Designing a Friendly Space for Technological Change to Slow Global Warming

William Nordhaus
Yale University

Snowmass Workshop
on Technologies to Combat Global Warming

August 4-5, 2008

Basic question and proposition

Question: What is the best strategy to encourage research and development on technologies for a rapid and economical transition to a low-carbon economy?

Answer: To a first approximation, a necessary and sufficient condition is the appropriate price on carbon emissions.

Terminology

"Brown products": ones with negative externalities (CO2, SO2, …)

"Green innovation": innovation that reduces the ratio of brown products per unit output

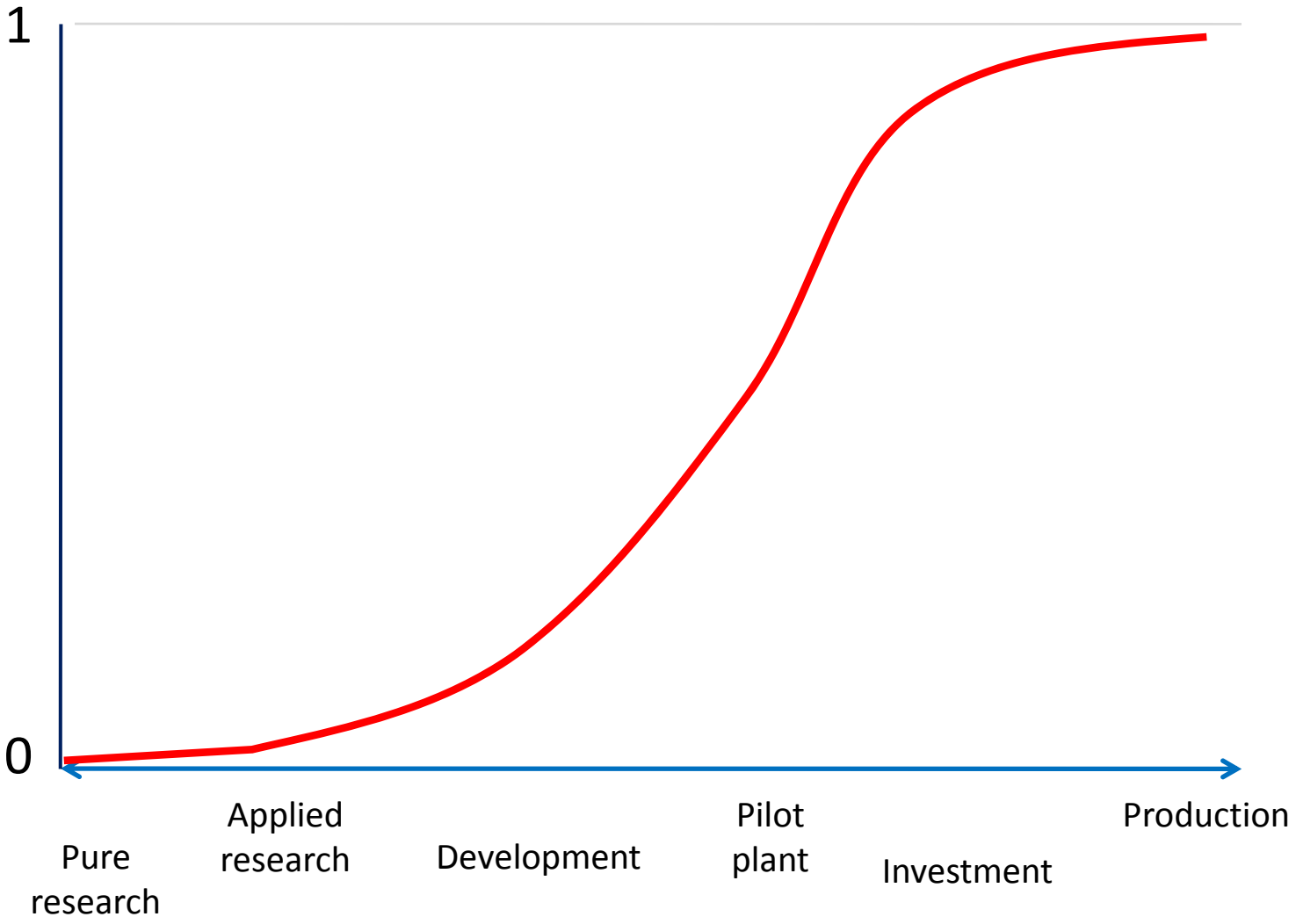
"White innovation": innovation on neutral output, ones with no significant externalities

