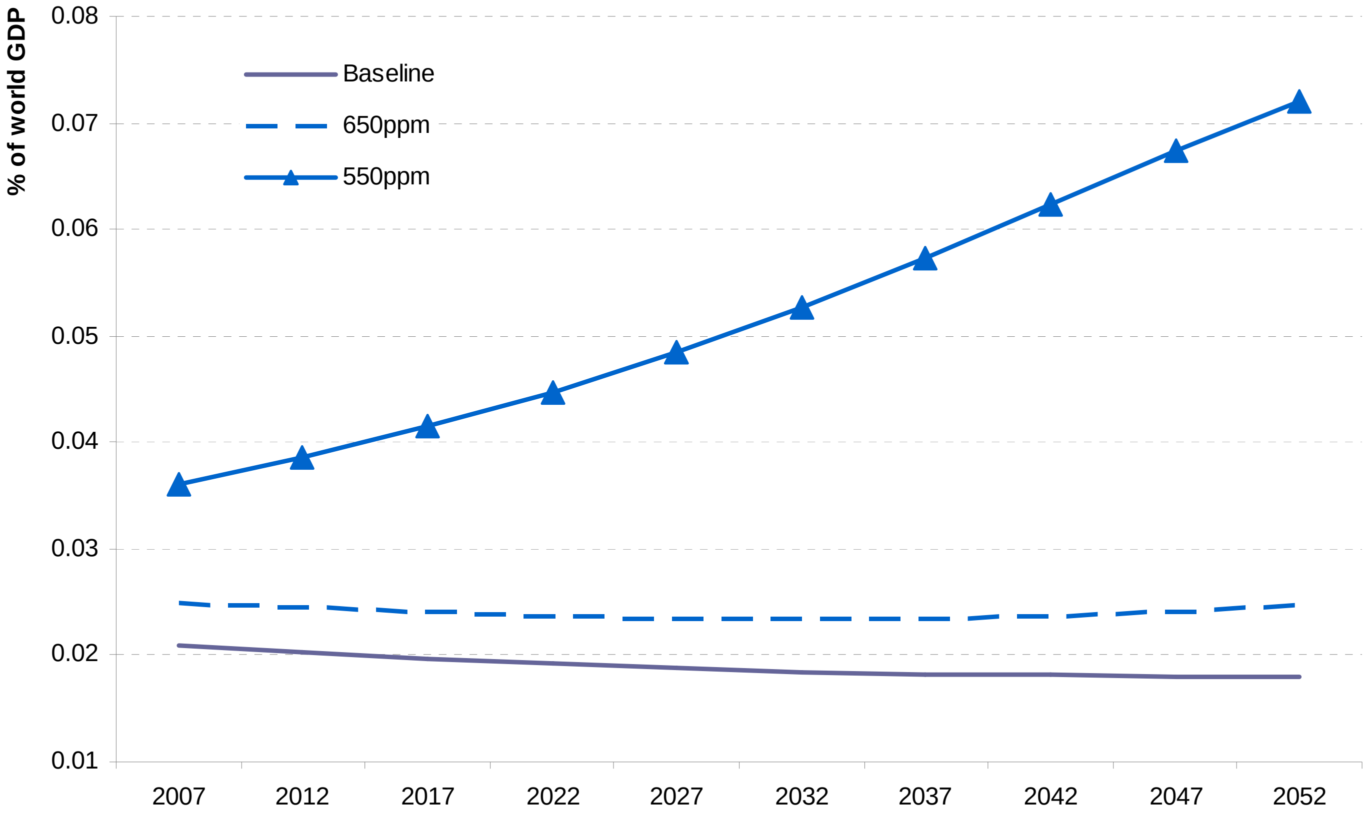
- Climate policy scenarios generated by WITCH model.
- Two (intertemporally optimal) carbon price paths consistent with:
  - 450ppm (550ppm all gases);
  - 550ppm (650ppm all gases).
- R&D improves only energy efficiency (efficiency of existing technologies).

