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Advances in Understanding Technology Learning

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Technology Learning: Measurement and Energy Policy

- **Technology Learning:** deploying technologies in competitive markets increases skills and stimulates private R&D leading to cost reductions and improved technical performance.

- **Experience/learning curves:** measures technology learning when technical properties remains same

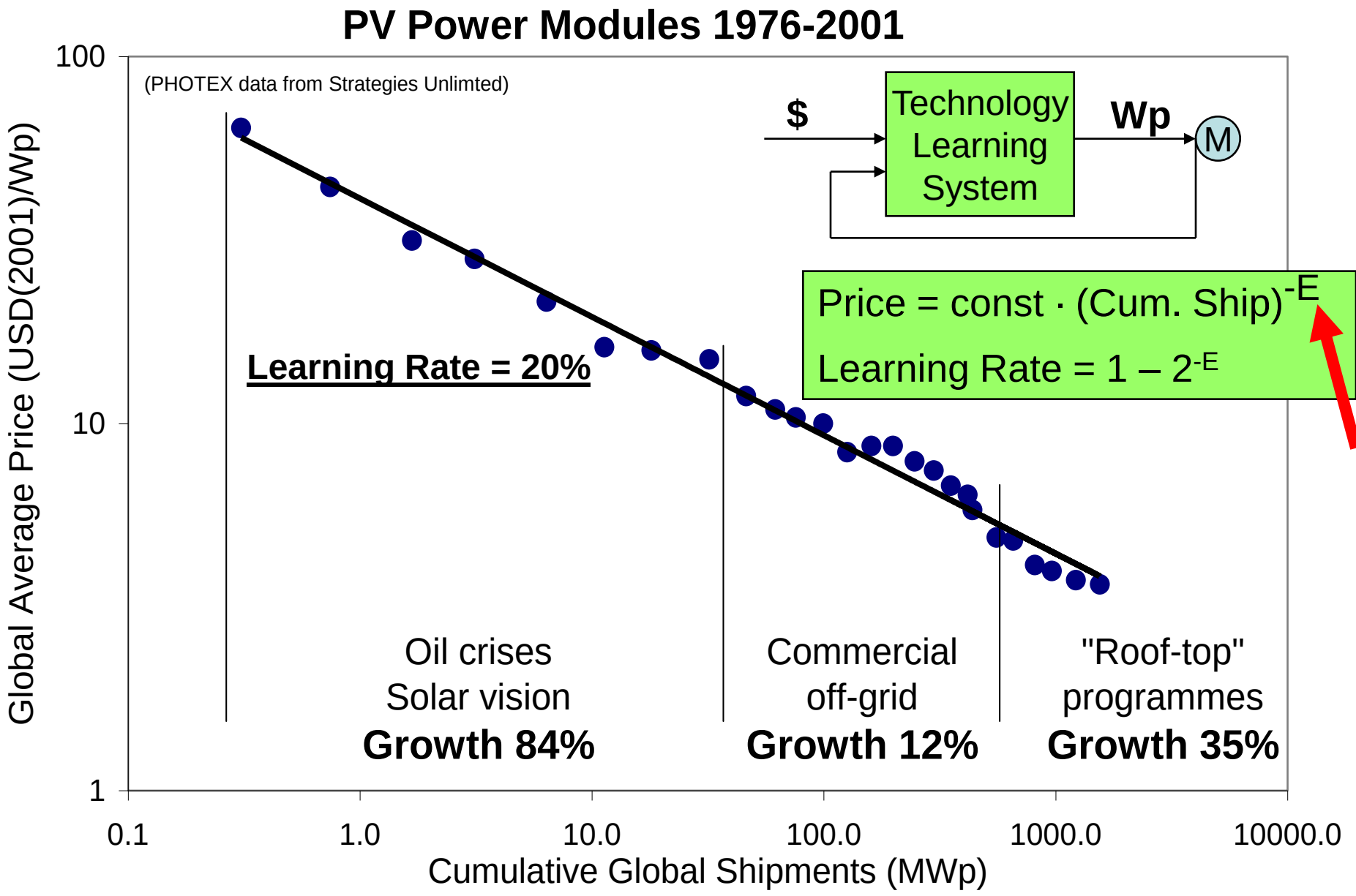
Deployment Policy

- Need: "No Learning without Market Action"
- Balance gov't Deployment Programmes and gov't R&D?
- Global vs. national learning: concerted action among gov'ts?