Reasoning

Necessary: To ensure appropriate incentives for innovation (research, development, entrepreneurship, commercialization, software, plant, and equipment), firms and innovators must have clear financial incentives. These can only be ensured by a credible, universal, and durable price on the externality.

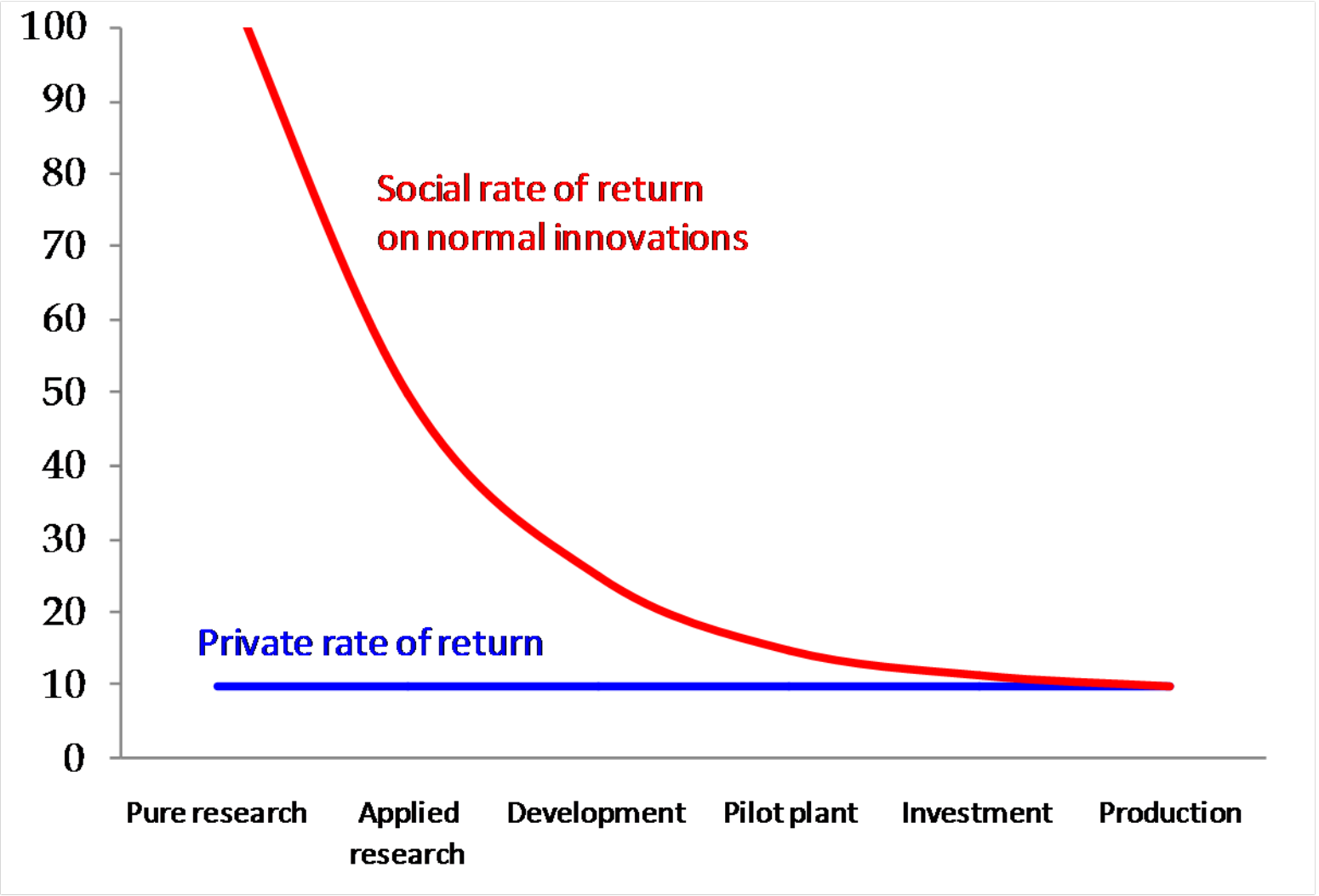
Sufficient: Once the carbon price is at the correct internalizing level, then green innovation will be on a level playing field with white innovation. At that point, the social returns to green innovation will be equal to those on white inventions.