1. Carbon Price Under Two Stabilization Policies



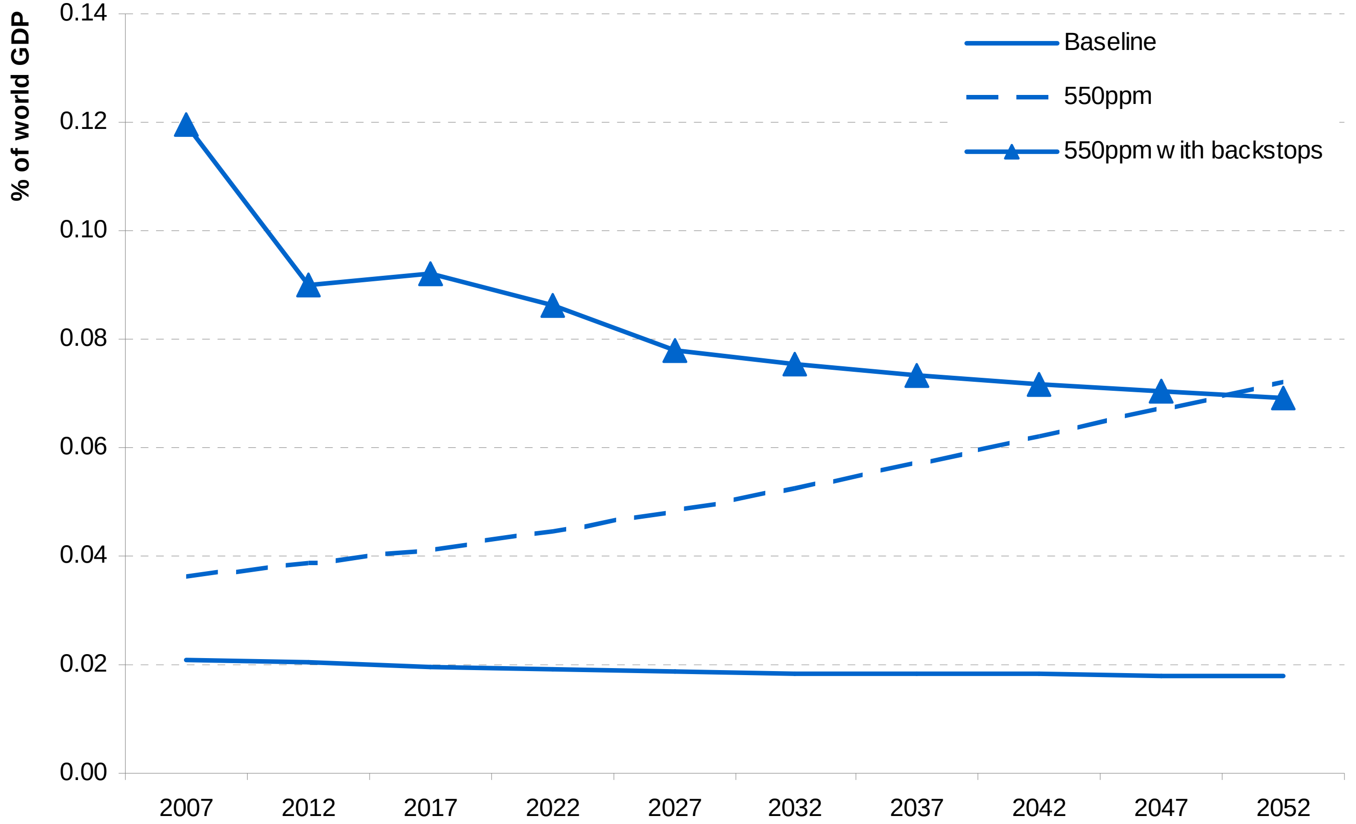
- ➢ Non linearity in abatement cost as a function of concentration target (550 or 650 ppm all GHG included).
- ➢ Increasing difference over time.