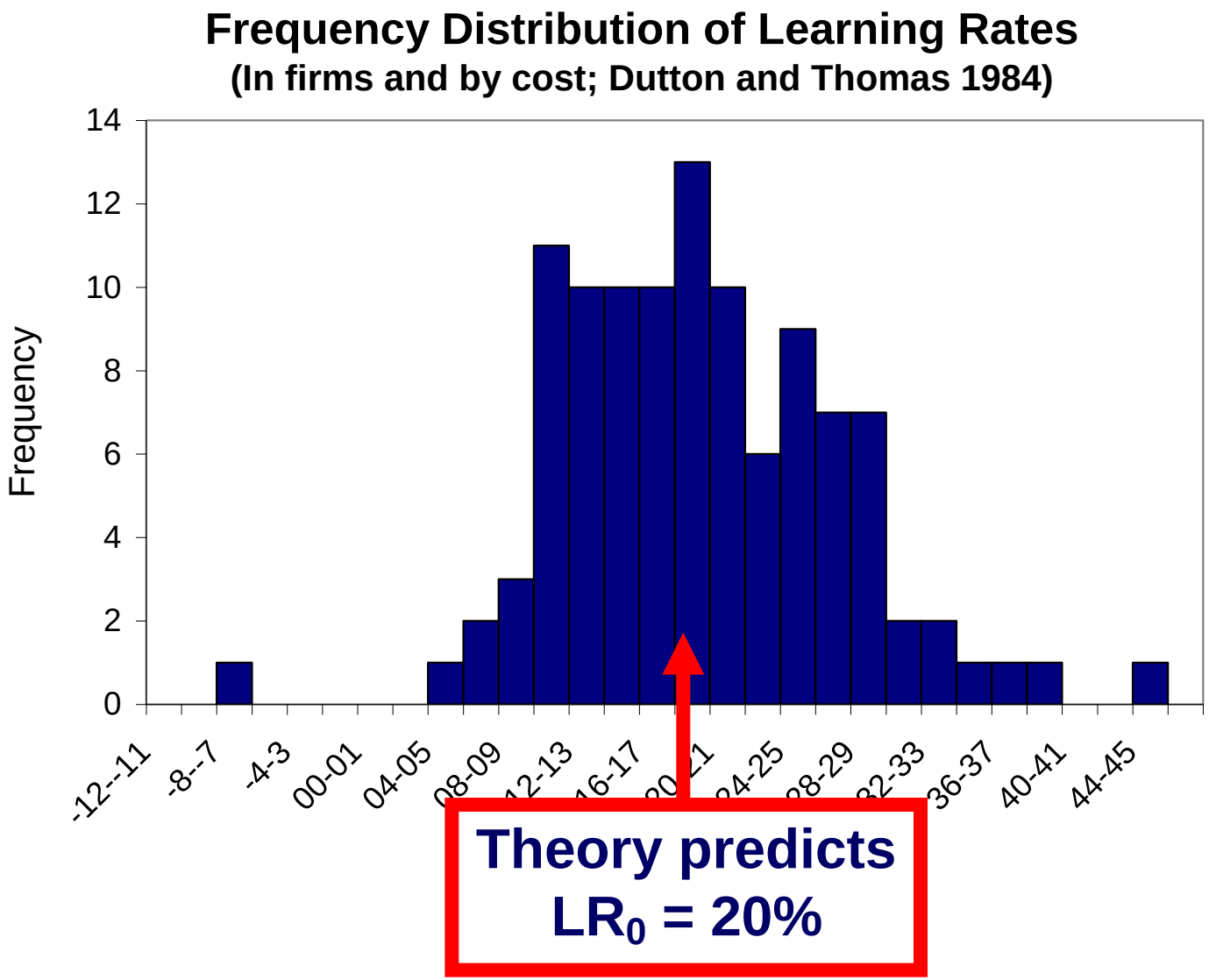
Scenario Modelling

- Coupling between energy system and technology development and production
