

# Generating Ideas: Academic and Applied Research

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# Generating Ideas: What Matters?

1. An “idea production function”

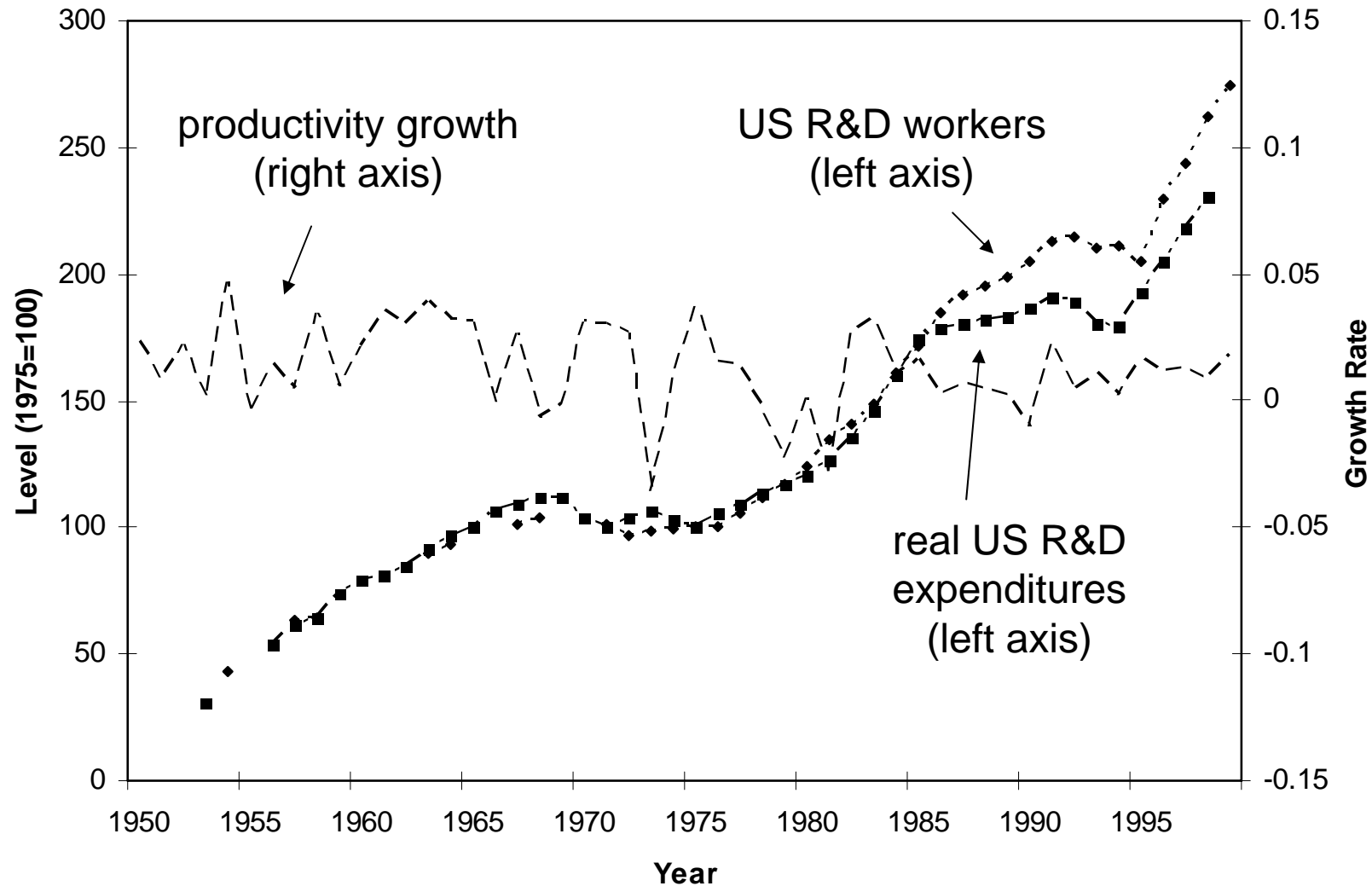
$$\dot{A} = F(A, H, K, Z)$$

1. A: the state of existing knowledge/technology
2. H: human capital
3. K: physical capital