1. Investments in Energy Efficiency R&D



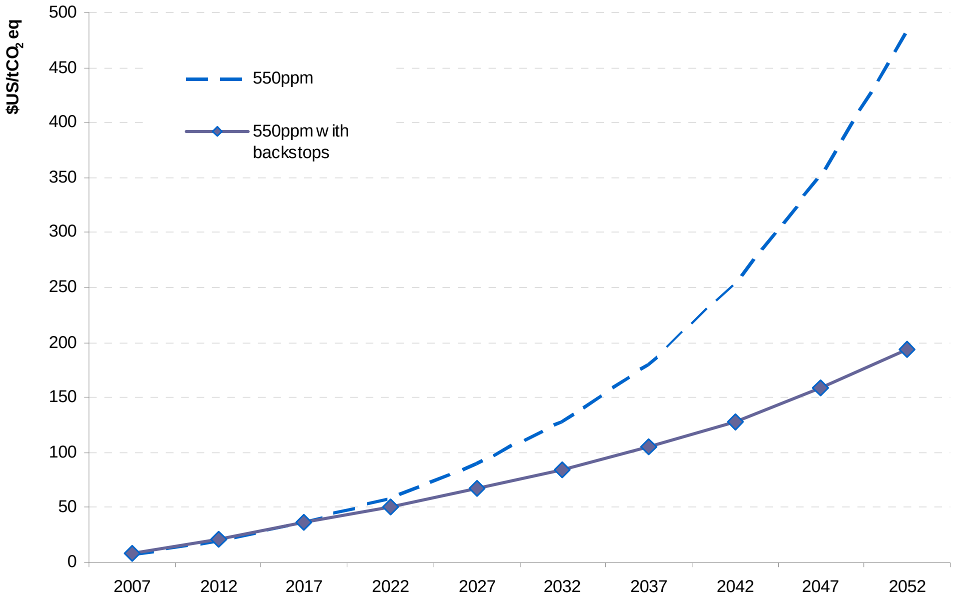
- Investments in energy efficiency R&D are significantly higher with just a strong carbon price signal.

2. Modeling Breakthrough Technologies

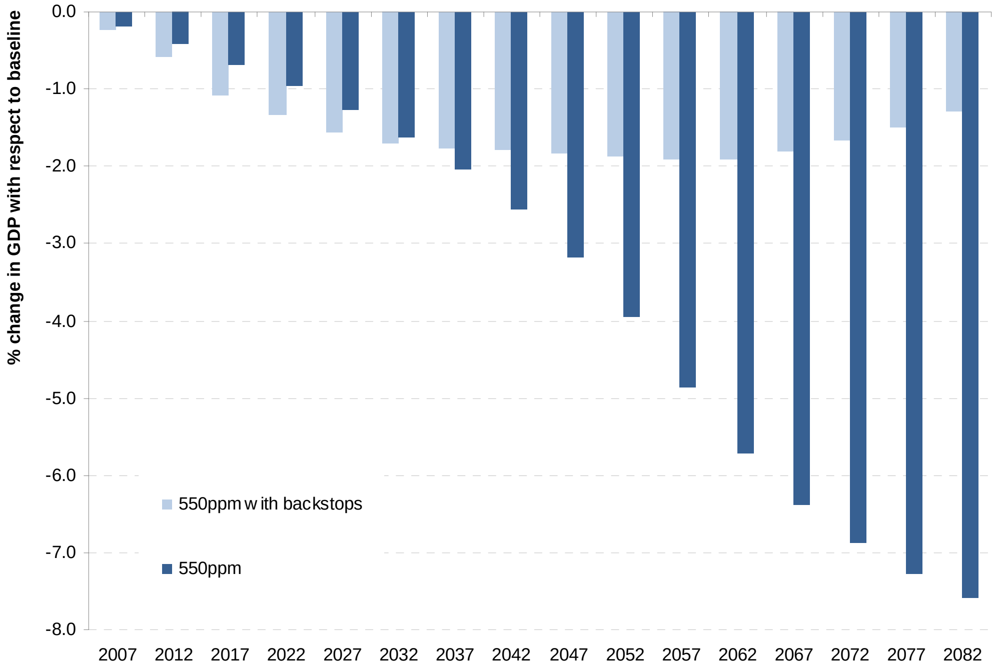


- ➢ Breakthrough technologies can only become available with substantial investments in R&D.
- ➢ Energy R&D expenditures increase to about 0.12% of GDP, vs. 0.02% in the BAU.

