Electricity Policy Research Group

UNIVERSITY OF CAMBRIDGE

The economics of oil shortages and climate change policy

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Outline

What can economics bring to the debates on addressing climate change?

- Exhaustible resource theory: prices and rents
- Oil - exemplar of an exhaustible resource
- Mitigating Climate Change
  - The EU Emissions Trading System and its flaws
  - the case for a carbon tax/price
- Effect of carbon tax on climate change
- Problems: prisoners' dilemmas
- Solutions - incentives for compliance

Fuels, GHG and markets

- Fossil fuels: main source of anthropogenic CO_2
- Oil is an exhaustible resource

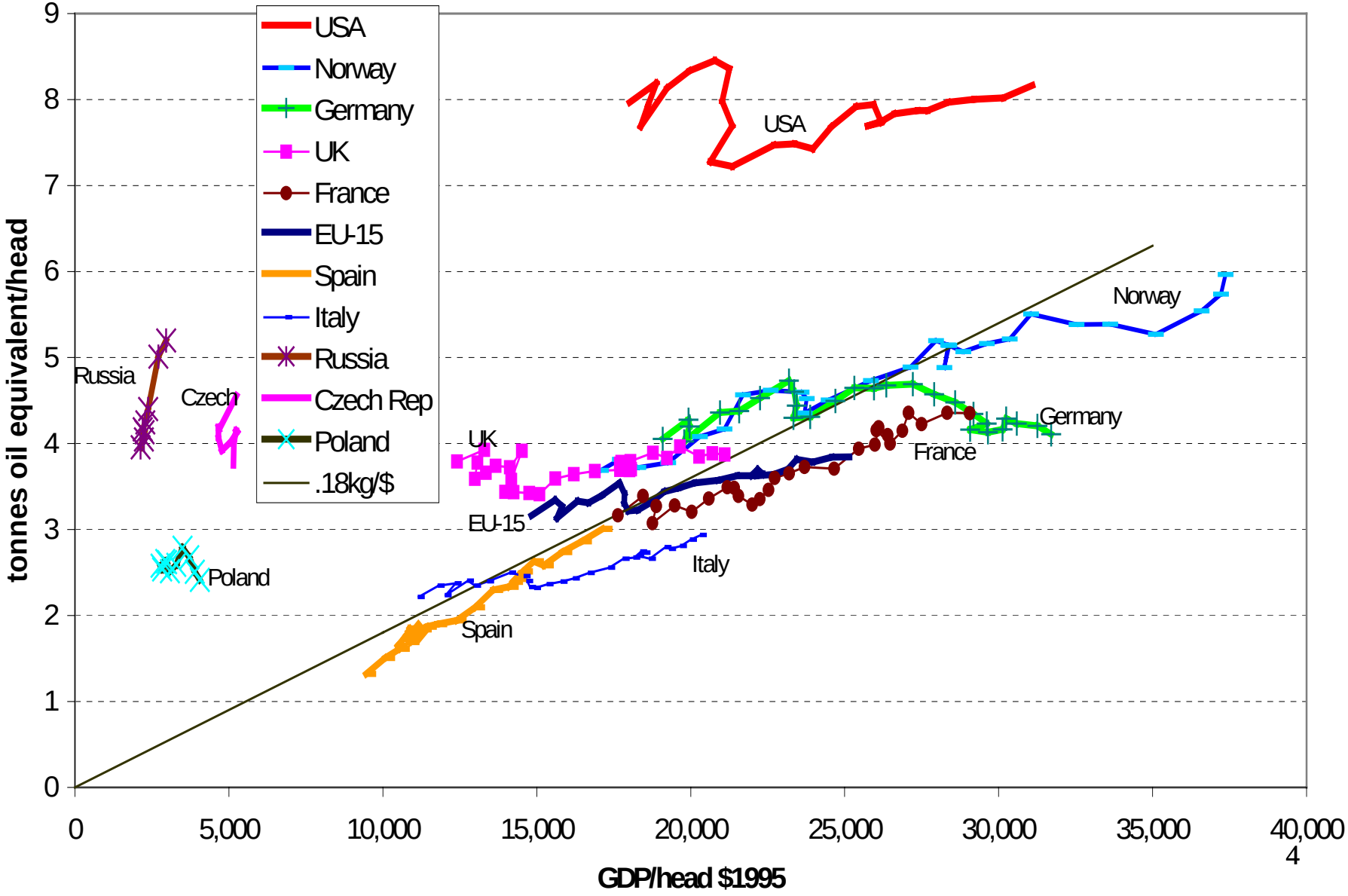
=> competitive markets can price for scarcity

  – but oil markets are not competitive
  – and they suffer from a massive market failure

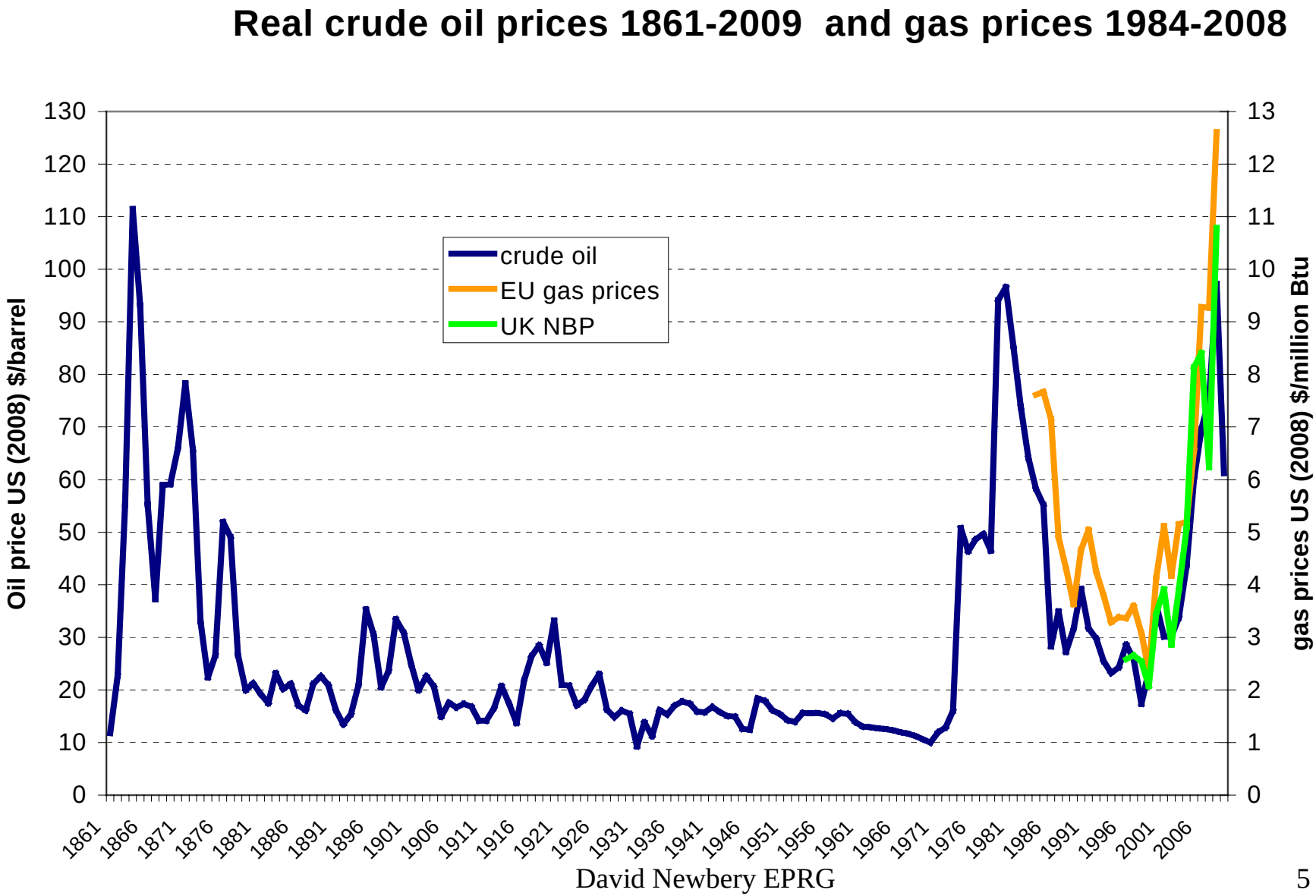
GHG emissions are a global public bad

"greatest .. market failure ever seen" (*Stern*)