- Path dependence leading to ε/Ω solutions
- Non-linear models required

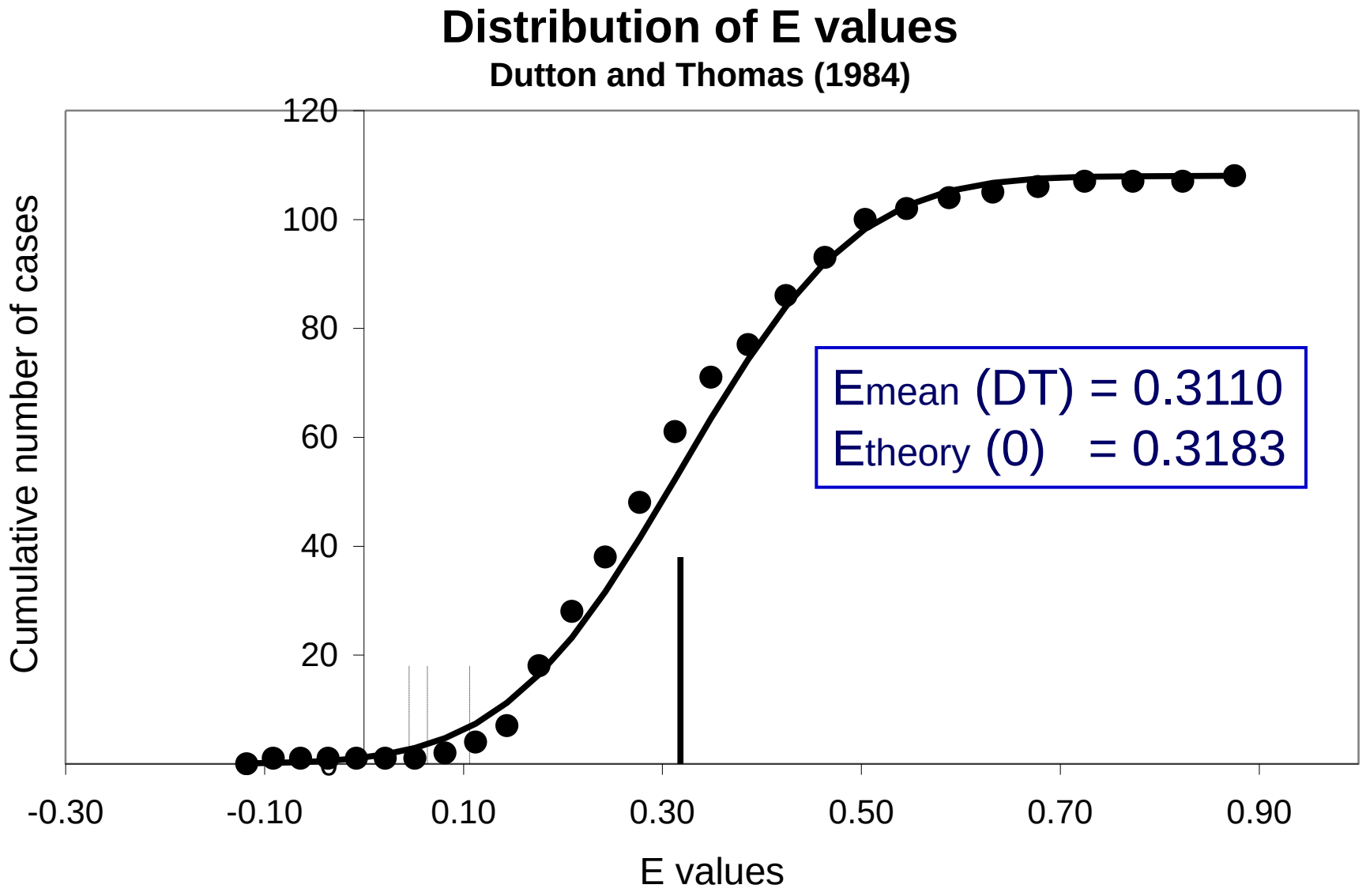
Experience curves as measurement of Technology Learning