2. Mitigation Costs with the Backstop Technologies



- The price of carbon is much lower with breakthrough technologies.
- Crucial role to decarbonize non-electric energy (transport).



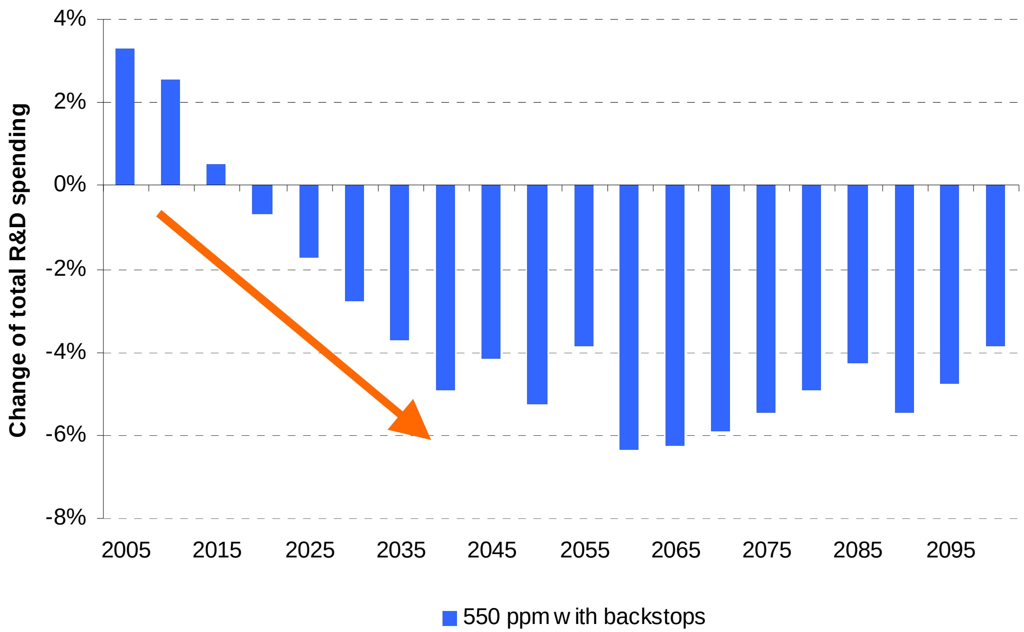
- And therefore the costs of stabilisation are much lower, especially in the long term.

3. Energy and Non-Energy R&D Dynamics

- The macroeconomic cost of increased energy R&D spending.
- Will higher R&D spending in the energy sector crowd out some investments in R&D in other sectors?
- Short term frictions may emerge but…
- … in the medium-long run, there is no constraint for societies to increase the supply of laboratories and scientists.
- We introduce directed technical change in the WITCH model:
  - Investments in Energy and Non-Energy R&D;
  - Endogenous crowding-out effects.

3. The Impact of Climate Policy on Total R&D

- No direct crowding-out effect of energy R&D on non-energy R&D.
- Climate policy induces a contraction of non-energy R&D spending.
- Overall R&D activity is lower under climate policy.
- Only in the short term there might be tensions in R&D market.



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4. International Spillovers: Global R&D Fund

- 550 ppm all GHG stabilization policy, global carbon market.
- International R&D spillovers in energy sector.
- International R&D Fund:
  - To fully internalize the externality in the R&D sector;
  - Additionality of R&D spending.

4. International Spillovers: Limited Scope for Global Fund

- When the Fund subsidizes investments in energy efficiency R&D, it has a limited impact on costs of meeting the mitigation target.

- The Fund has more impact (although still limited) when used to “decarbonise” the economy:

  - Subsidizes R&D in the backstops;
  - Subsidies to deployment of existing low carbon technologies.