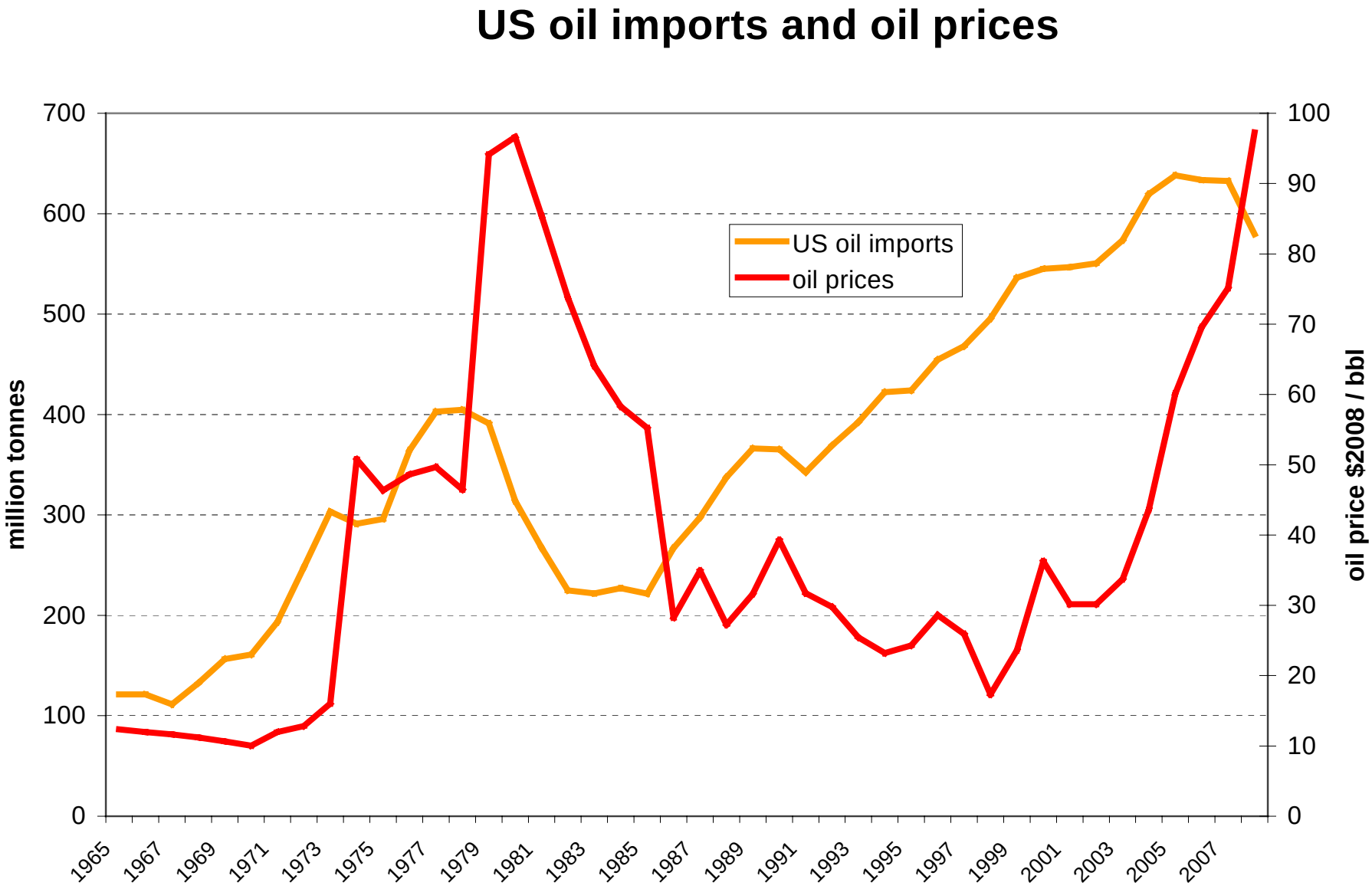
Energy use/hd vs GDP/hd 1972-99



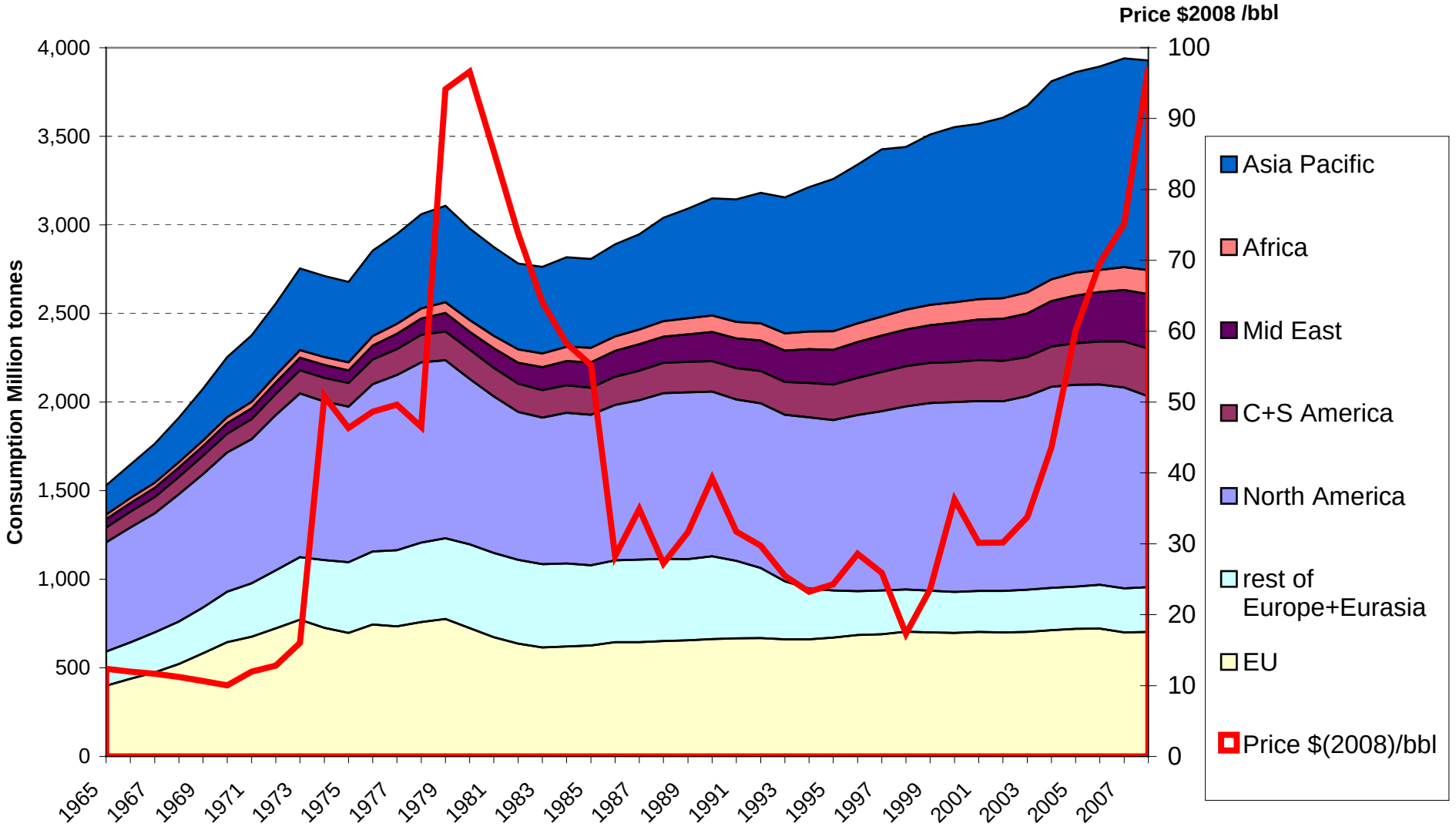
How does one explain market prices of oil?



What caused the oil shocks?



Regional oil consumption 1965-2008



Exhaustible Resource Theory

Competitive case, no externalities

- current price depends on expectations about future
- price p_t *less* marginal extraction cost = rent
- rent rises at discount rate r during extraction
- backstop price p^* set by substitutes or exhaustion
- p_0 depends on stock, cost profile, future R&D, p^*, r

- Shocks affecting current price
  - new discoveries, technical progress, backstop p^*, changes in ownership affecting r, supply constraints

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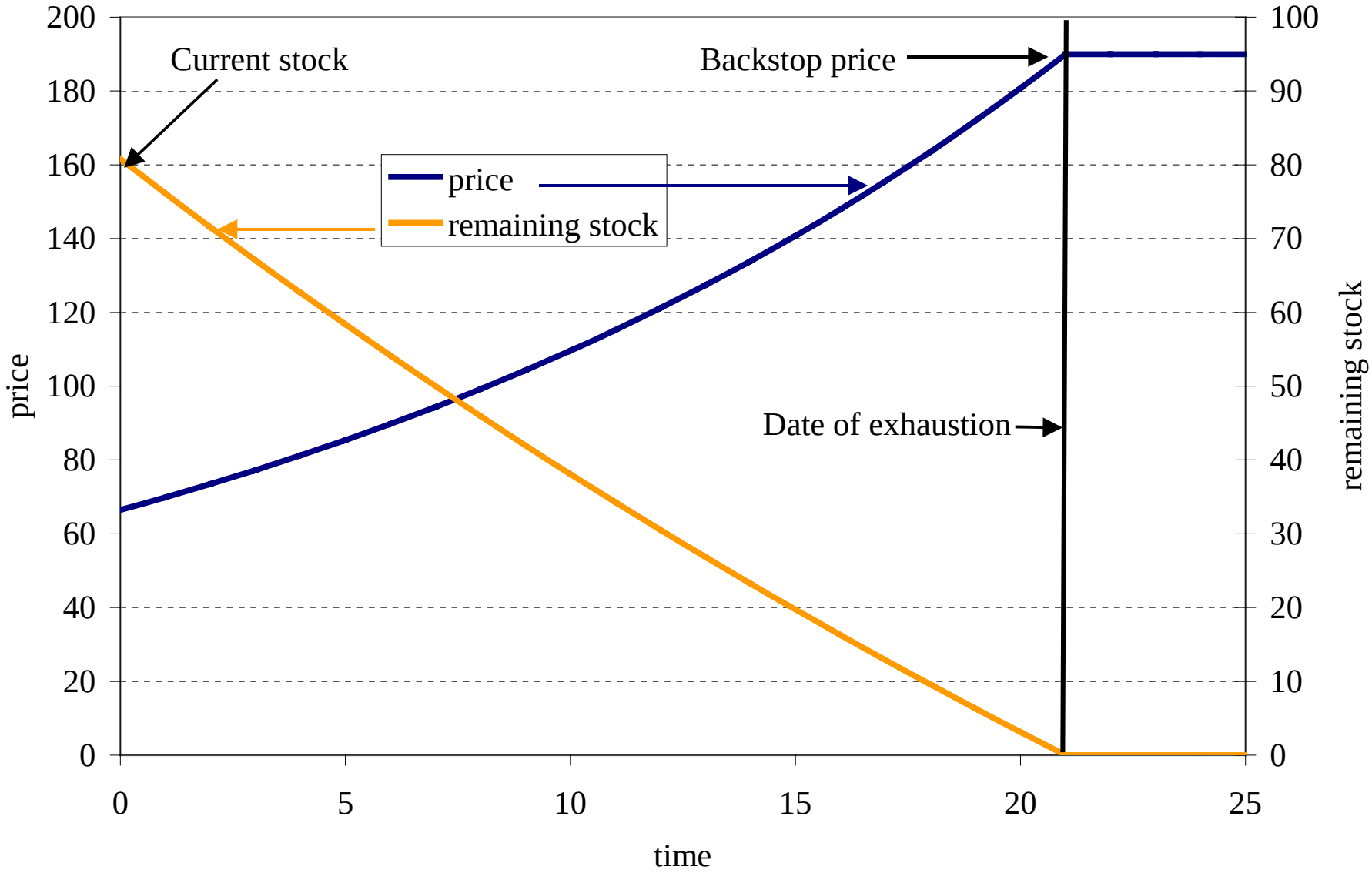
Simplest Hotelling case

