How Should Countries Stimulate Innovation for the Environment?

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Should governments

- provide longer patent lives for green inventions?
- give a higher R&D tax credit for green R&D?
- give longer copyright lives to green songs and books?
- give tenure preference to green professors?
- give special stipends to green graduate students?
- give product subsidies to green products and services?
- include a special innovational bonus in Pigovian taxes or emissions standards?

The surprising answer is

If the environmental externality is priced at the marginal damage,

No.

Basic proposition

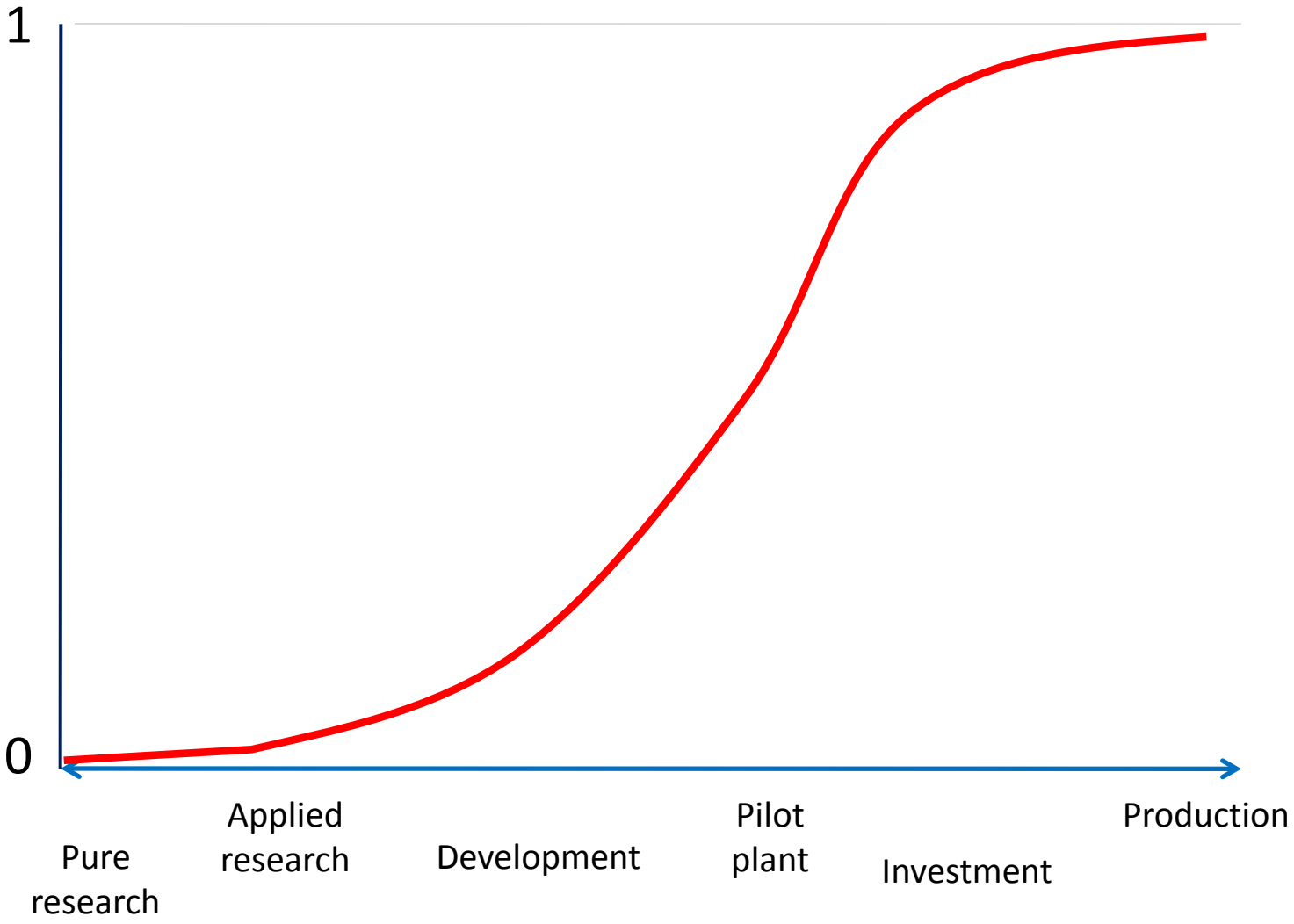
To a first approximation, a necessary and sufficient condition for the efficient generation of market R&D is to ensure an appropriate externality price on carbon emissions. That price should not include a special premium for innovation.

Reasoning

Necessary: To ensure appropriate incentives for technological change, innovators must have clear financial incentives. These can only be ensured by a credible, universal, and durable price on the externality.