4. Z: institutions

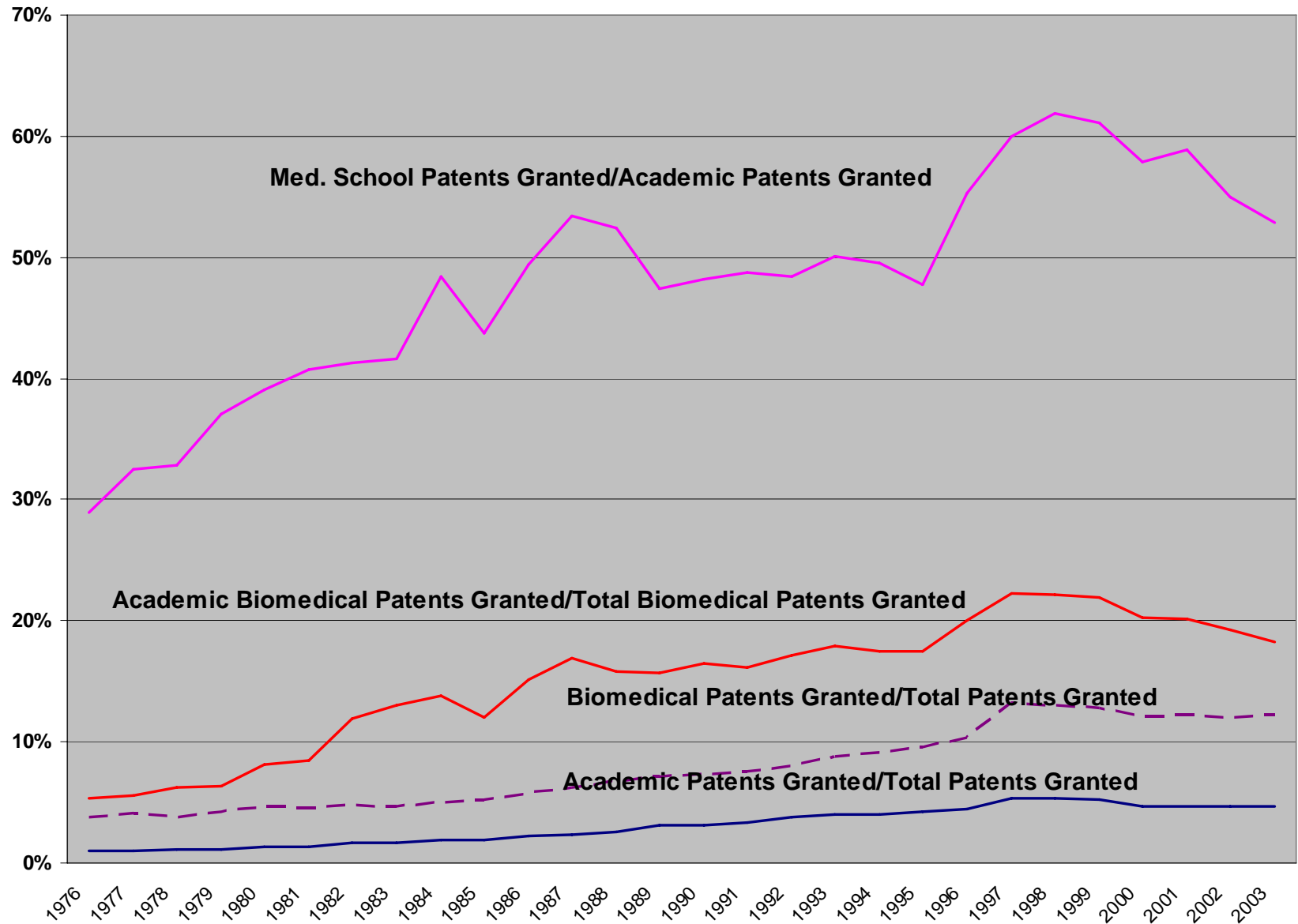
# A Little History

- Industrial Enlightenment (Mokyr 2002)
  - Method: Cultural shift to believe that reason can explain phenomena
  - Access: Open sources of knowledge
- Industrial Revolution
  - Sustained scientific/ technological/ economic progress
  - Demographic transition