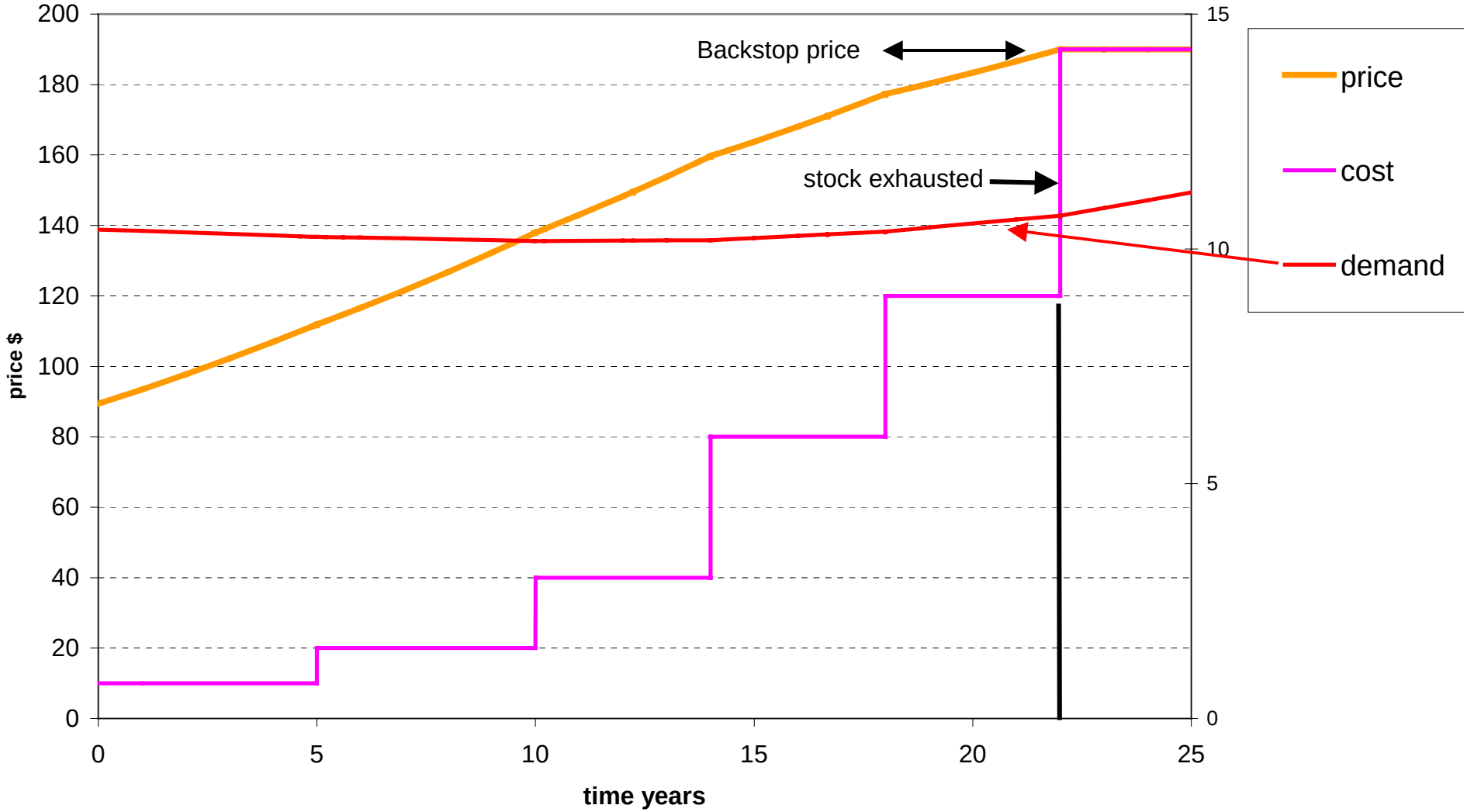
- Oil - very low variable cost, elastic supply
- competition => price rises at rate of interest
- future price fixed by backstop
- work back to find demand at each price
- cumulative demand exhausts at backstop

current price found from future price and current stock

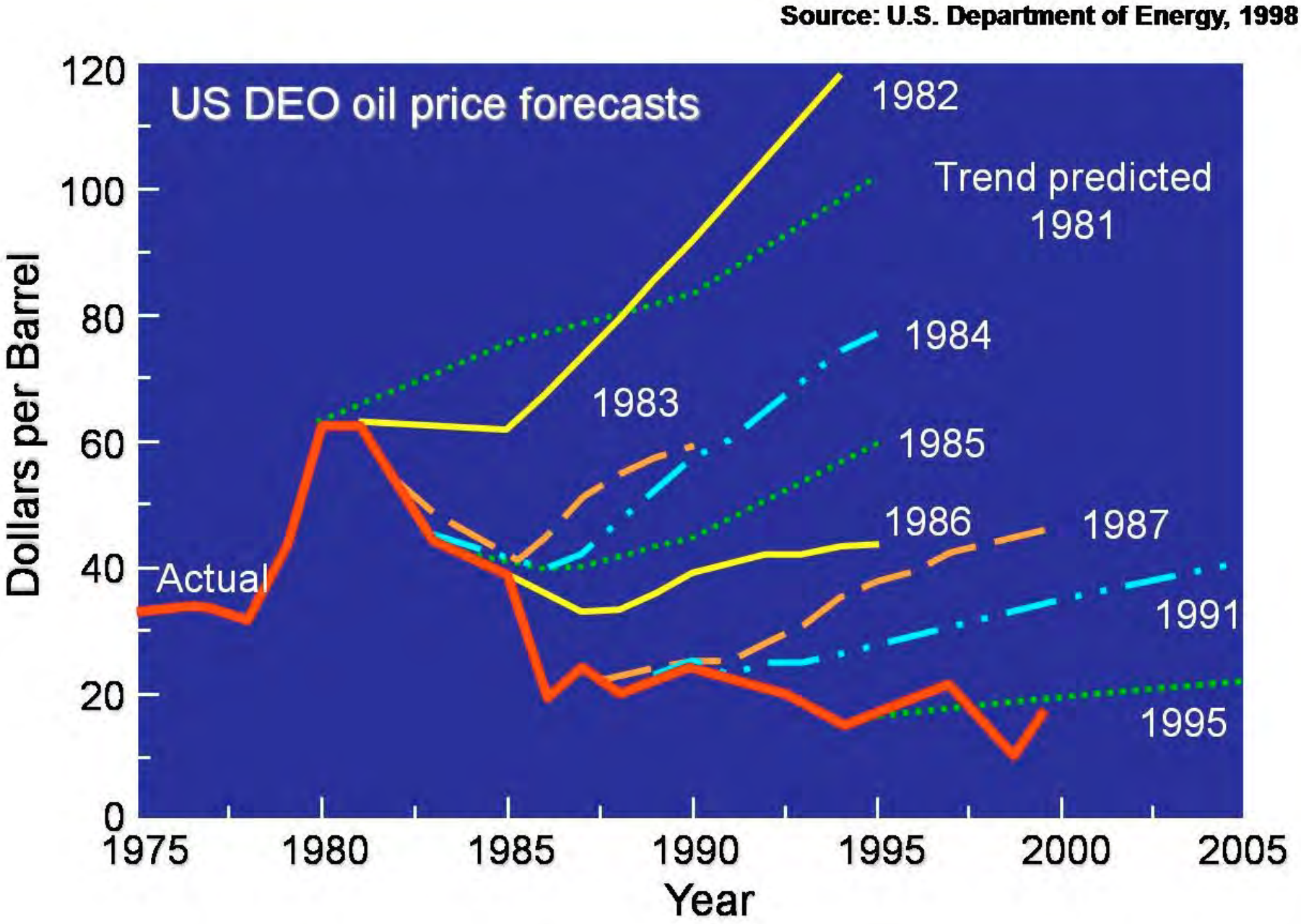
Hotelling theory - zero extraction cost



Price, cost and demand for an exhaustible resource



Expectations can be wrong!