Frequency distribution of Learning Rates: 108 cases from individual firms and by cost

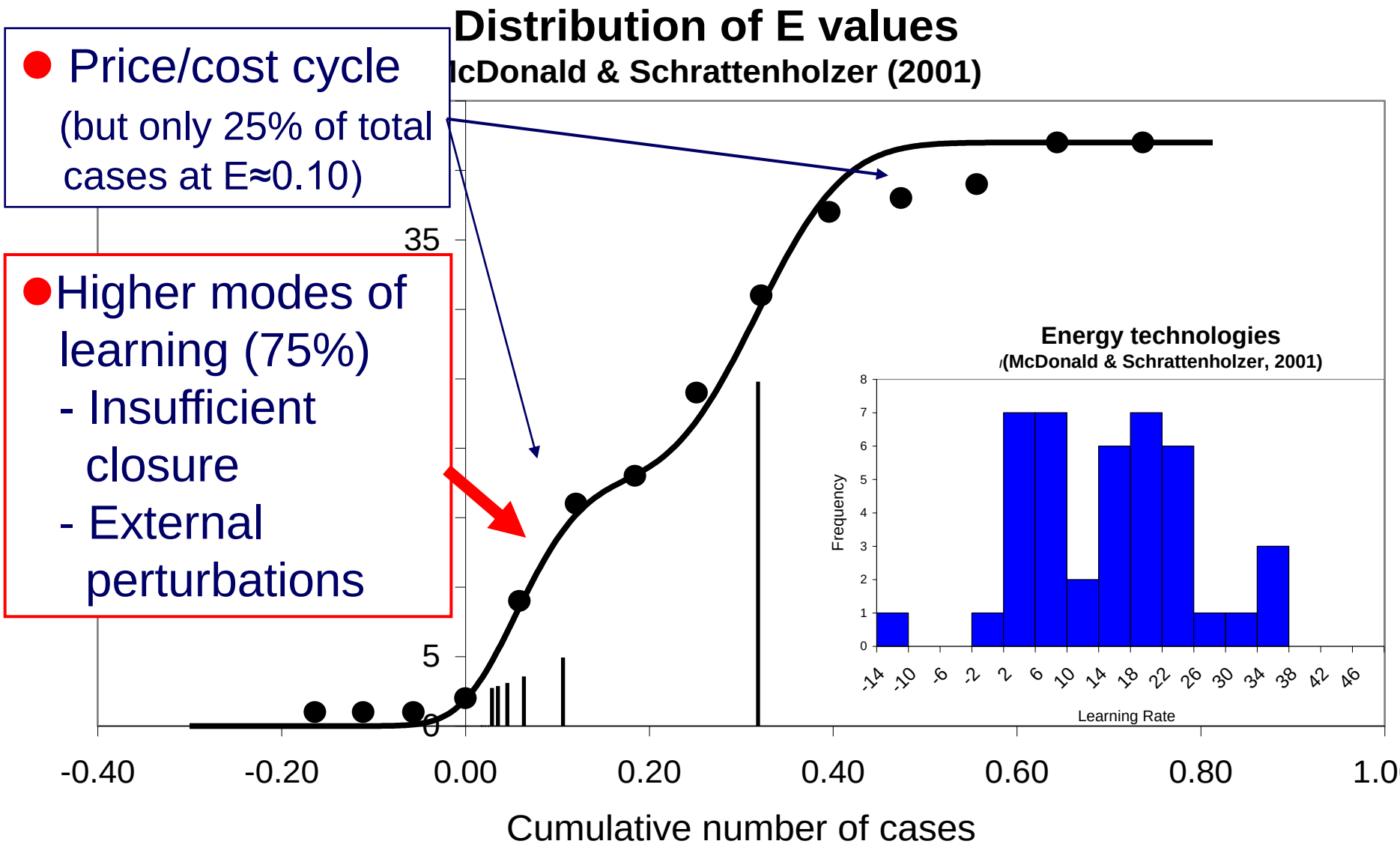


Comparison theoretical and measured distribution: 108 measurements in individual firms and by cost