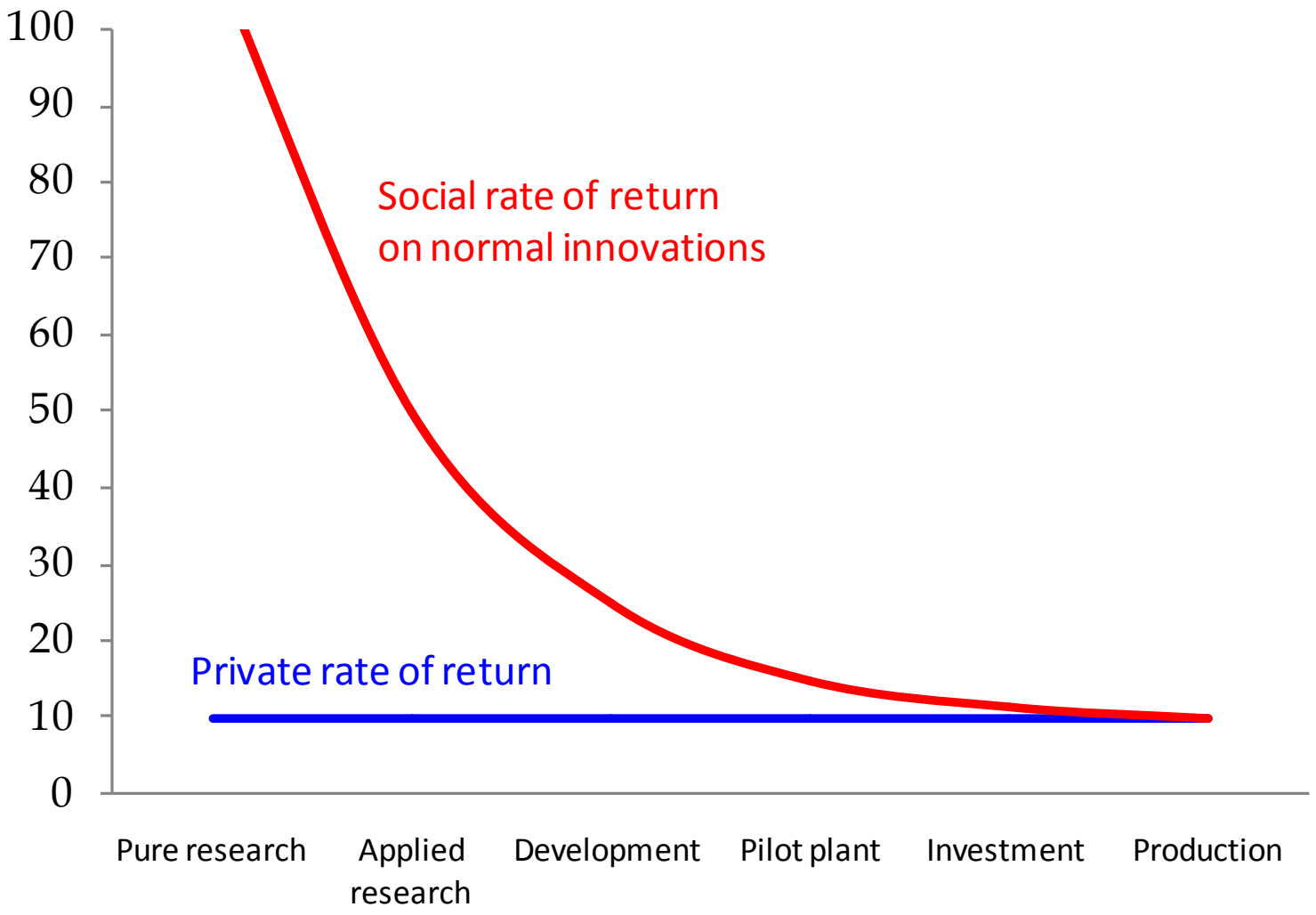
Sufficient: Once the carbon price is at the correct internalizing level, then green innovation will be on a level playing field with other innovations. At that point, the social returns to green innovation will be equal to those on normal inventions.