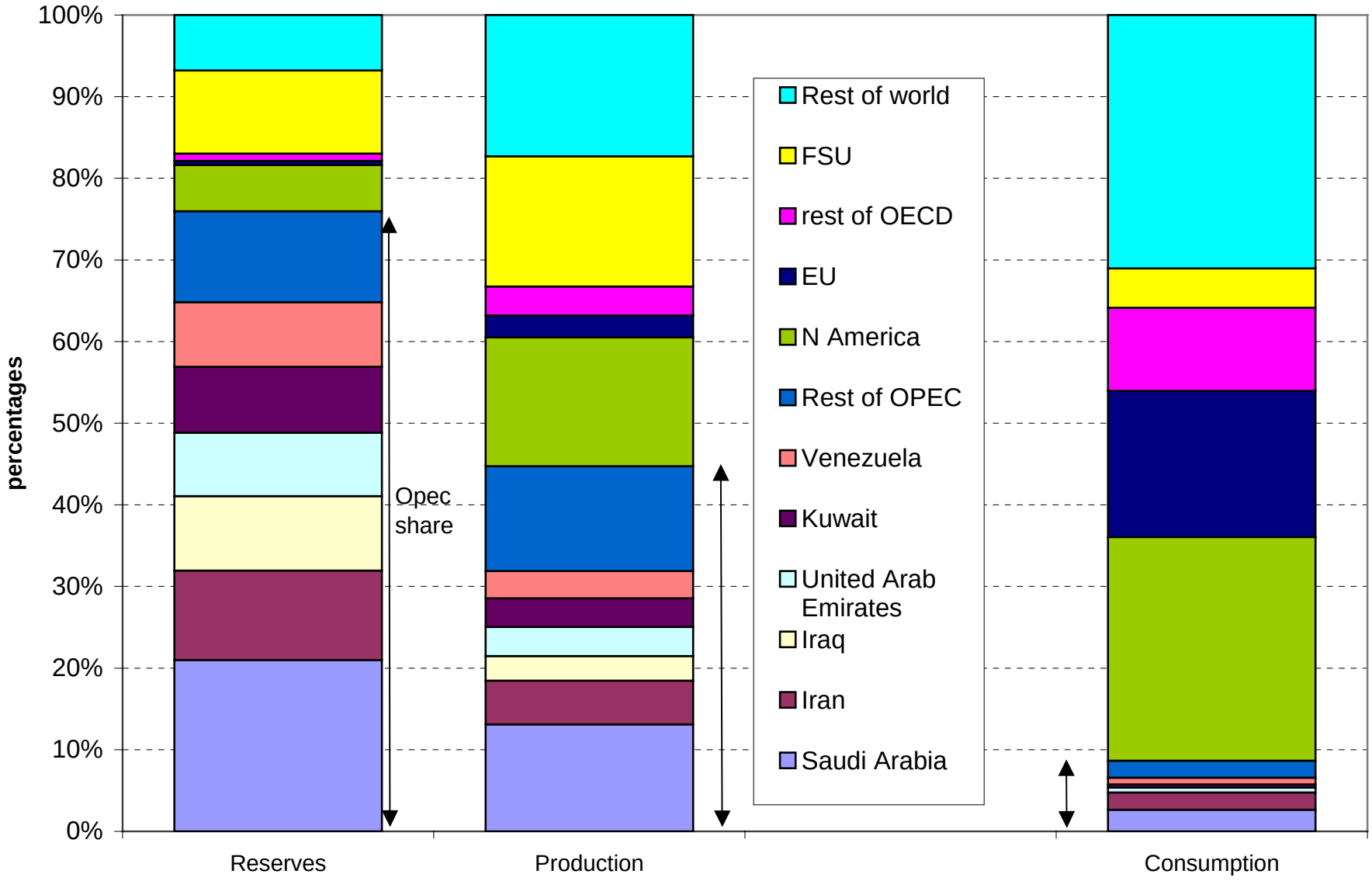


Market failures

- Oligopoly => prices higher than otherwise
- Imperfect property rights => overexploitation
- Import cartels - e.g. fuel import tariffs
  - raise domestic price => reduce demand => lower world price *(but how much?)*
  - not credible? hard to distinguish from road taxes?
- Externalities in use - GHG emissions

=> restrict use, lower demand and world price

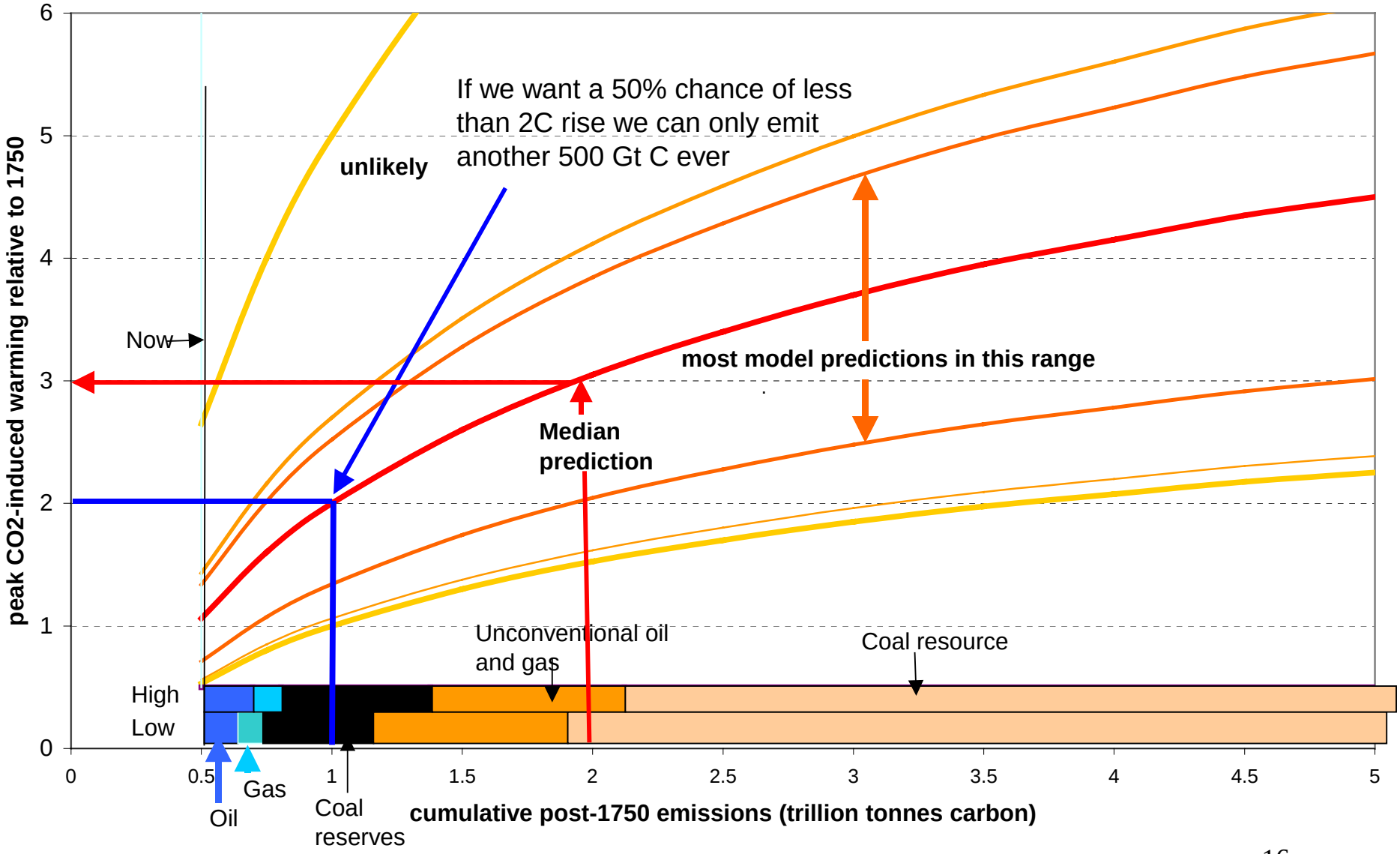
Reserves, Production and Consumption shares 2008



Policies for mitigating climate change

- GHG emissions are a global stock public bad
  - uncertain distant damage with uneven impacts
    => very hard to agree coordinated policies
  - damage regardless of emissions location, persistent
    => damage moderately independent of date of emission
  - much irreversible over historical time scales
- Solution: uniform charge for GHG emissions,
  - charge rises at discount rate
  - reset in light of new information

Peak CO_2-warming vs cumulative emissions 1750–2500

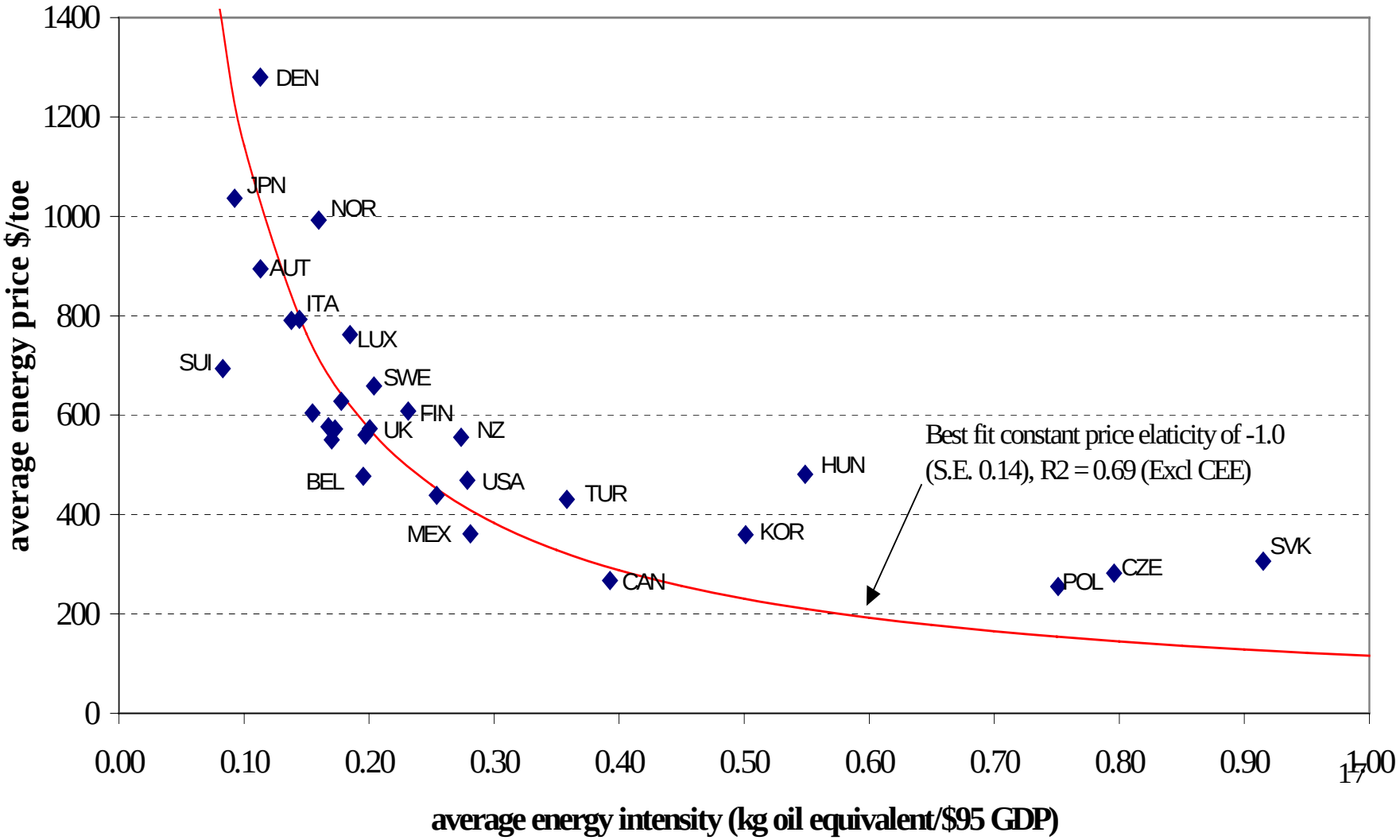


After MR Allen *et al. Nature* **458**, 1163-1166 (2009) doi:10.1038/nature08019

nature

Prices matter for energy use!