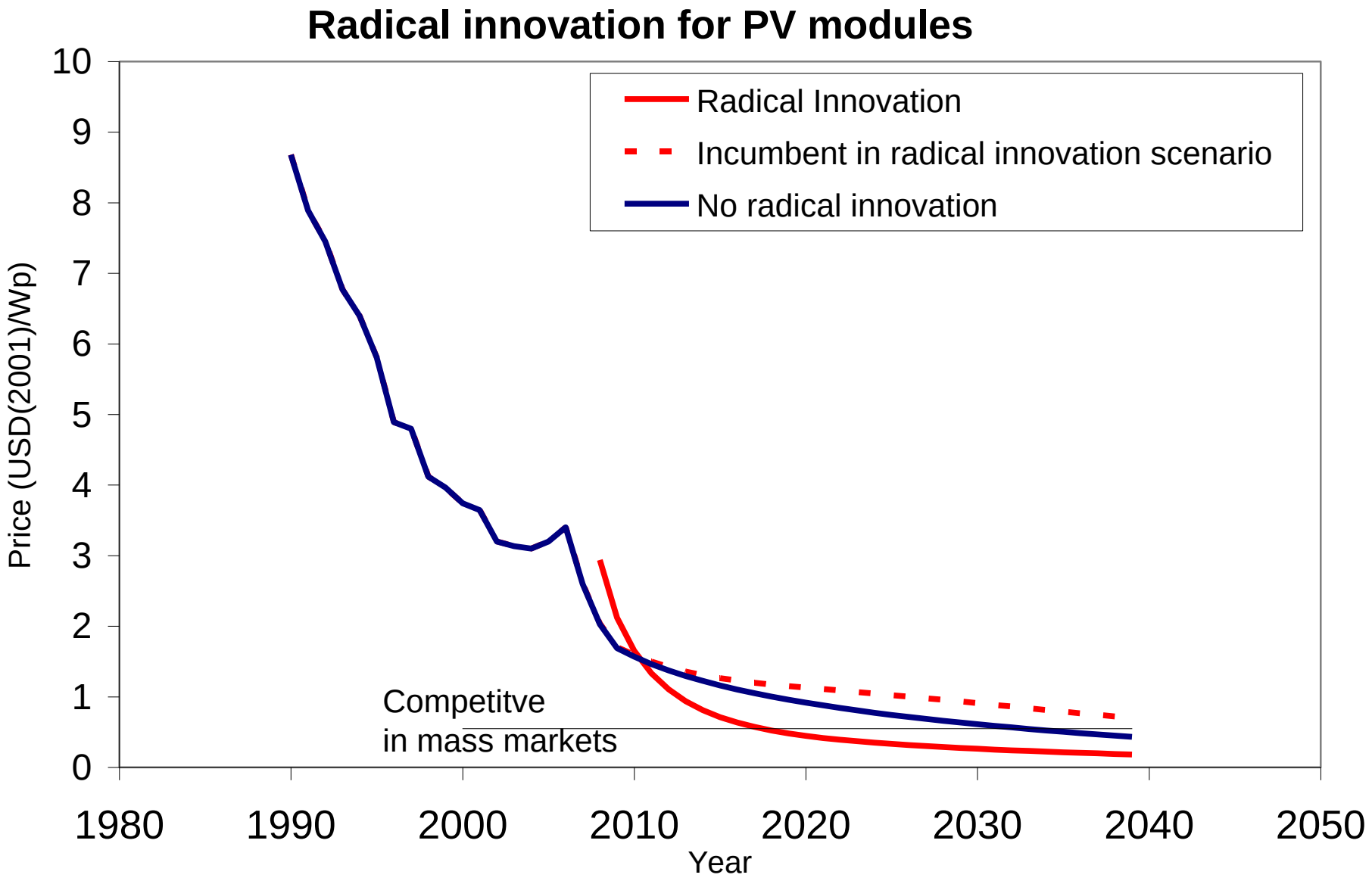


Comparison theoretical and measured distribution: 42 Energy technologies on industry level and by price

- Price/cost cycle (but only 25% of total cases at E≈0.10)
- Higher modes of learning (75%)
  - Insufficient closure
  - External perturbations



Effect of Radical Innovation
Resetting the cumulative sales (resetting feedback)



Conclusions

- **Task:** Making experience curves into a reliable benchmarking tool for energy technology policy requires better theoretical understanding of technology learning
- **Approach:** Cybernetic theory
- **Present achievements:**
  - Explaining observed learning rates by eigenvalues
  - Estimating effect of radical innovations
  - Insight into roles of gov't R&D and Deployment programmes
- **Potential & Ambitions:**
  - Grafted technologies (incl. very fast coupled learning)
  - Balance of gov't R&D and Deployment Programmes
  - Variance of distributions around eigenvalues
  - Global vs local learning
  - Technology learning with consumer value added
  - Organisational theory (Beer's Viable System Model)

Thank you!

References:

On Scenario Modelling:

Edenhofer, O., Lessmann, K., Kemfert, C., Grubb, M. and Köhler, J. (2006), "Induced Technological Change: Exploring its Implications for the Economics of Atmosheric Stabilization", *The Energy Journal*, Endogenous Technological Change and the Economics of Stabilisation Special Issue, p. 57

IEA/OECD (2006), *Energy Technology Perspectives 2006 – In support of the G8 Plan of Action, Scenarios and Strategies to 2050*, International Energy Agency/Organisation for Economic Co-operation and Development, Paris