Appropriability



The spectrum of innovation

Rates of return



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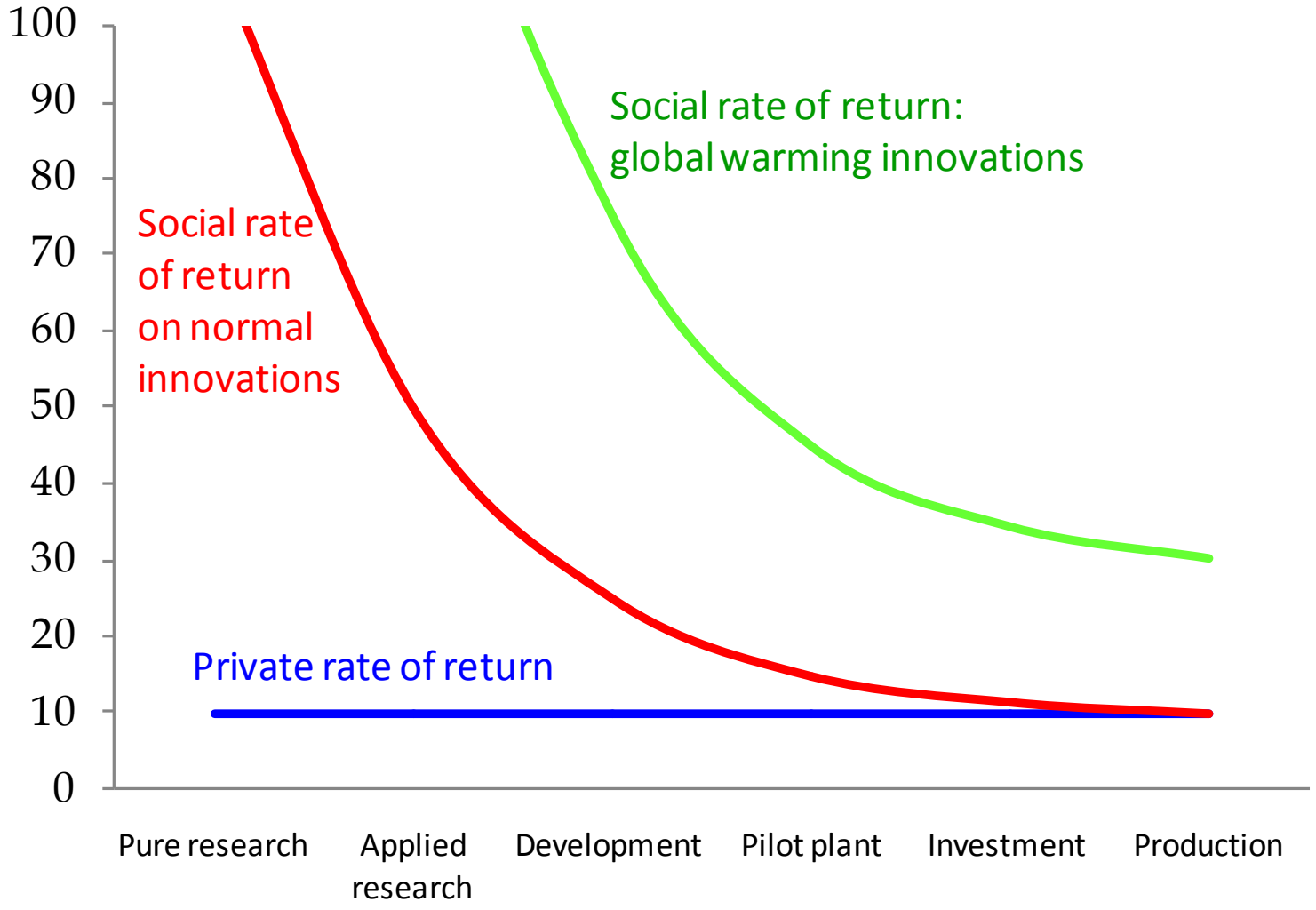
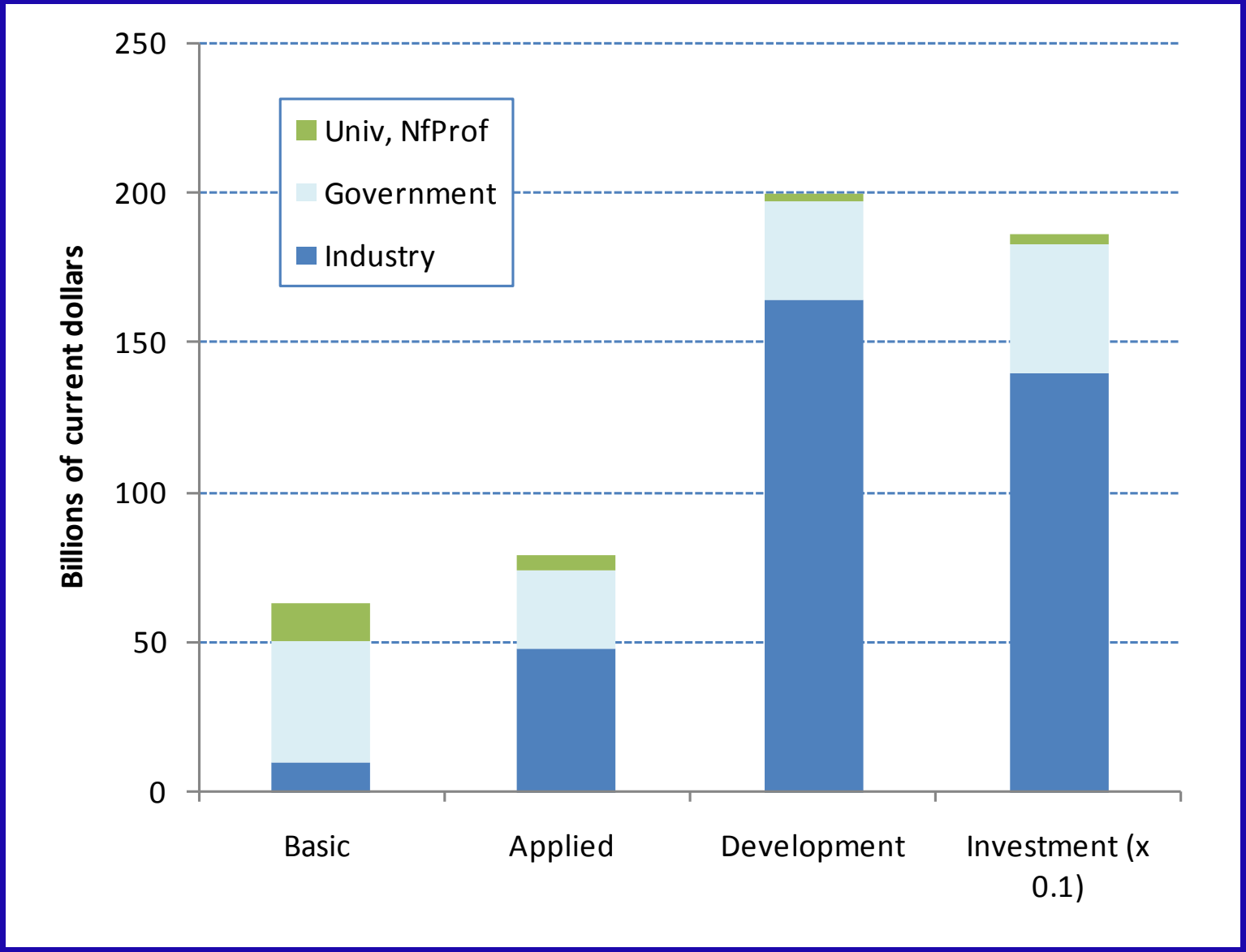
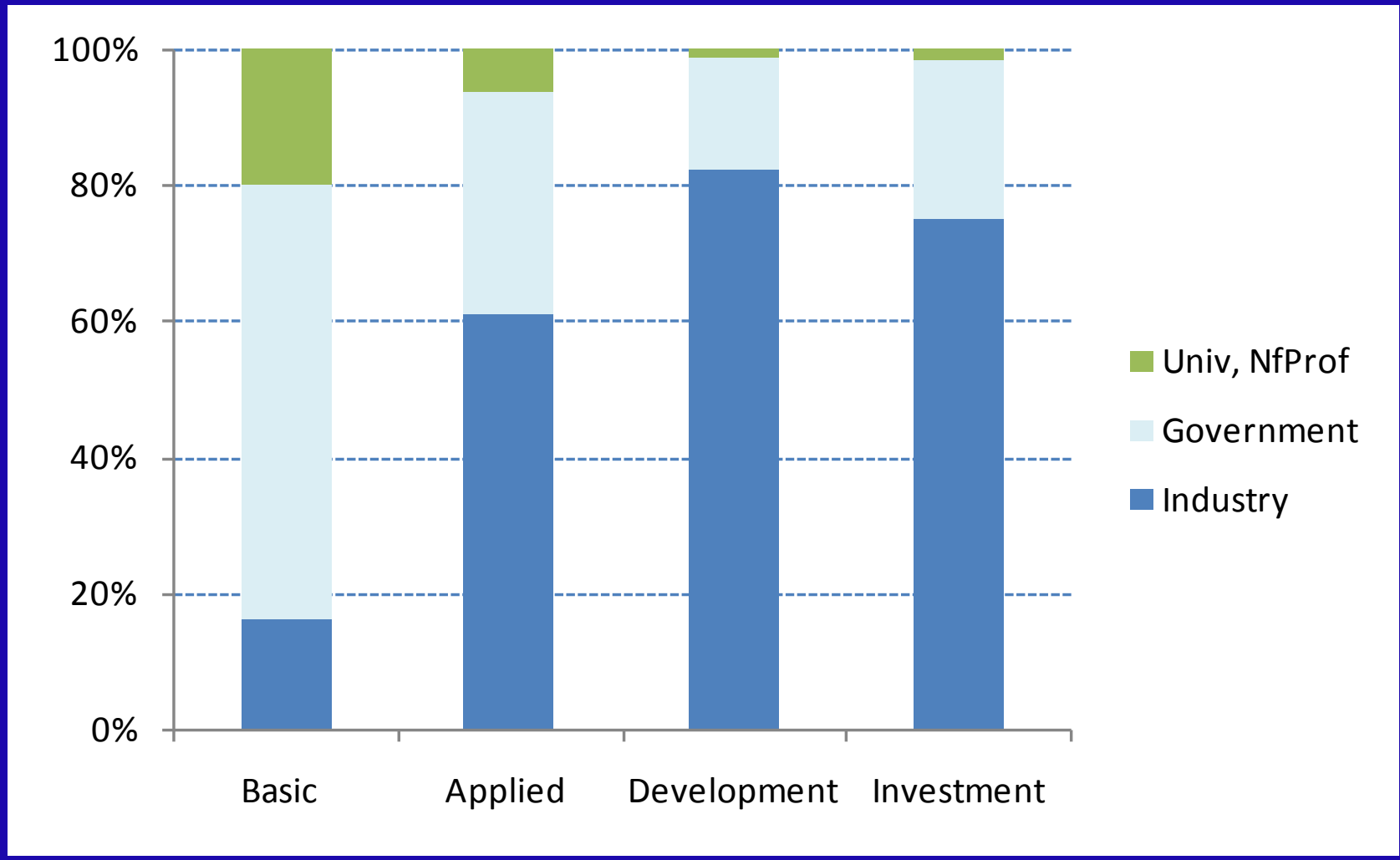