Cross-section relation between average energy intensity and average energy price 1993-99



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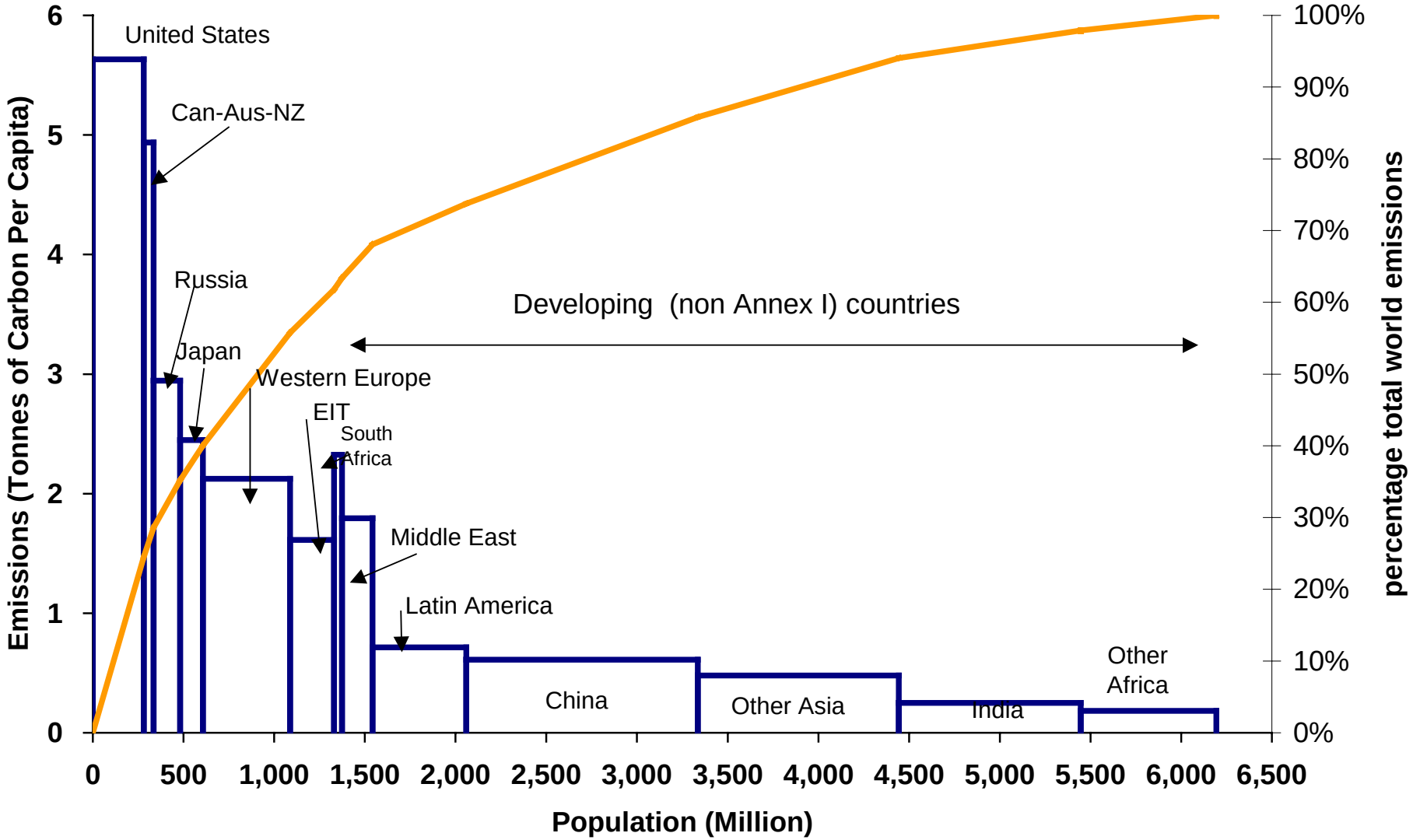
Controlling GHG emissions

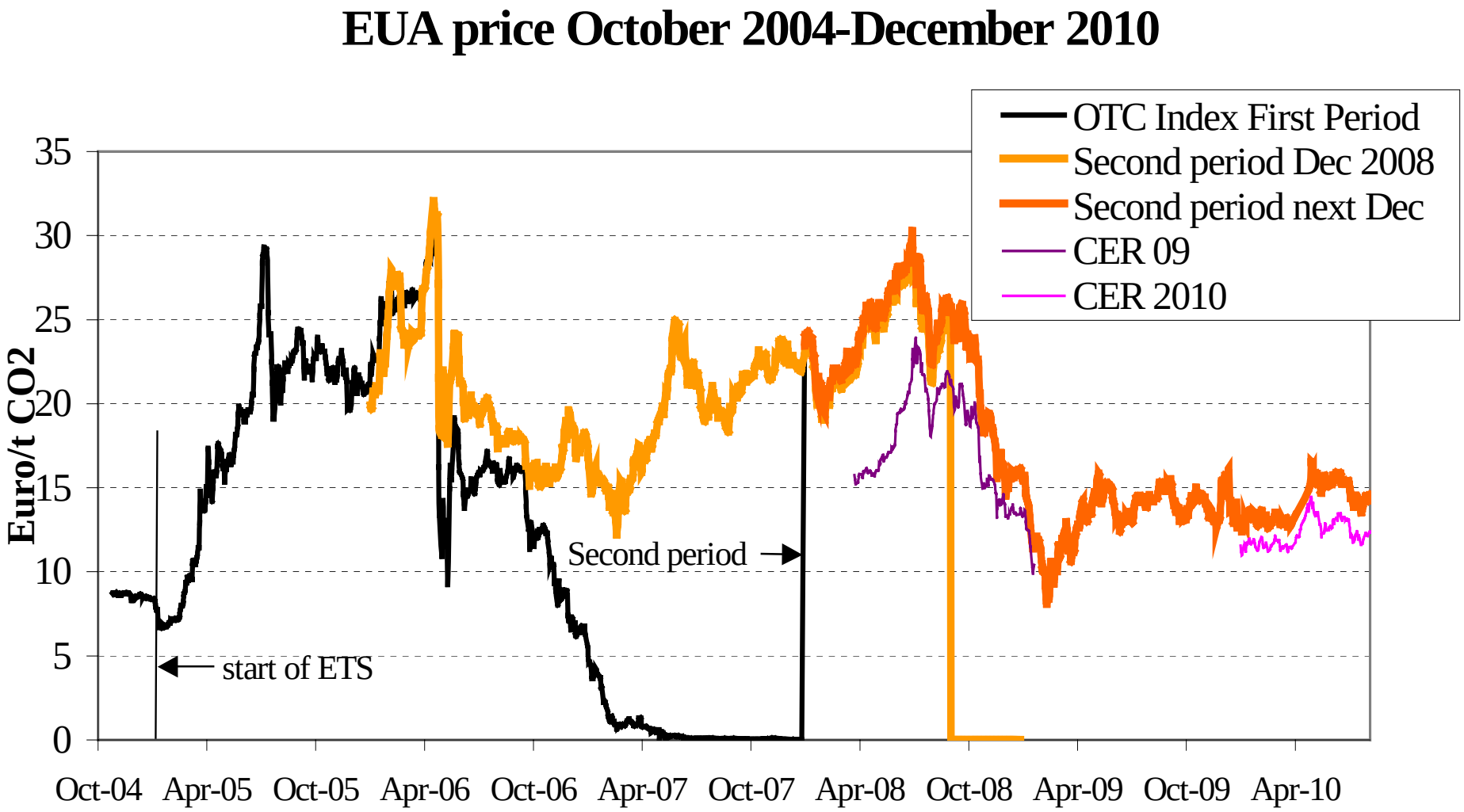
- Kyoto to agree targets for reduction by 2012
  - Annex 1 countries, CDM/JI to encourage others
  - But Copenhagen failed to extend adequately
- European Emission Trading System
  - Allocate allowances to member states
    - National Allocation Plans overstated for national gain
- Fixes total quantities: cap and trade in EUAs