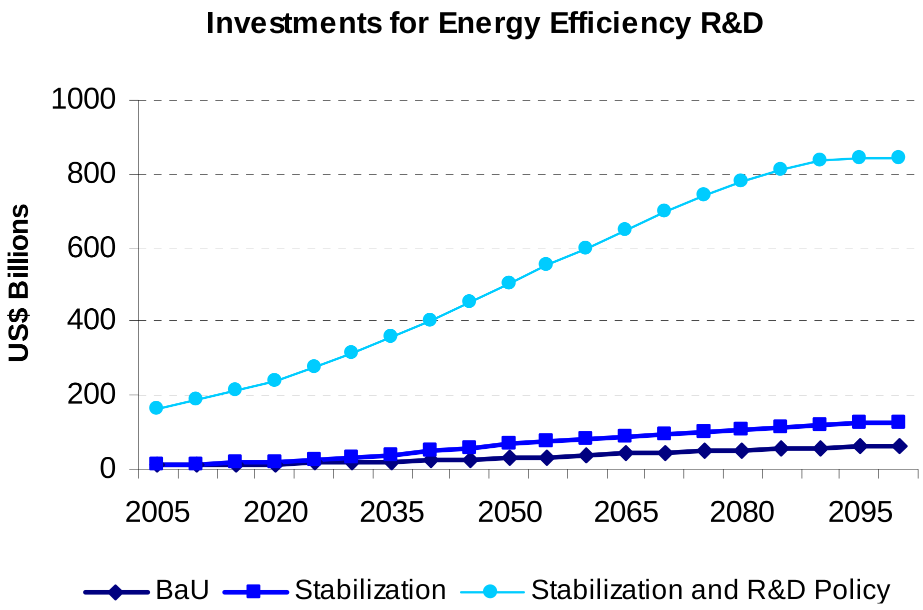
- The carbon price signal alone has significant impacts on energy services, so the additional R&D in energy efficiency has a low marginal effect.

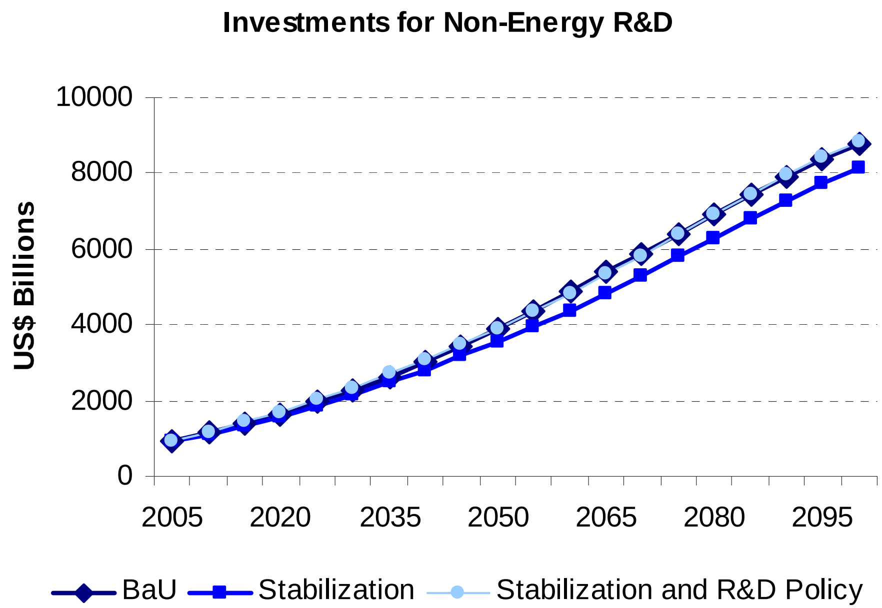
- The environmental externality dominates the knowledge externality.