# Rising Research Effort, Flat Growth



# The Rise of Academic Patenting



# Which Inputs Matter Most?

- The average R&D worker adds only 15% as much to TFP in 2000 as the average R&D worker did in 1950. Why?
- A, K, H, Z?
- Types of A
  - “Basic research”
  - “Applied research”
  - But what do “basic” and “applied” really mean?
- Roles for Z
  - Type of research given H and K
  - Effect on accumulation of H and K

# Generating Ideas: Issues with A

- Models of creativity
  - Combinations (Weitzman 1998, Burt 2004)
  - Sequences (Mokyr)
- Fishing out (e.g. Kortum 1998)
  - Declining combinatoric or other opportunities
  - If this is core mechanism, we can all go home?
- But also idea selection & search
  - Z-based stories influencing type of A researchers try to produce

# Idea Selection and Search [1]: Manso (2006)

- Where agency models fall short:
  - Assume the agent and the principal know what it is that the agent should exert effort on
- In fact, creativity involves trying actions whose payoffs are yet unknown
- Productivity in creative domains (including science and R&D) involves balancing
  - exploitation (effort on actions with known payoffs)
  - exploration (finding which actions in fact have high payoffs)
- What do optimal incentive schemes that take this trade-off seriously look like?

# Idea Selection and Search [2]: Manso (2006)

- Tolerance for early failure
- Reward for long-term success
- (Some) job security
- Feedback from principal

# Idea Selection and Search [3]

- Many open questions, including
  - How does this intersect with collaboration? Benefits/ punishments for success/failure
    - Revisiting the Matthew Effect (Merton)
  - What is the objective function of researchers, e.g. what explains the open-source movement?
    - Discover truth?
    - Fame?
    - Curiosity?
      - Might lead to overexploration
    - Correlation with social welfare?

# Institutions

- Is there an efficient division of labor between the public/academic sector and the private sector?
  - Sorting of individuals
  - Sorting of capital
  - Sorting of ideas

# Aghion Dewatripont Stein (2005): Sorting of Ideas

- “Linear” Model of Innovation
  - k stages in a research project
  - Applied research closer to the final stage
- Ignores question of appropriability
- Key assumption: scientists require wage premium to give up discretion over research agenda
- Explores implication of trade-off between:
  - Creative control in academia
  - Focus in the private sector

# ADS Results

- In all cases, critical stage  $k^*$  after which it is more efficient to organize in the private sector
- Privatization (=end of scientist discretion) can happen too soon from social point of view
- Main insight remains even if one allows for hybrid firms
- Main insight strengthened if one allows the possibility that creative control increases the probability of “offspring lines”

# Issues

- Is the linear model reasonable?
- Probably a good first-order description, but:
  - What about feedback? (Rosenberg on chemical engineering, Mokyr)
  - Pasteur's Quadrant: What does basic and applied mean?
    - Results harder to appropriate? No.
    - Results closer to ultimate commercial payoff? [ADS]
    - Results that provides broader shoulders, for more follow-on innovators, to stand on? (GHM vs. AT)
- Why do universities patent?
  - Because they hold on too long in the linear model?
  - Because they do research located in Pasteur's Quadrant?

# Human Capital

$$H = hL$$

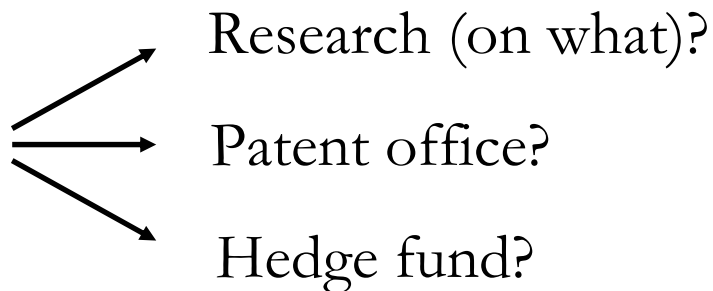
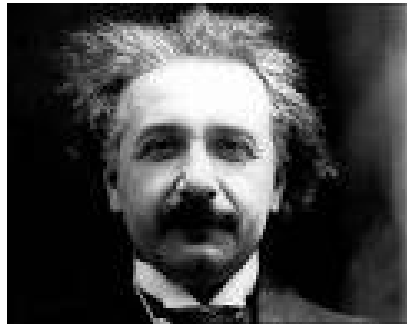
Raw ability  
Education