But EUA prices volatile, collapse in 2009

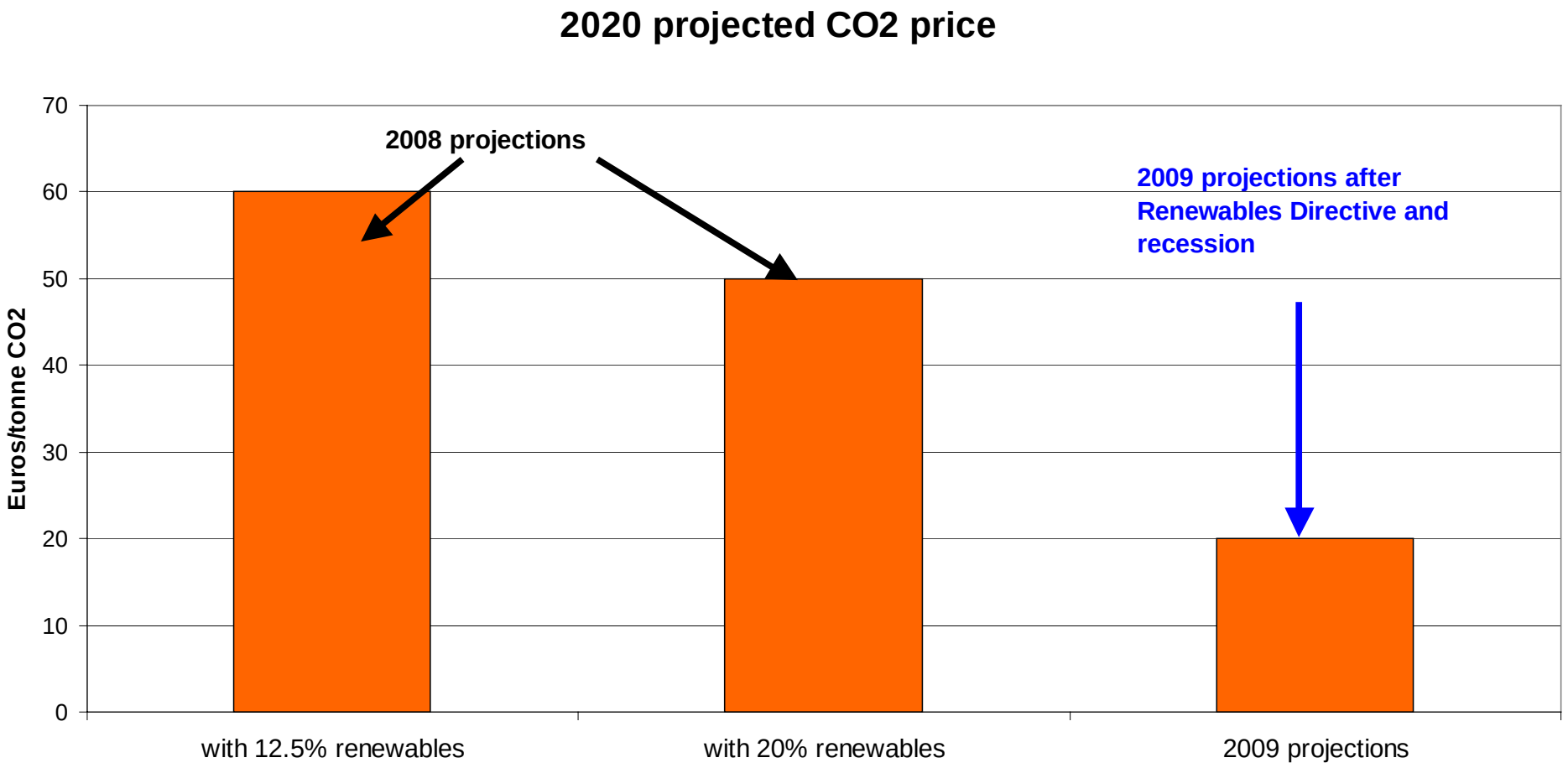
CO_2 emissions/hd (areas = total emissions)



CO_2 prices are volatile and now too low



Current forecasts too low for low-C generation



Source: Committee on Climate Change, 2008 and 2009

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Permits vs Taxes

Weitzman: Taxes superior to permits unless MB of abatement steeper than MC

CO_2 is a ***global persistent stock pollutant***

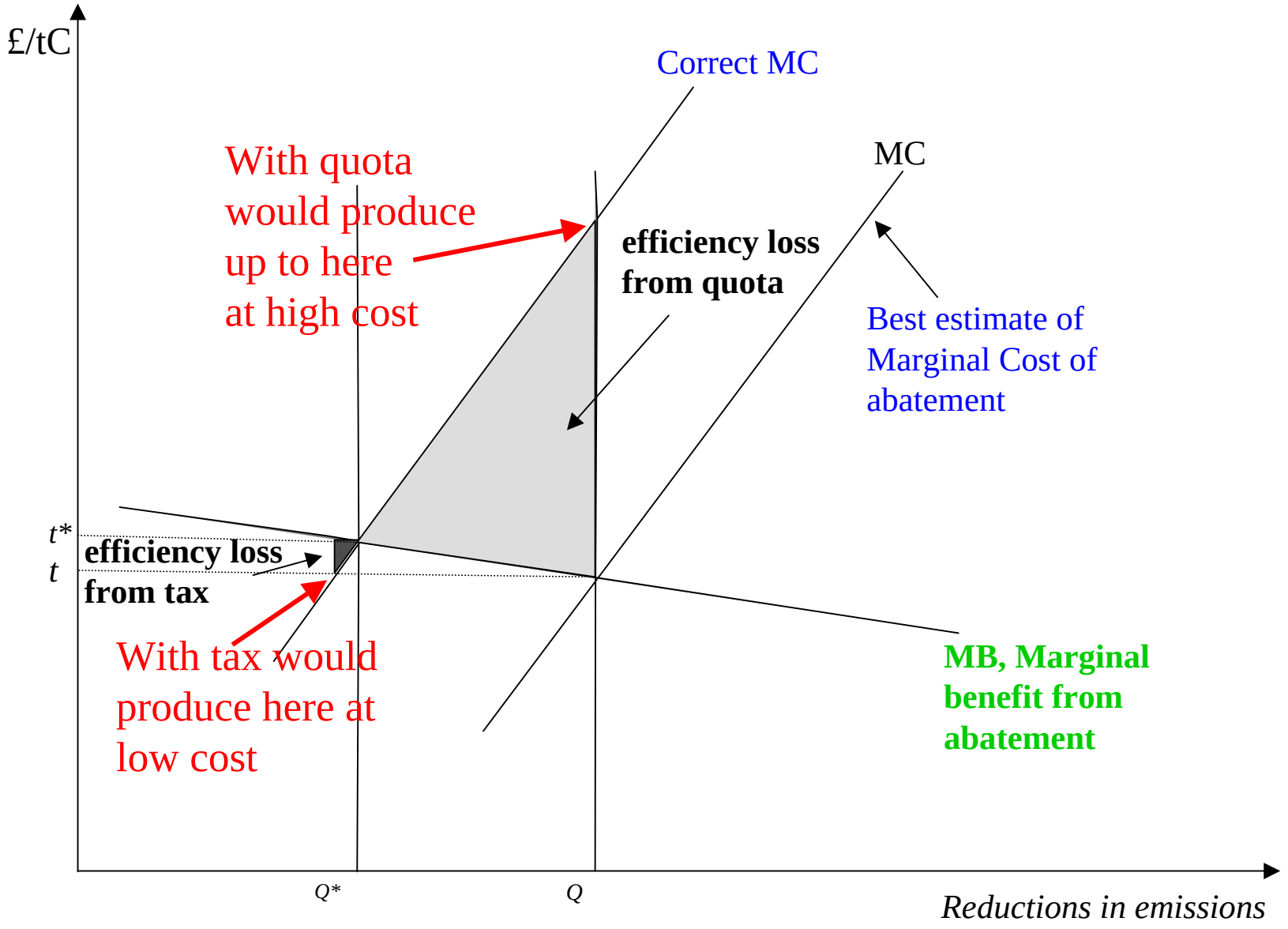
- CO_2 damage today effectively same as tomorrow

  => marginal benefit of abatement essentially flat
- marginal cost of abatement rises rapidly
- hazard of global warming very uncertain, as are the future abatement costs

Carbon tax superior to tradable permits

but permits easier to introduce

Costs of errors setting prices or quantities



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Prisoner's dilemma

- Players: UK (or Annex 1) and rest of world (ROW)
  - UK: 2% of GHG; EU: 15%; OECD: 47%; Annex 1: 57%
- Actions: abate (A) or not abate (N)
  - Tax/price GHG or not; countries keep C-tax revenue
- Pay-offs (e.g. India, 5%, ROW 95% total):
  - (N,N) => no costs now but damaging climate change
  - (A,A) => costs now, future CC damage averted
  - (N,A) => India: no costs, cheaper fossil fuel, AND most CC damage averted

Incentive not to co-operate

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Prisoners' Dilemma

		Player 2 A	Player 2 N
Player 1	A	10, 10	-50, 110
Player 1	N	110, -50	5, 5

If P1 plays A, P2 plays N, P1 gets -50

If P1 plays N, P2 plays N, P1 gets 5

(N,N) is a dominant strategy and Nash Equilibrium in one-shot game

Repeated game

- If the players repeatedly play they can sustain co-operation and enjoy (10,10) instead of (5,5)
- temptation to deviate and gain 110 can be punished by refusing to co-operate ever again

=> gain 100 for one period, lose 5 for ever

=> worth co-operating if discount future at 5% or less

Co-operation in PD requires penalties on deviants

Game theory and climate agreements

- Climate damage is not a static repeated game
  - Gradual increase, significant after 50-100 yrs
  - Once damage apparent it may be too late to act
- Strong mitigation now lowers energy prices
  - Increases incentive to cheat
- Unequal impacts around world
- Not two parties but large number
  - Coalitions like EU help, but China, India both large