The spectrum of innovation

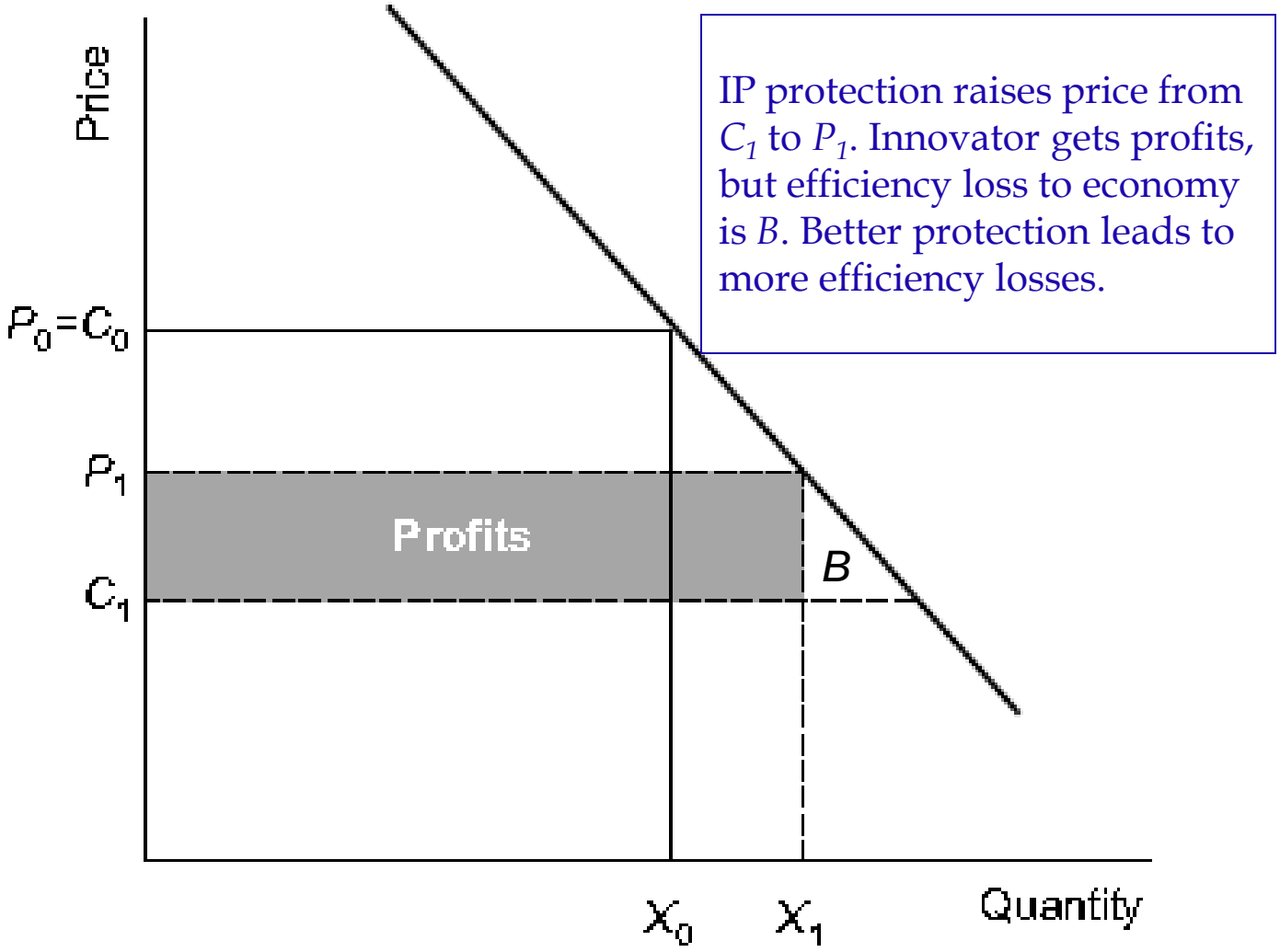
Innovational spending by sector and type