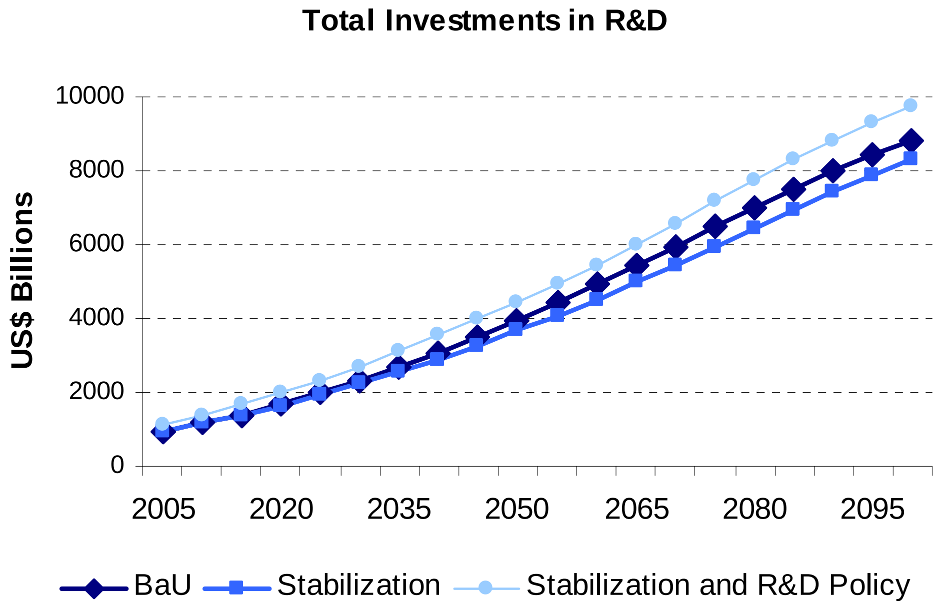
4. Domestic Spillovers: R&D Policy and Climate Policy

- 550 ppm all GHG stabilization policy, global carbon market.
- WITCH with directed technical change (energy and non-energy R&D investments).
- Intersectoral, domestic, R&D spillovers.
- Size of the Fund:
  - Endogenously chosen by each social planner.

4. Domestic Spillovers: R&D Policy and Climate Policy







- R&D Policy triggers much higher energy R&D investments;
- Total R&D increases (compared to a decline when externalities are not internalized).

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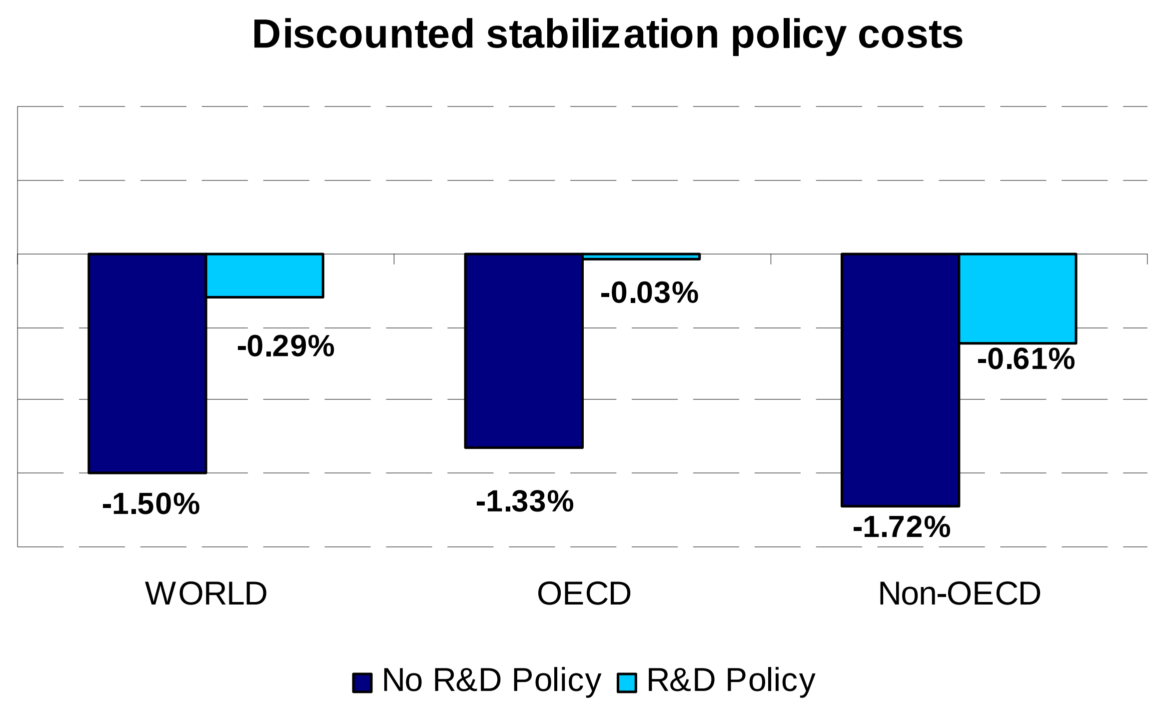
4. Domestic Spillovers: R&D Policy and Climate Policy