=> Increase benefits of cooperation, costs of deviation

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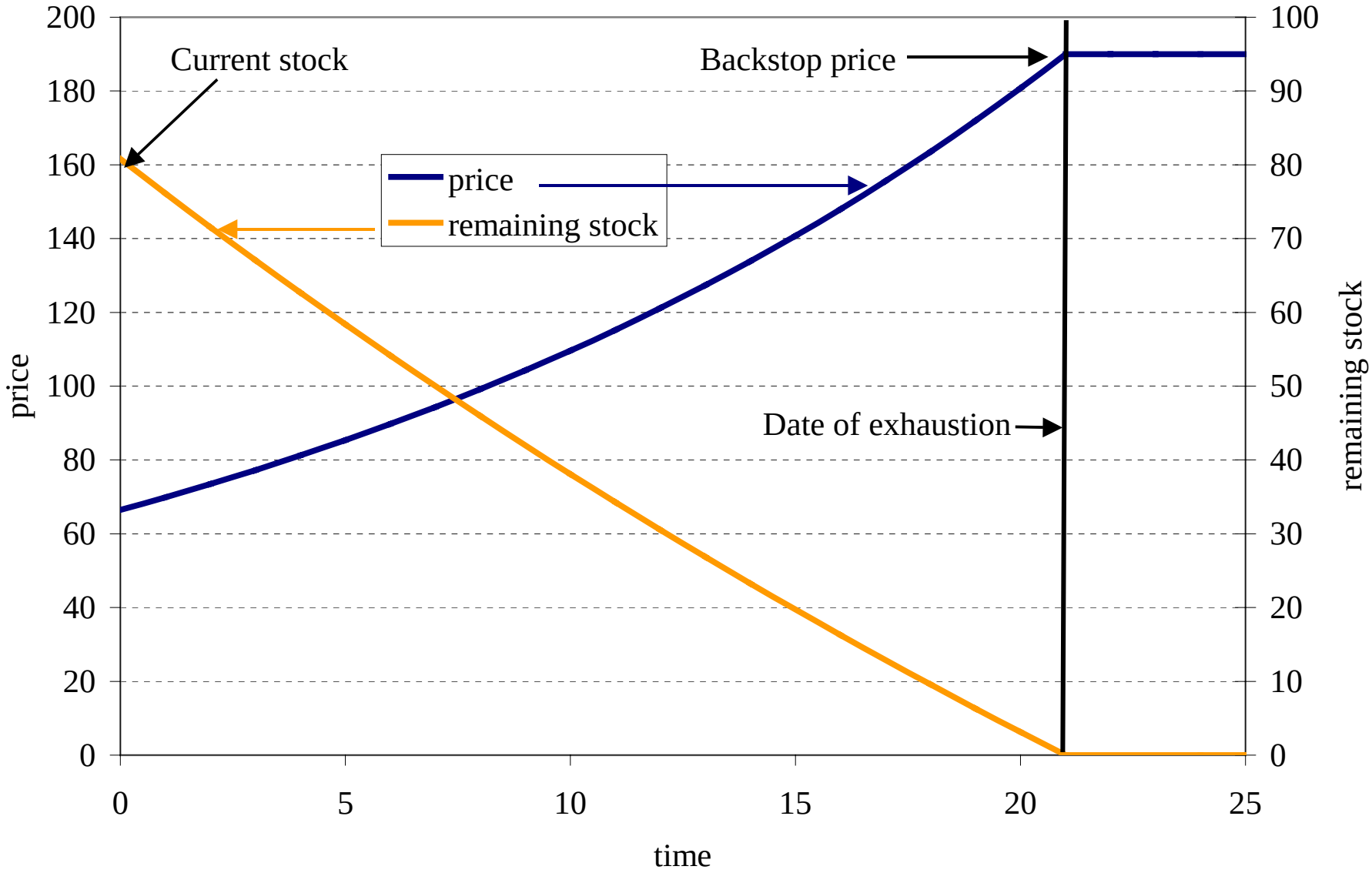
Efficient global carbon tax

- Rises at rate of interest
  - solution where CO_2 has very long residence time
- emission allowances are financial assets
  - their price would rise at rate of interest

As an oil tax rise at rate of interest

Hotelling theory - zero extraction cost



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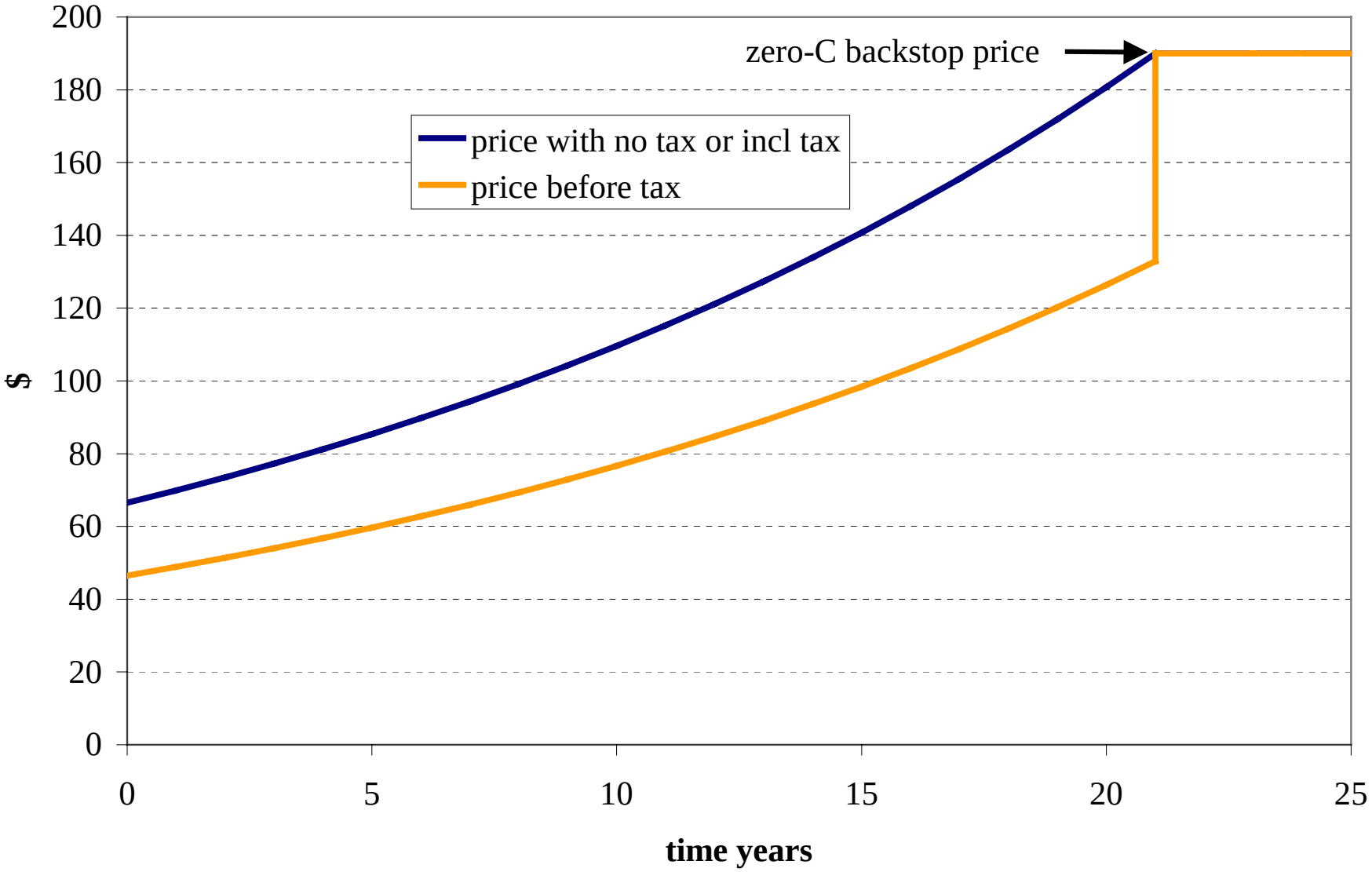
Green paradox

- Oil - very low variable cost, elastic supply (?)
- competition => price rises at rate of interest
- future price fixed by backstop
- efficient global tax rises at rate of interest
  - no distortion in intertemporal use
- No tax on backstop => post tax price = pre-tax price; all tax borne by oil suppliers