Innovation by sector and type

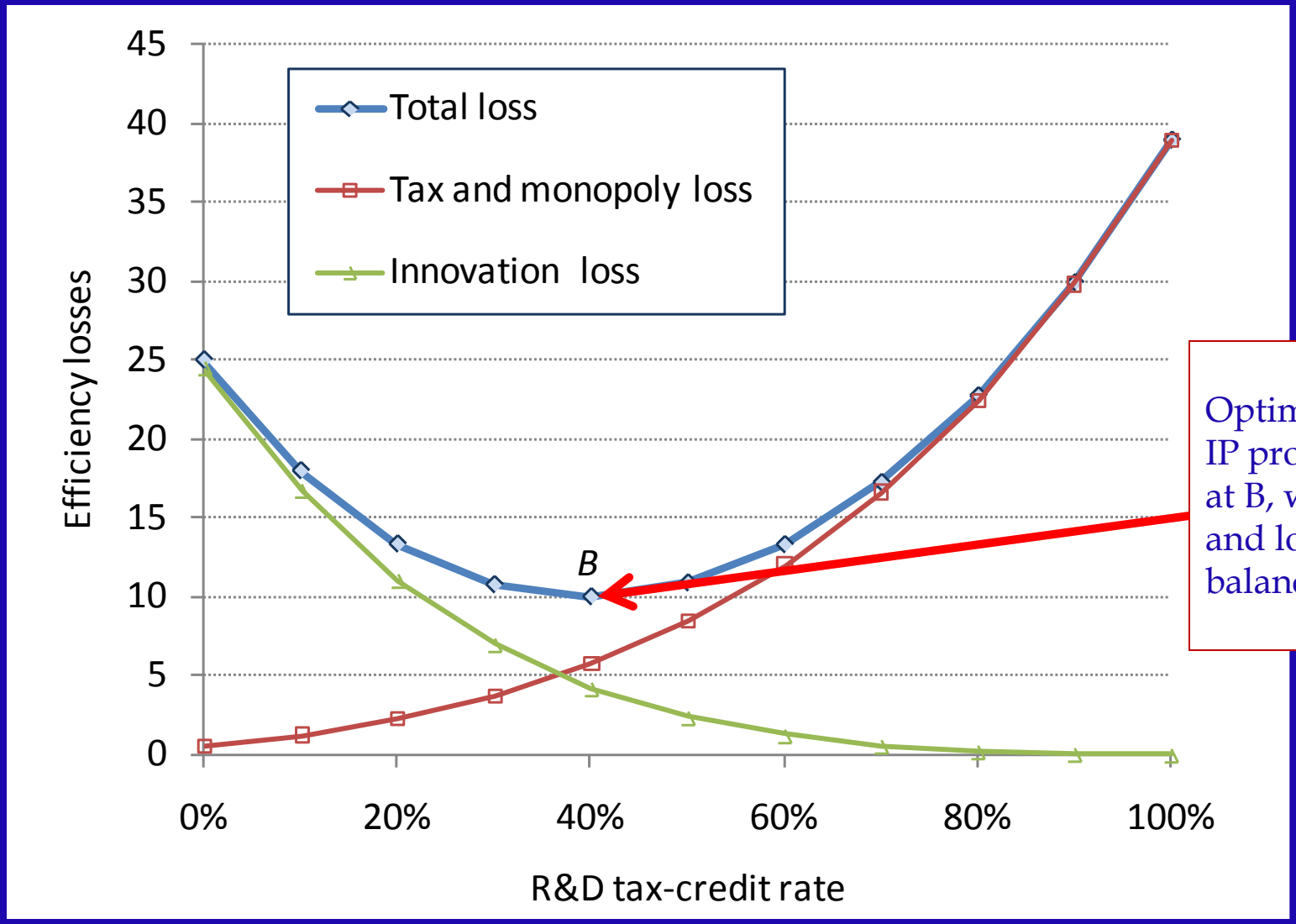


Inefficiency loss from patents or other intellectual property protection



IP protection raises price from C_1 to P_1. Innovator gets profits, but efficiency loss to economy is B. Better protection leads to more efficiency losses.

Tradeoff between efficiency and innovation losses



Optimal degree of IP protection comes at B, where gains and losses are balanced.

The simple mathematics

Write the social welfare function as the sum of the innovational losses and the monopoly losses as a function of the entrepreneurship instruments, θ_k:

(1) $$L = \sum_{i=1}^{n} \{ f[X_i(\theta_1, ..., \theta_m)] + g[X_i(\theta_1, ..., \theta_m)] \}$$

where *f* is the inefficiency losses due to IPR protection and *g* is the inefficiency resulting from the gap between the social and the private return to innovation.