On Deployment Policies and Programmes

IEA/OECD (2000), *Experience Curves for Energy Technology Policy*, International Energy Agency/ Organisation for Economic Co-operation and Development, Paris.

IEA/OECD (2003), *Creating Markets for Energy Technologies*, International Energy Agency/ Organisation for Economic Co-operation and Development, Paris

On the Cybernetic Theory

Wene, C.-O. (2007), "Technology Learning Systems as Non-Trivial Machines", *Kybernetes, Special Issue on Management Science*, Vol. 36, No ¾, pp. 348-363 (chosen as a Highly Commended Award Winner at the Literati Networks Award for Excellence 2008)

Wene, C.-O. (2008), "A Cybernetic Perspective on Technology Learning", in: T. Foxon et al. (eds*.)* *Innovations for a Low Carbon Economy: Economic, Institutional and Management Approaches*, Edward Elgar, London (to be published in May 2008)

High-level Reports positive to experience/learning curve to inform energy policy. But there are important caveats

- **IEA Energy Technology Perspectives**

  "Technology learning is the key phenomenon that will determine the future cost of renewable power generation technologies. Unfortunately, the present state-of-the-art does not allow reliable extrapolations."

- **UK Stern Report**

  "There is a question of causation since cost reductions may lead to greater deployment; so attempts to force the reverse may lead to disappointing learning rates. The data shows technologies starting from different points and achieving very different learning rates. The increasing returns to scale can be used to justify deployment support, but the potential of the technologies must be evaluated and compared with costs of development."