No impact on carbon emissions

pre-tax price falls => cheat => more CO_2

Green paradox



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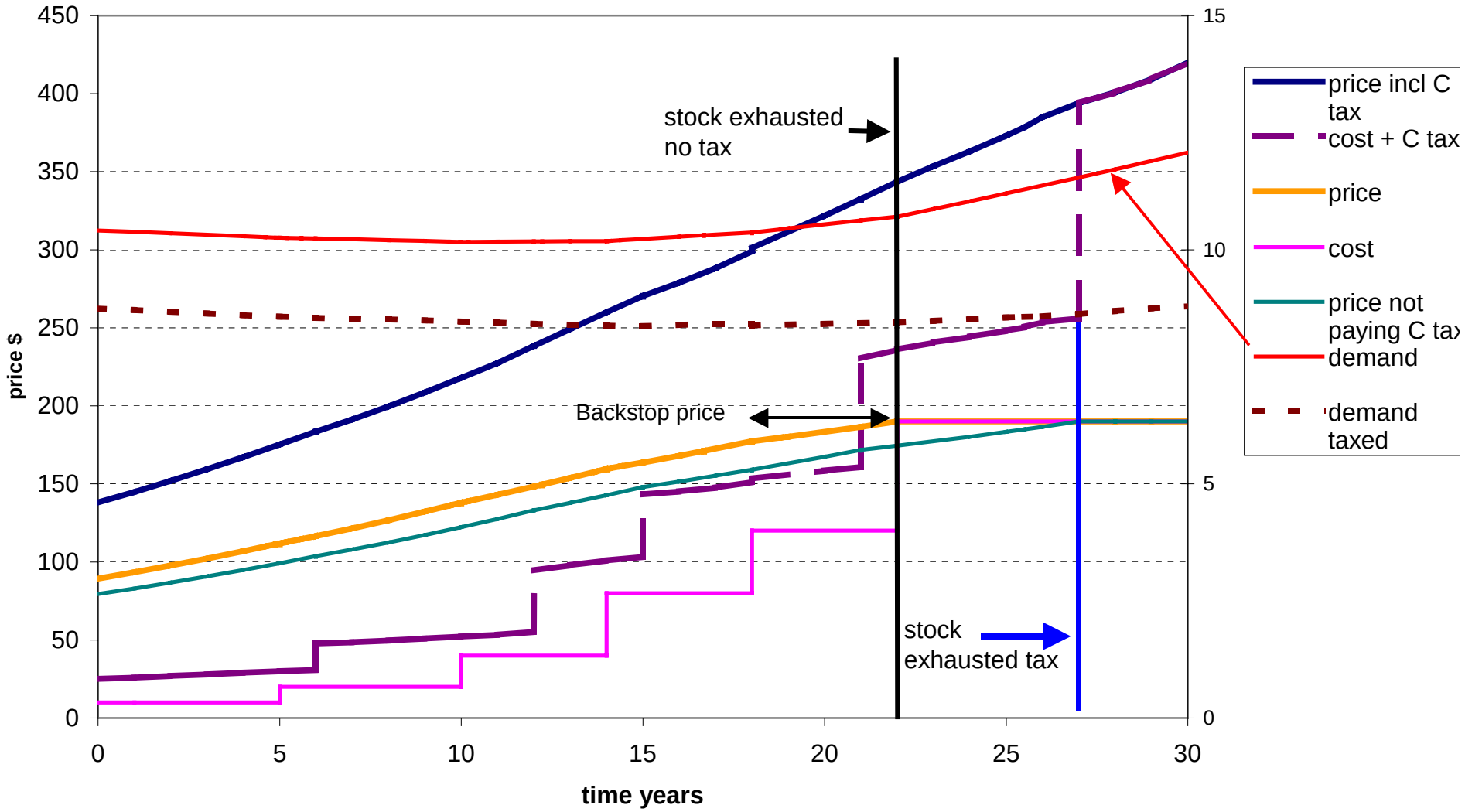
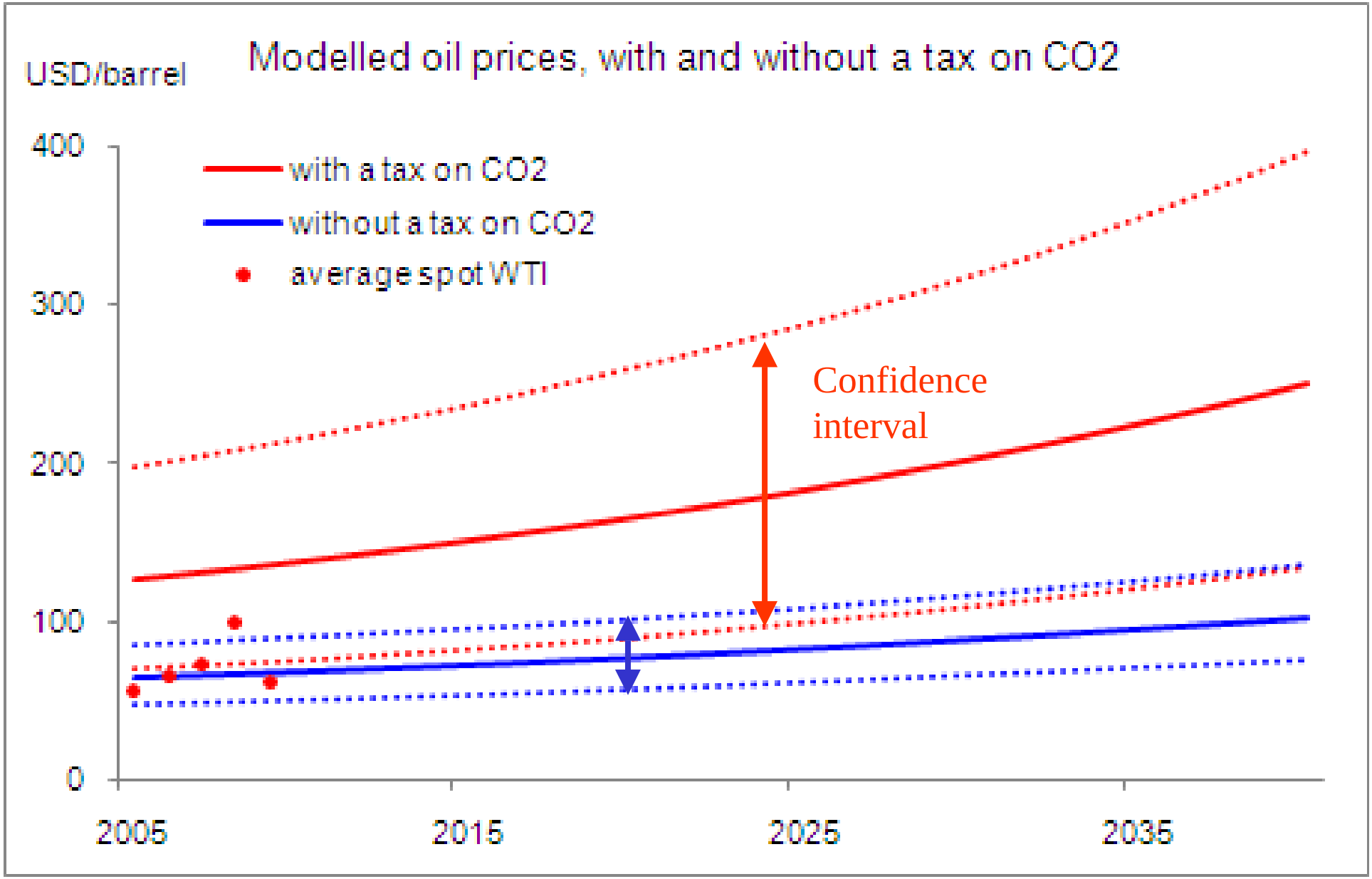
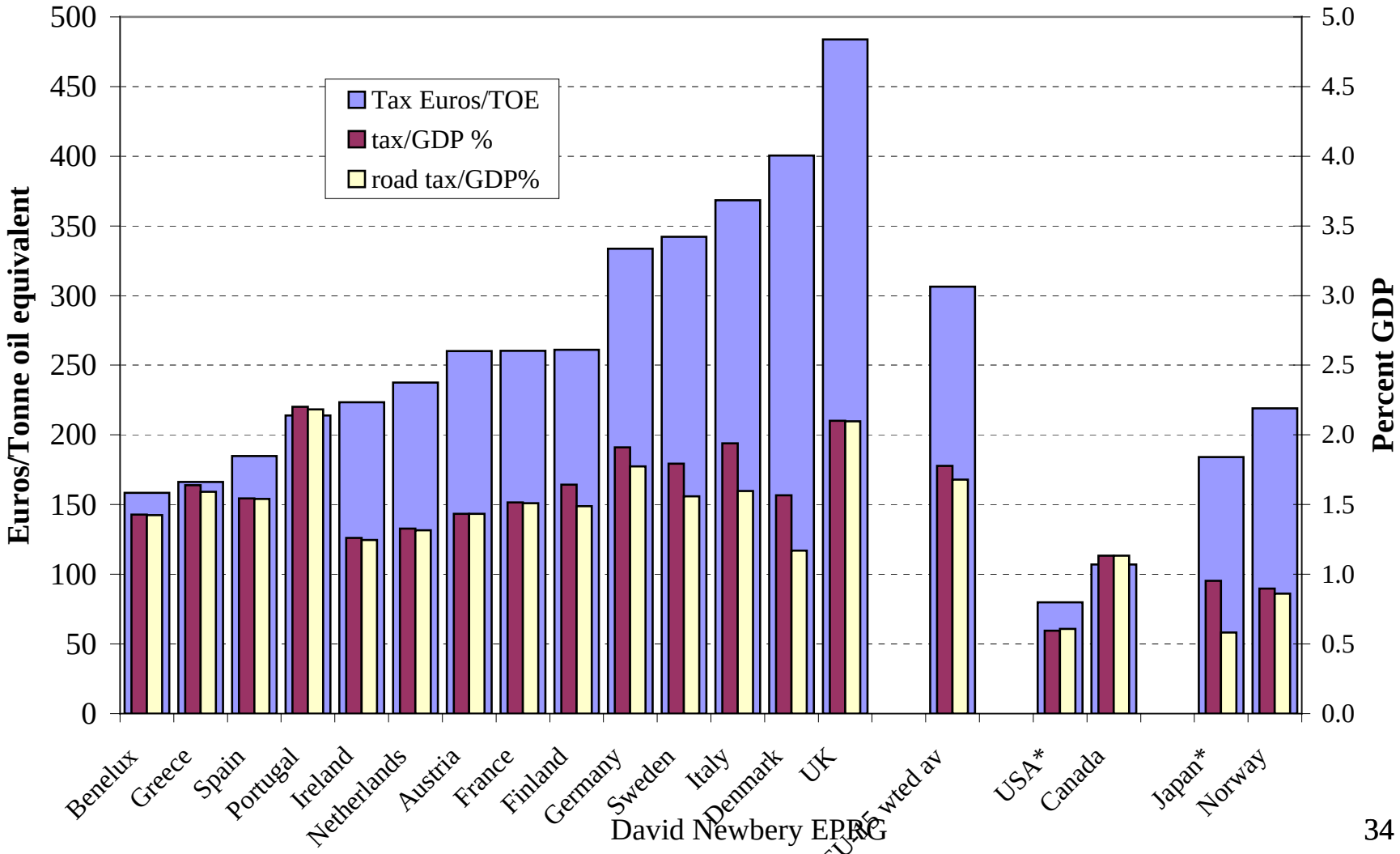




Source: Mejean and Hope 2010

Taxes on oil and products 2002



Encouraging mitigation

- Charge GHG emissions everywhere to correct failure to properly price GHG
  - => C-tax on fossil fuel (rebates for ETS)
  - => countries replace other taxes with C-taxes
- Encourage compliance with border taxes
  - – VAT on imputed carbon content
  - – corrects for subsidy in non-taxing countries

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Conclusions

Economic theory helps think about fossil fuels and climate change

- Hotelling exhaustible resource theory
- externalities and public goods

=> corrective taxes/prices

- but Prisoners' dilemma requires incentives

=> penalties for non-compliance

=> border tax adjustments

But equity and efficiency in conflict

damage distant and uncertain

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