Time

1. Roles for institutions (Z)
  1. Selection of innovators (ability)
  2. Training of innovators (education)
  3. Use of time (L)
    1. Basic research vs. applied research
    2. Innovation vs. teaching/committee work/etc.
    3. Working vs. slacking

# Human Capital I: Selection

- Do institutions provide the right incentives for the right people to work on innovation?
- Some literature
  - Murphy, Shleifer, and Vishny (1991)
  - Stern (2003)
- But we know very little about this



# Human Capital I: Open Questions

- How is the ability of people going into research changing over time
- How is the ability of people going into *different types* of research changing over time
  - Phil Sharp's students

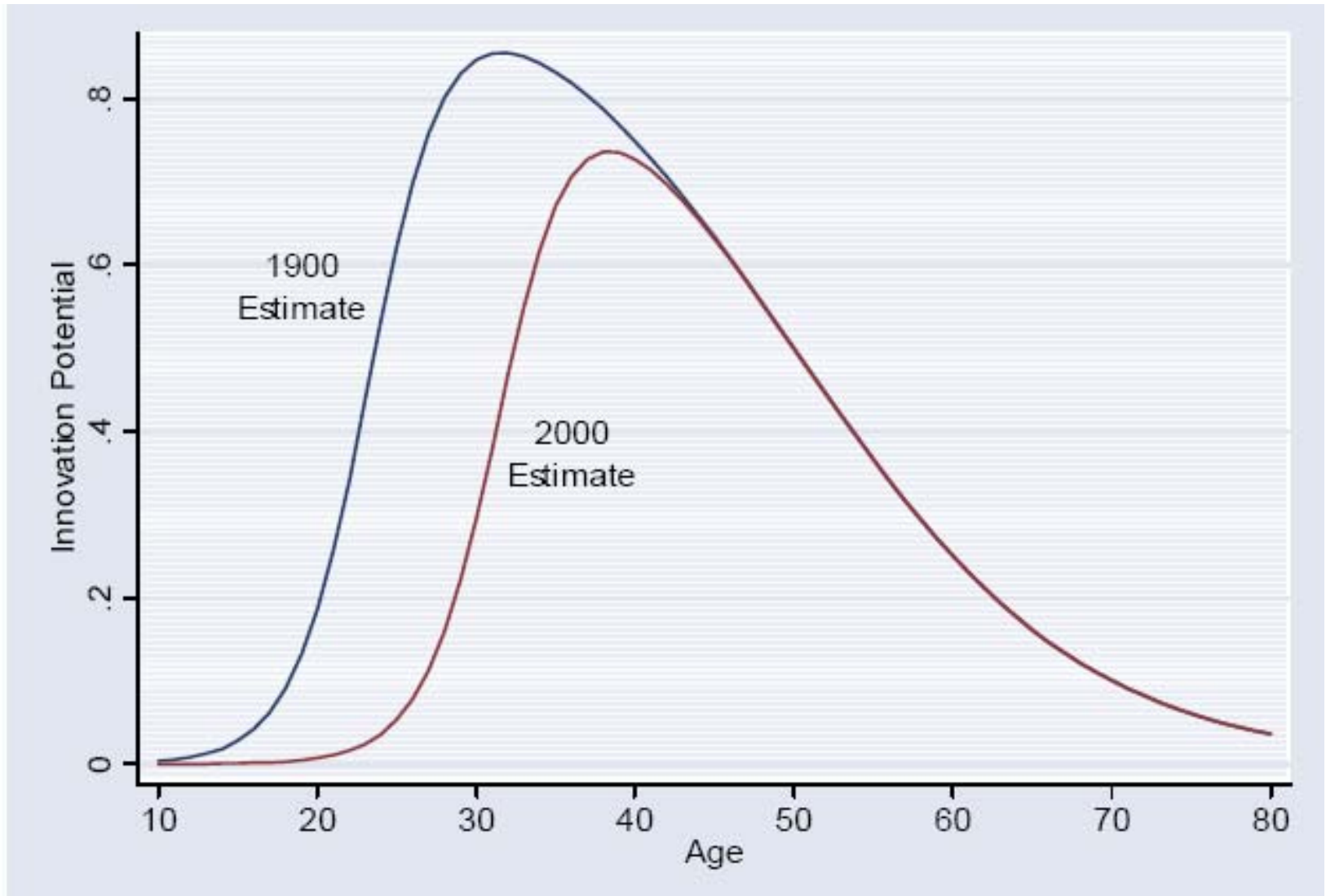
# Human Capital II: Education

- Does formal education matter?
  - Duration
  - Content
  - Time constraints => tradeoffs
    - within set of knowledge learned
    - between learning and innovating
- Do educational systems provide the right training for innovators?
  - Too much, too little?
  - Too specialized, too broad?

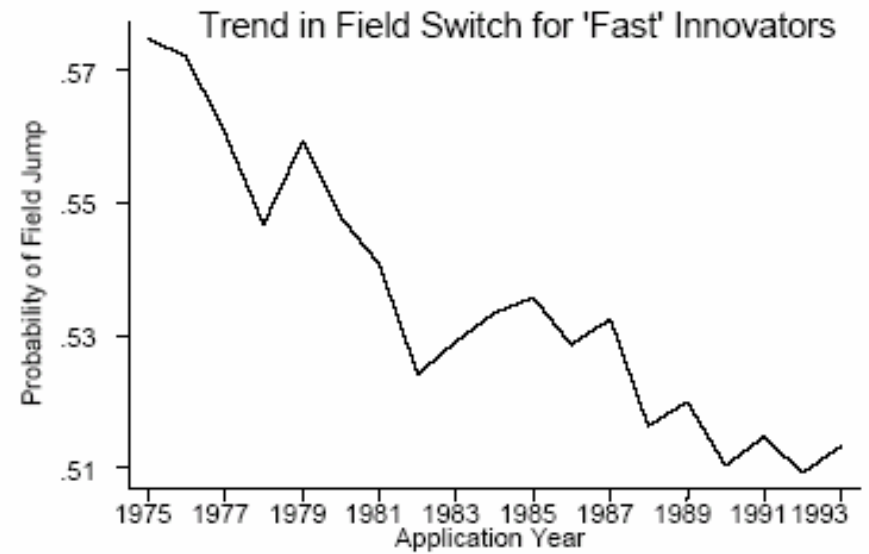
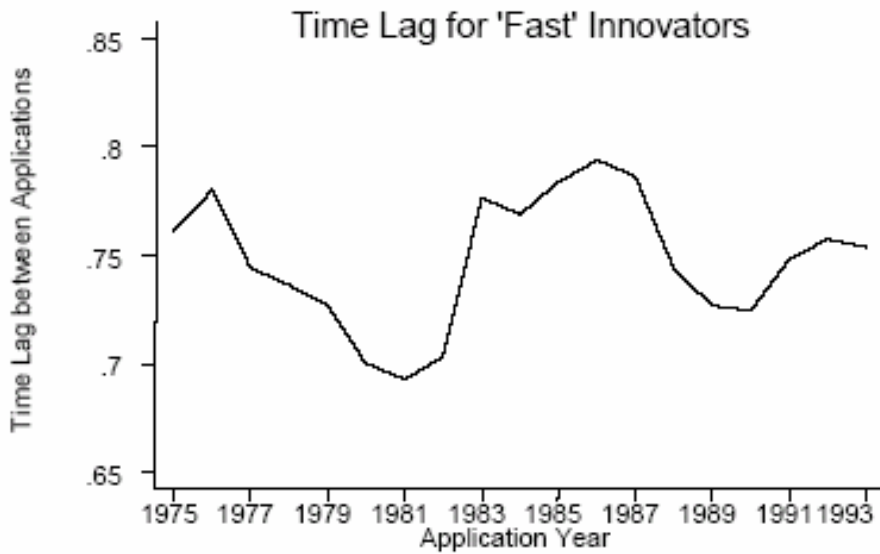
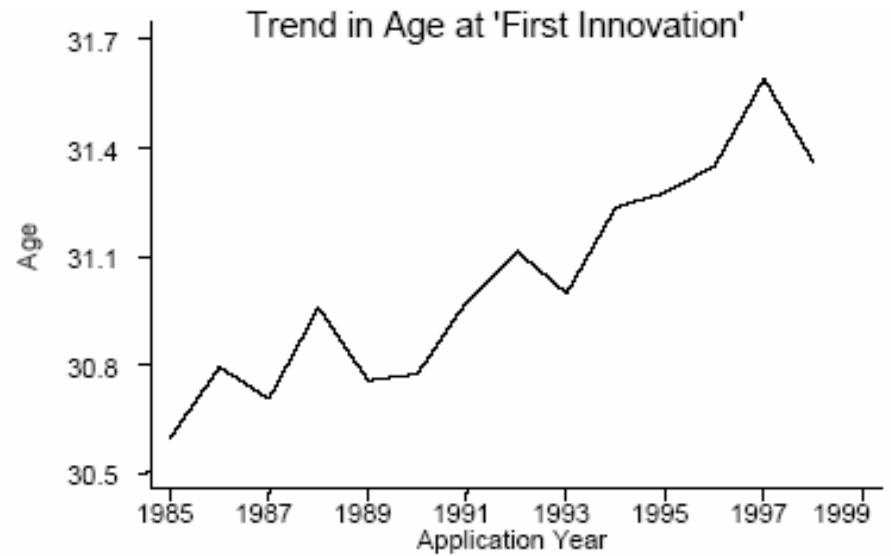
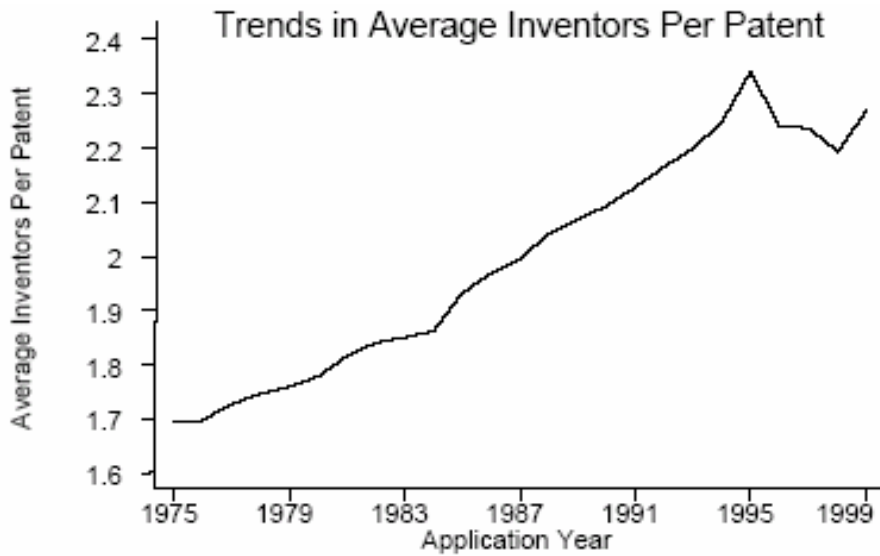
# Human Capital Theory