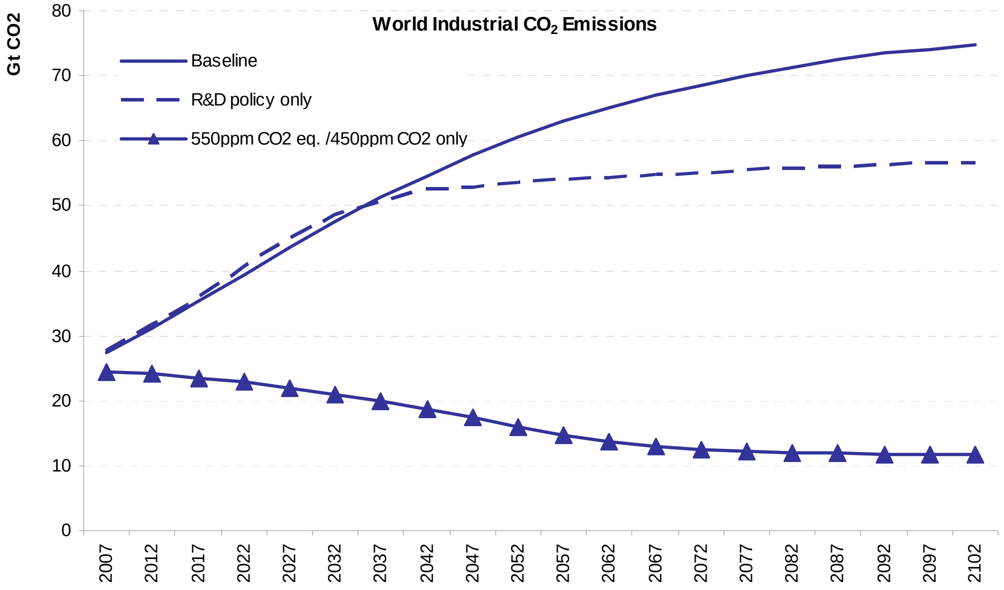


- Internalizing domestic knowledge externalities is not in contrast with climate policy.

- Climate policy only is not sufficient to stimulate the socially optimal level of R&D.

- The knowledge externality dominates the environmental externality.

5. Technological Innovation as a "Stand-Alone" Policy

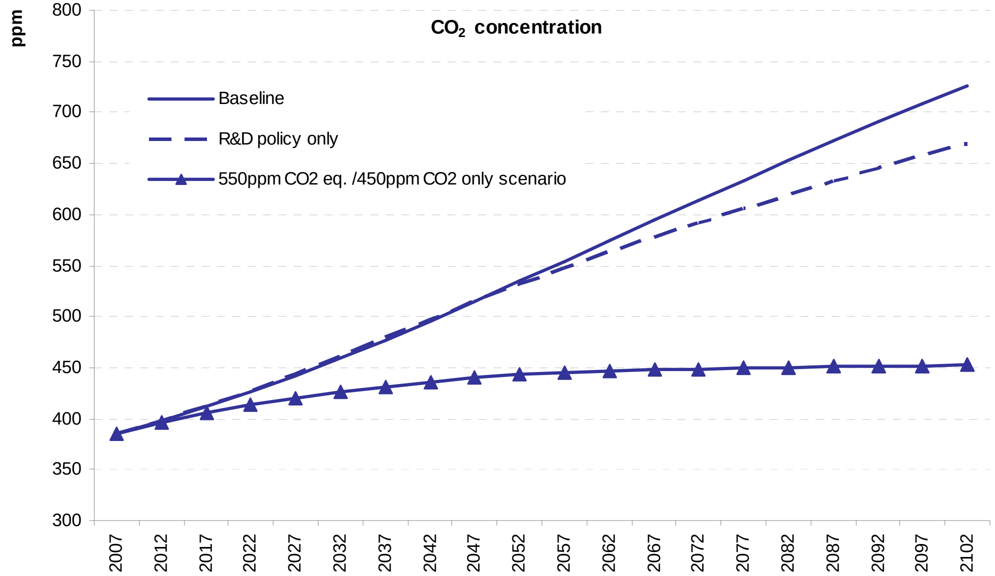


- Backstop technologies;