Appropriability



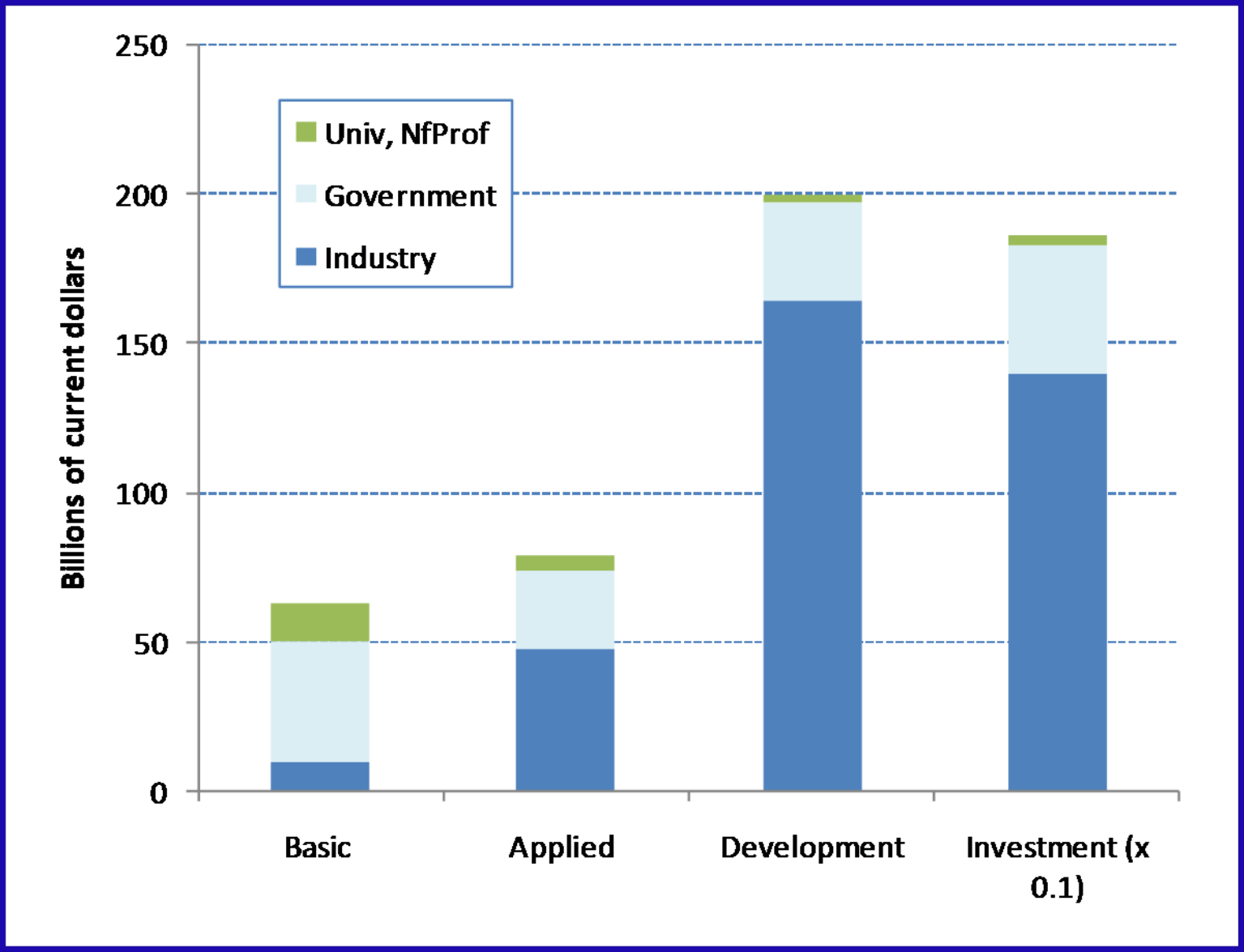
The spectrum of innovation

Rates of return

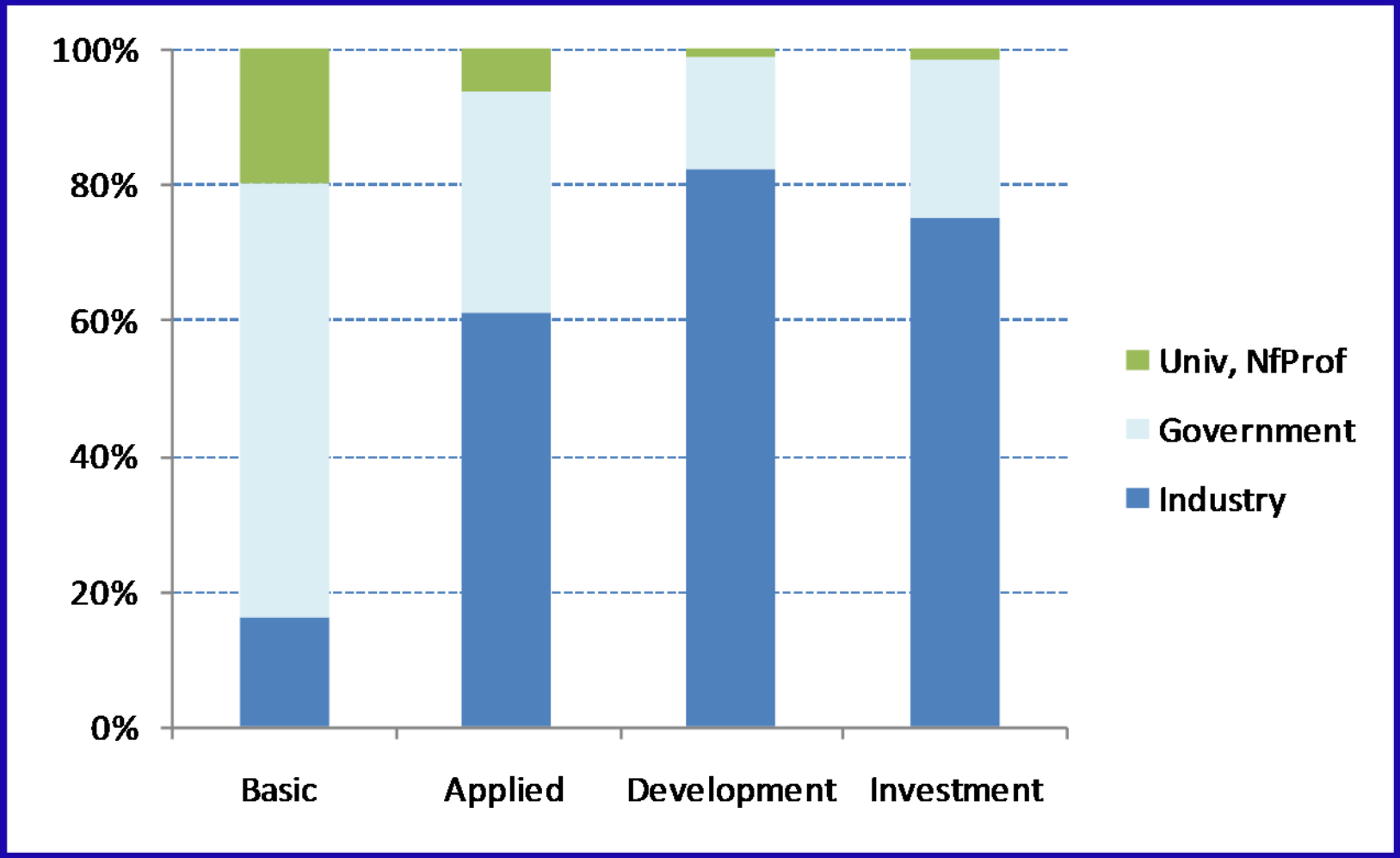


The spectrum of innovation

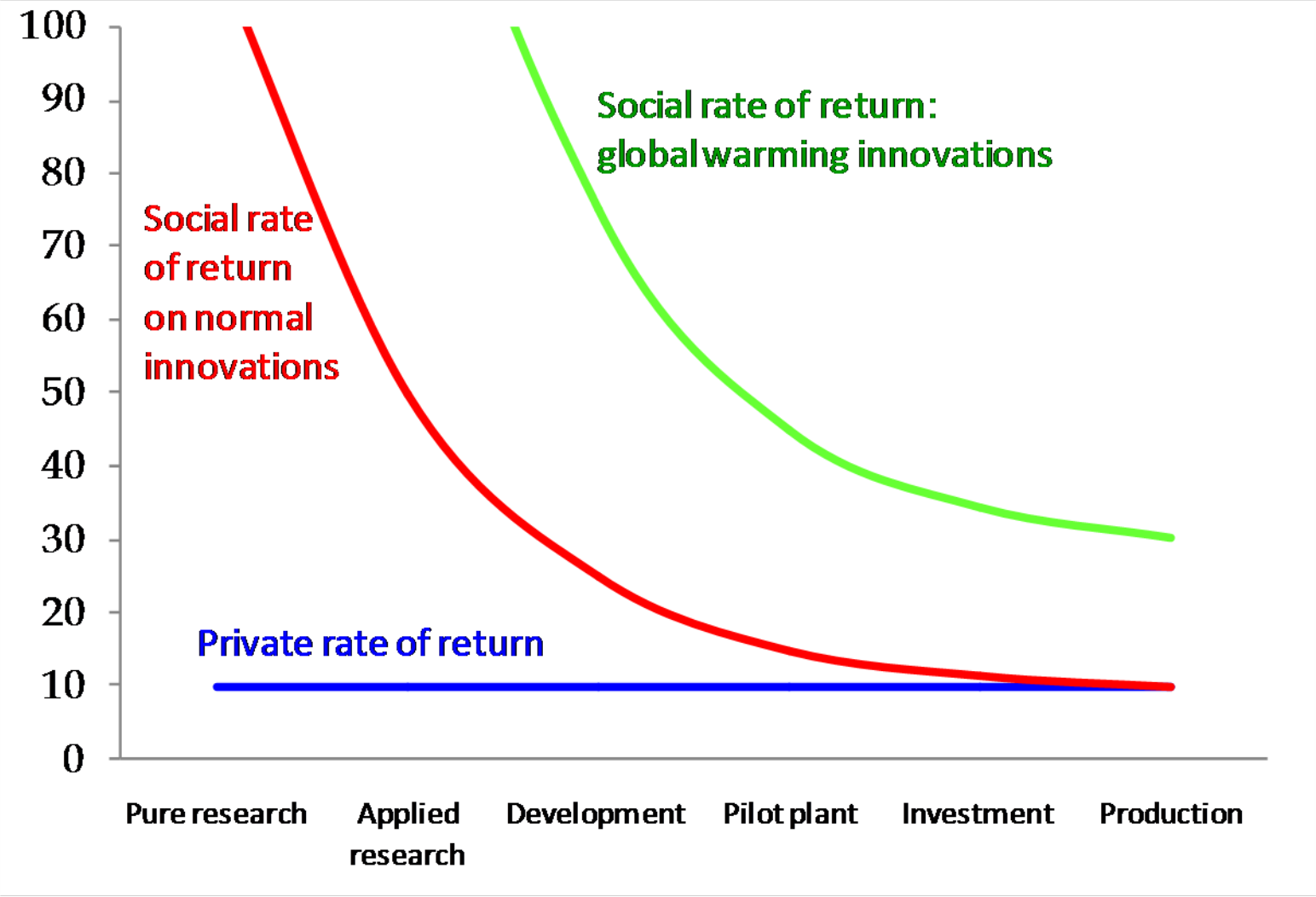
Innovation by sector and type



Innovation by sector and type

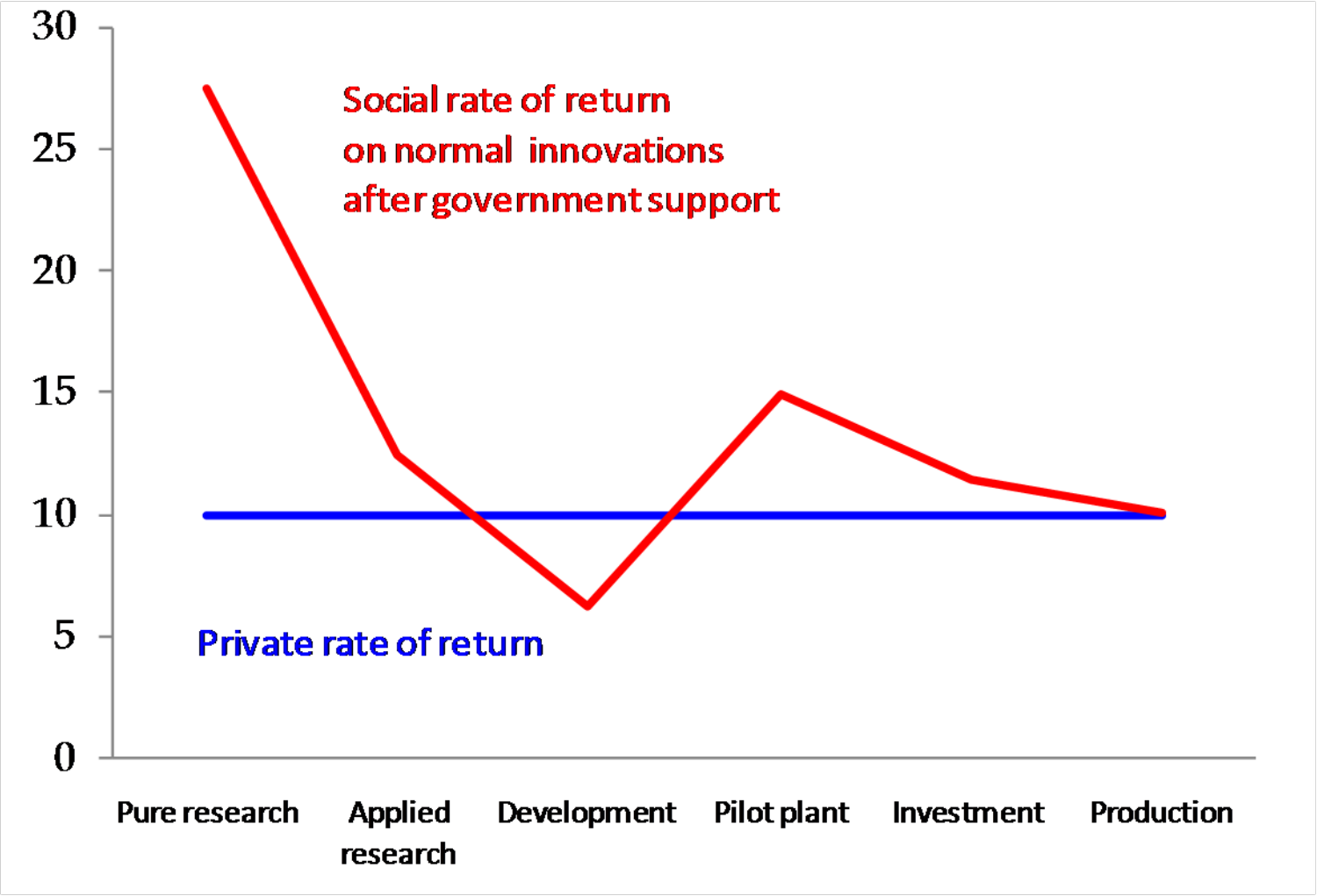


Rates of return



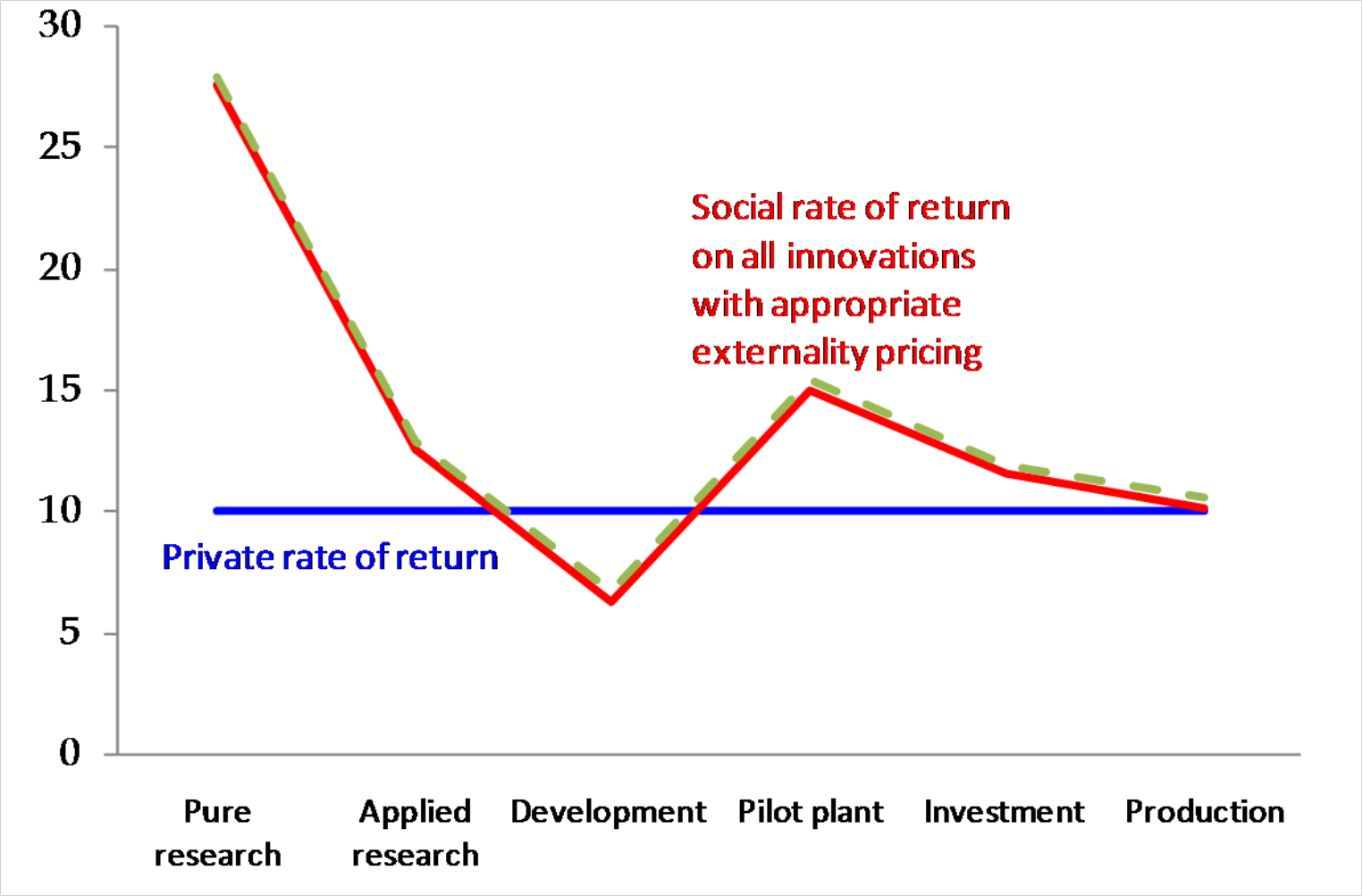
The spectrum of innovation

Rates of return



The spectrum of innovation

Rates of return



The spectrum of innovation

Qualifications

Reservation 1. Incorrect pricing of the environmental externality