Minimizing the loss function in equation (1) with respect to each of the innovational policy instruments:

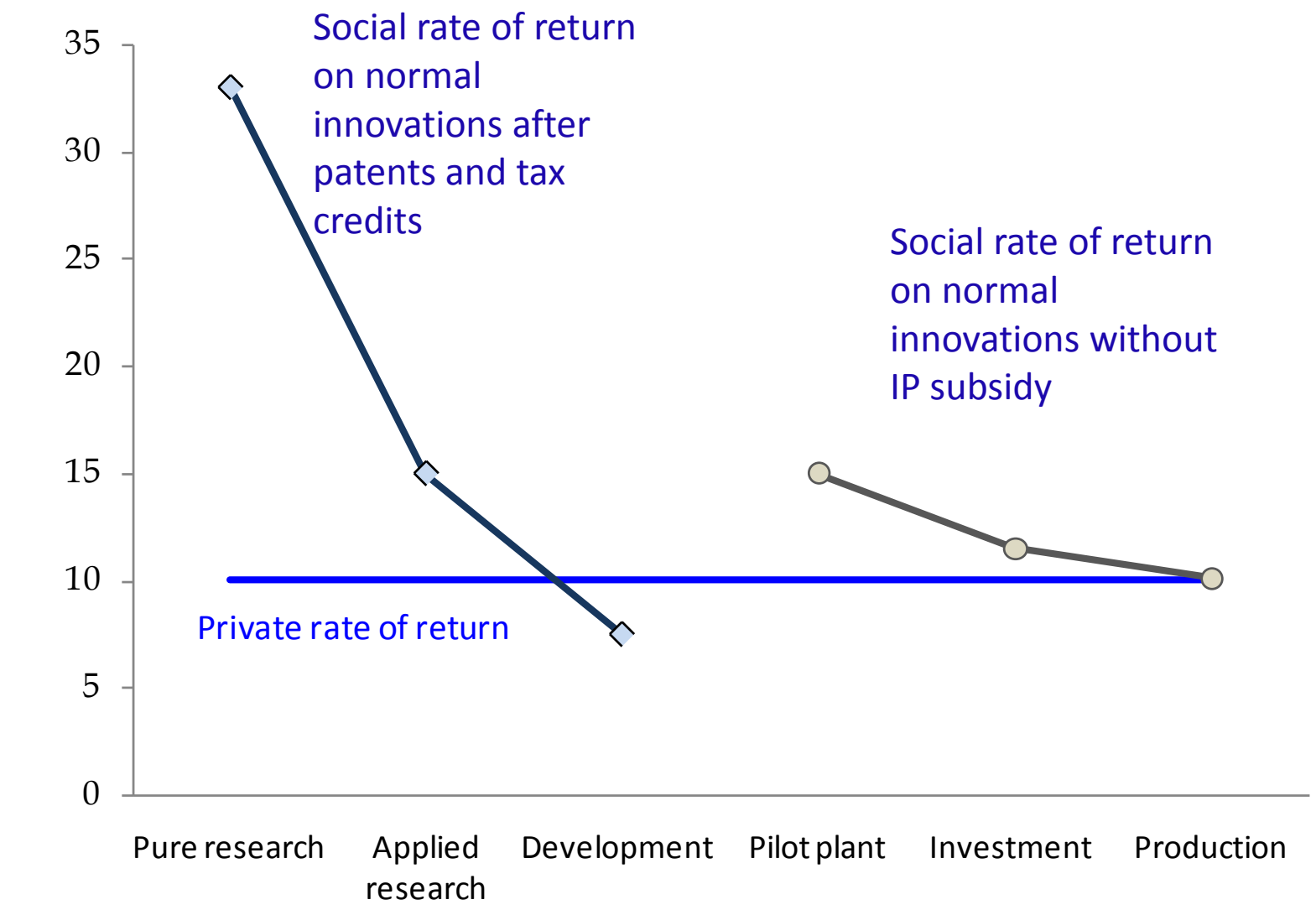
(2) $$\frac{\partial L}{\partial \theta_k} = 0 = \sum_{i=1}^{n} \left\{ \frac{\partial f[X_i(\theta_1, ..., \theta_m)]}{\partial \theta_k} + \frac{\partial g[X_i(\theta_1, ..., \theta_m)]}{\partial \theta_k} \right\}, \quad k = 1, ..., m.$$

The solutions of the equations take the form of *m* optimal settings for the IPR instruments, $(\hat{\theta}_1, ..., \hat{\theta}_m)$.

Once the IPR instruments are optimized, we have balanced the marginal gain from further IPR protection against the inefficiencies There is no reason to provide further incentives for any individual industry, green or otherwise.