- Without a carbon price signal, the subsidies to backstop R&D stabilise emissions by mid-century.

- The effect on concentration is negligible because of inertia in the system.

- GDP gains because the knowledge externality is internalized.



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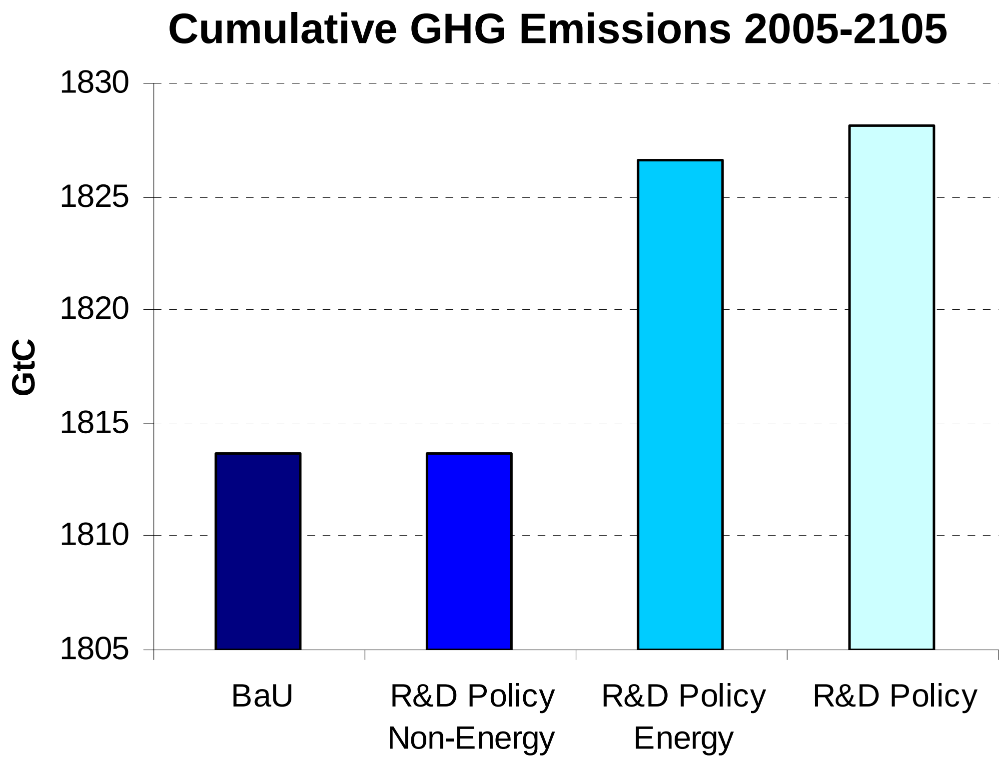

- Policies to internalize domestic knowledge externalities lead to higher emissions if a climate policy is not implemented.

Conclusions

1. Carbon price signals:
   - Extremely important;
   - credible price signal is created by credible climate policy.

2. Role or technological innovation in reducing stabilization costs:
   - Desperately looking for breakthrough technologies in non-electric energy.

3. Pressures on the R&D market and crowding out:
   - Not a major issue, weak or no competition among R&D sectors.

Conclusions

3. Global institutions to manage R&D:
   - The contribution to costs saving is limited; technological externality is dominated by the environmental externality.

4. Domestic institutions to manage R&D:
   - The correction of domestic knowledge externalities is not in contrast with climate policy.

5. R&D policy alone:
   - Not a policy option to tackle climate change.

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www.economicsclimatechange.com

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