- What happens if innovation, by creating new knowledge, imposes an increasing educational burden on future innovators?
- Two margins of response
  - Spend more time in training
  - Choose narrower expertise
- Implications
  - Individual innovators are less capable
    - Less time to innovate if more time in training
    - Harder to have broad impact if narrowing expertise
  - Greater need for collaboration in research

# The Decline of Innovation Potential in the Early Life-Cycle



Source: B. Jones (2005) "Age and Great Invention"



Source: B. Jones (2005) "The Burden of Knowledge and the Death of the Renaissance Man: Is Innovation Getting Harder"

# Human Capital III: Collaboration and Distance

- What set of stories explain increased prominence of collaboration?
  - Accumulation of knowledge
  - Increasing market size (Smith, patent races)
  - Declining communication costs (Agrawal and Goldfarb 2006)
- Efficient team design?

# Physical Capital

- Is research becoming more K-intensive?
  - Labs, etc.
  - “Big Science,” “Hyper Science”
- Increasing reliance on grants?
- Open issues
  - Efficient grant targeting
    - Optimal length
    - Projects or people?
  - Reputation establishment (PhD, Postdocs, etc)
    - Discouraging bright people from entering?

# Physical Capital

- Does the grant system fail to provide adequate incentives for exploration?
  - Compared to what?
  - Example of the Howard Hughes Medical Investigator Program

END