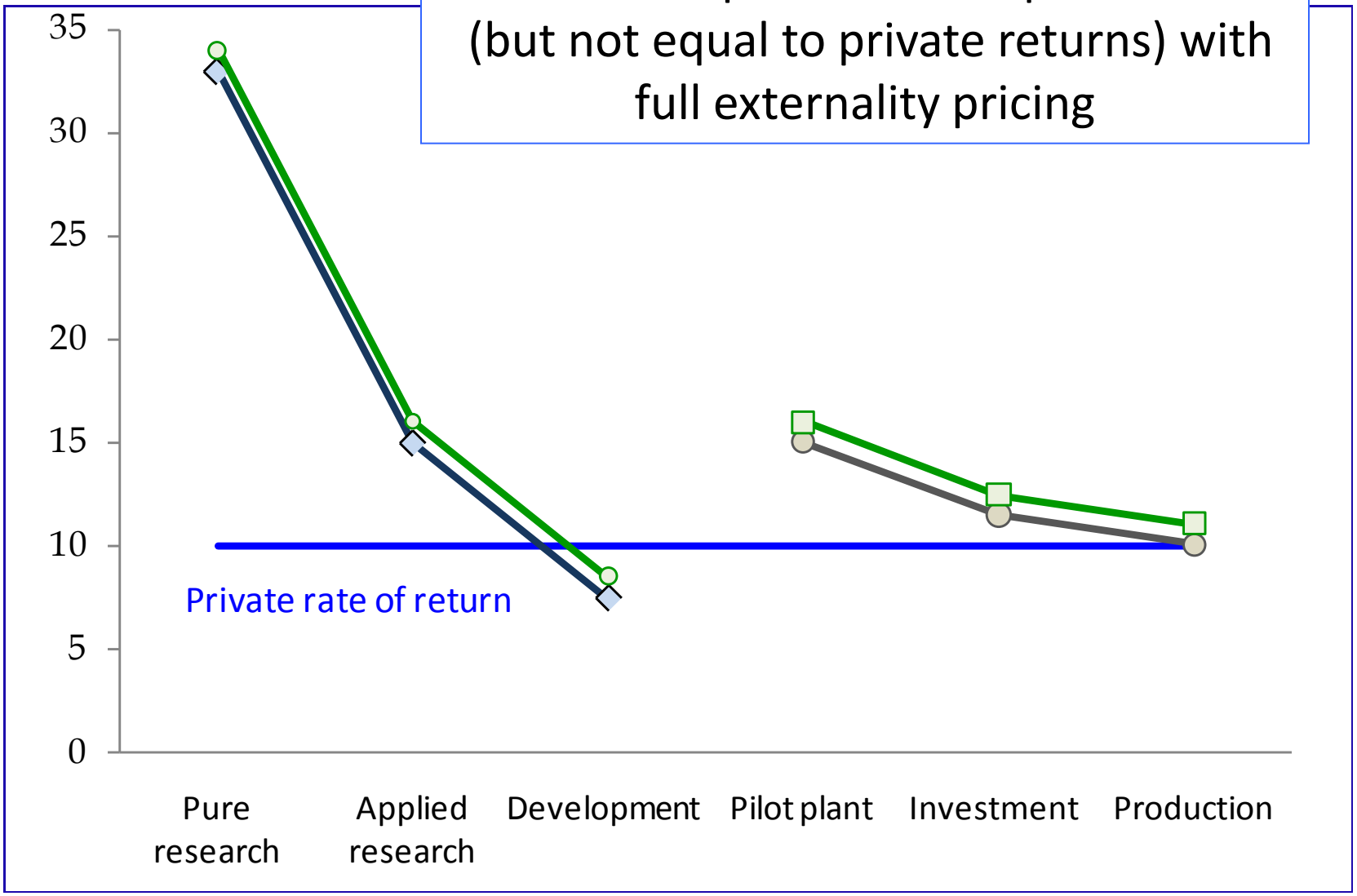
Entrepreneurship!!!

Rates of return with partial intellectual property subsidies



Rates of return

Rates of return are equalized in different points of the spectrum (but not equal to private returns) with full externality pricing



Reservation on externality pricing

Reservation 1. Incorrect pricing of the environmental externality

- The reasoning for the "level playing field" between green and normal investments assumes that innovators have the same incentives in different sectors. Clearly, this 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 R&D, 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.

Reservation on innovation policy

Reservation 2. Inefficient internalization of the innovation spillover

- Recall that it is not efficient to completely remove the gap between social and private returns to innovation.

- However, some areas may have inefficient IP regulations (e.g., network externalities, learning spillovers, …).

- This would require specific interventions, but these should not be specific to green industries (i.e., learning spillovers should be universally subsidized, not just in green industries).

Reservations specific to climate change

1. *Question:* 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. *Question:* How can we avoid catastrophic climate change?

   Answer: If the impacts are very large, then the carbon price should be correspondingly high

3. *Question:* 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!

Reservations for non-market innovations

This theory applies primarily to innovations that are driven by cost-profit calculus.

This leaves open much activity in non-profit, university, curiosity, and non-profit innovation.

The support of non-profit research and innovation is another topic and clearly responds to other incentives.

However, the scope of profit orientation is clearly expanding through the intellectual domain (e.g., number theory).

Reservation on globalization

Energy technology has a particularly global dimension.

- This will require correct *global* pricing
- But if innovation is centered in high-income countries, then a narrow Kyoto Protocol structure may be close to sufficient.
- 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%

Summary

- The technology problem with externalities 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.