- The reasoning for the "level playing field" between green and white innovation lies centrally on the assumption that inventors and innovators have the same incentives in different sectors. Clearly, this assumption does not hold at present for climate change, since the price of carbon emissions is zero in most countries.

- This of course is the central difficulty today. Even if governments subsidize basic research, it will be extremely difficult to make the link to profit-oriented innovation because firms simply won't care (or won't care enough about green innovation). Period.

Qualifications

Reservation 2. Incomplete internalization of the innovation spillover

- In reality, it seems highly unlikely that there is no remaining gap between social and private returns to invention. If the gap is not offset by technology policies, this implies that, even though green investments are on a level playing field with white investments, they still have supernormal returns.

- At this point, if the carbon price is right, we are best off just accepting the inability to find perfect instruments to close the social-private gap for innovation.

  - If we cannot solve the knowledge-externality problem in general, why do we think we can solve it for global warming
  - Also, we have the "von Neumann problem" for scarce research talent.

Proviso to the reservation

Assume that reservation 2 holds (knowledge externality not internalized). Why not just subsidize green investments heavily?

Opportunity cost problem: perhaps the R&D resources will come from other R&D. This would offset the benefit.

Examples:

- TRIPS and big pharma
- The "John von Neumann problem"

Other qualifications

Green innovations have important network characteristics; are especially large; involve a large component of basic research; have great inertia, or are highly uncertain:

- These are variants on qualification 2

Energy production has many other externalities

- These are variants on qualification 1

Energy technology has a particularly global dimension.

- An interesting twist. See next slide

International Distribution of GDP and R&D

Country or region	R&D	GDP
United States	268	9,764
Germany	52	2,130
Japan	99	3,246
France	34	1,532
United Kingdom	28	1,505
Five country total	480	18,177
OECD total	607	26,652
Five country as % of total	79%	68%

What about the carbon price?

1. How can we be sure that the carbon price will induce any technological change? Won't we need a humongous carbon price?

   Answer: If it doesn't induce a response, then the innovations are not cost-effective and we should use substitution.

2. How can we avoid catastrophic climate change?

   Answer: If the impacts are very large, then the carbon price will be high.

3. Don't we need an adjustment in the carbon price to induce the technologies?

   Answer: No. The price should just reflect the damages. Suppose that we calculate an optimal C tax with exogenous technologies. Then inducing innovation will only lower the optimal C tax!

Summary

So the technology problem with global warming is centrally a problem of getting the price of the environmental externality to reflect the true social cost.

The interesting twist on this is that the price should not have any special correction for the need to induce technological change.