Innovation from a micro-economic perspective
An introductory overview to some themes of the week

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Why Study the Economics of Science and Technology?

- Innovations in science and technology play an important role in economic growth.
- Thus, it is useful to understand what factors influence the development of technology.
- In general, economists study of the allocation of scarce resources.
  - resources needed in production of innovations are scarce;
  - but innovation implies also a structural change in which resources are used in and their productivity.
Some general questions

1. What determines how much effort is invested into the scientific process?
   ▶ Who are the decision makers: firms, governments, universities, scientists . . .
   ▶ How do they decide in which projects they invest?
   ▶ How do they decide how much to invest?

2. What are the consequences of innovation?
   ▶ For the innovator (appropriability issues)
   ▶ For industries (competition, prices, . . .)
   ▶ For economic growth
   ▶ For income distribution
   ▶ For social well-being

3. What role for policies?
   ▶ Why should governments intervene
   ▶ Should they only provide legal rules (IPRs) . . .
   ▶ . . . or also invest money and regulate private R&D
A first premise: knowledge and its measures

- Impossible to measure knowledge directly
- We can measure inputs to R&D activities
  - R&D expenditures
  - expenditures in Universities and research labs
  - workers in R&D
- We can measure outputs to R&D activities
  - patents
  - publications and citations
- All measures present strong limitations.
A second premise: market failures in knowledge

- markets’ invisible hand: \( p = MC = MB \)
- otherwise we have allocative inefficiencies (“deadweight losses”)
- sources of market failures in knowledge:
  1. knowledge presents positive externalities: social benefits are higher than private benefits
  2. indivisibilities
  3. uncertainty and moral hazard
  4. high sunk costs
- thus insufficient production and free-riding (quasi-public good)
Market failures in knowledge I

- Knowledge diffusion vs. (involuntary) knowledge spillovers
- Spillovers are due to:
  1. free flow of information
  2. human capital
  3. publications and presentations
  4. reverse engineering
- Sources of appropriation:
  1. patents
  2. secrecy
  3. lead time
  4. learning curves
  5. complementary assets and capabilities
Sources of technological knowledge

- Who are the innovators?
  1. private firms
  2. public institutions
  3. individual inventors

- different incentives

- different roles in the innovative process
  1. in US over 60% of basic research funded by government
  2. over 66% of applied research and 90% of development in private firms
Firms

- look for new processes and products
- in order to increase profits and market shares
- respond to market incentives and market conditions
- some research topics
  1. small vs. large firms in R&D and innovation
  2. age of firms and innovation
  3. persistence vs. re-shuffling in R&D and innovation (and firm size and growth)

- ...but not all innovation is the product of deliberate investment (tacit knowledge, learning by doing and by using, spillovers, etc.)
Some conditions for innovation in firms

- Incentives for firms
  1. demand pull (Schmookler), induced innovation (e.g. labour saving)
  2. technology push
  3. paradigms and trajectories
  4. appropriability

- Incentives for individuals within firms
  1. agency problems (with high uncertainty)
  2. ... but likely overestimation of the role monetary incentives
  3. property/control of key (complementary) intangible assets

- Some intra-firm conditions for innovation
  1. complementary assets
  2. organizational change
  3. problem-solving and division of labour
Evolutionary Theory I

- Evolutionary theory derives from work by Richard Nelson and Sidney Winter in the 1970s (in turn largely inspired by Schumpeter)
- Arose from dissatisfaction of standard neoclassical economics to explain many empirical facts about long-run economic development and technological change.
- Key features
  1. replaces profit-maximizing behavior of firms with decision rules applied routinely over a period of time.
  2. decision rules include routines for production, for managing workers, ordering inventory, advertising, or changing R&D.
  3. R&D in evolutionary theory has two fundamental mechanisms:
     - search for better techniques
     - selection of firms by the market
The search process

- search takes place if a firm is not satisfied with its current profits (???)
- search is more likely to yield results close to the current technology
- once a search is concluded, the firm decides whether or not the new technology is better

- search is cumulative
- is driven by technology specific opportunities
- is mainly local (no full picture of technology space)
Path dependence

- quasi-irreversibility of technology adoption
- due to high and increasing switching costs
- main causes:
  - learning by doing and using
  - technological interrelatedness and complementarities
  - network externalities
- examples: QWERTY, VHS/Betamax, PC/MAC
Diffusion of innovation

- fundamental questions:
  - what is the rate of adoption of an innovation?
  - what variables affect this rate?
  - how do policies affect this rate?

- early empirical studies (mainly in agricultural technologies) found S-shaped diffusion curves (Griliches 1957 on hybrid corn)

- main factors affecting diffusion:
  - relative advantage of the innovation
  - compatibility with current practices and complementary assets (modularity)
  - complexity
  - trialability (how easy to test)
  - observability (how easy to evaluate)
  - network effects (fundamental for ICT)
  - property rights
Diffusion example: diesel locomotives

- The first diesel locomotive was built in Europe in 1913.
- The first diesel locomotive in US in 1924.
- Slow and heavy: only advantage on steam less smoke and less risk of fire.
- In 1933 General Motors produces an improved model.
- First adopters rail lines not much involved in coal transport.
- At the end of WWII only 10% of locomotives were diesel.
- But then engineering refinements made cost per horse power fall.
- More reliable and less maintenance costs.
- On average firms passed from 10% to 90% of diesel in 9 years.
- 20% did it in 3-4 years.
- 10% in more than 14 years.
Diffusion example: environmental technologies

- slow rate of diffusion also of cost-effective technologies
- possible reasons:
  - lack of information
  - externality problems
  - agency problems
  - consumers have high discount rates
  - lack of access to credit markets
Models of diffusion: epidemic

- the contagion model:
  - innovation = information
  - adoption is slow at first
  - but then peaks quickly like a contagious illness

- implications:
  - adoption involves a positive externality
  - gradual diffusion is product of market failure
  - thus diffusion is a disequilibrium condition

- shortcomings:
  - once learned the new technology is adopted
  - technology does not change in the process
Models of diffusion: equilibrium models

- adoption is the result of rational calculation between costs and benefits
- adoption costs tend to decrease
- lock-in can be rational result of switching costs
- ex. probit models:
  - potential users differ in some important characteristics
  - thus, some firms benefit from adoption more than others
  - those with the highest benefit go first
  - examples of rank effects found to be important:
    - firm size
    - R&D investment
    - market share
    - market structure (ambiguous effects)
    - input prices
    - government regulations

- other equilibrium models:
  - stock models (as the stock of adopters increases benefit decrease)
  - order models (early adopters have higher gross returns, but costs may vary and reduce net returns)
Technology transfer

- types of technology transfer:
  - cooperative research and development
  - licensing or sale of intellectual property (existing firms or start-ups spin-offs)
  - technical assistance
  - public exchange of information (conferences, publications)

- government intervention?
  - market failure (high externalities, transaction and agency costs)
  - role of basic research
  - means of intervention: IPRs, R&D subsidies, R&D tax credits
Institutions for technology transfer

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Information technology

- information and digital goods:
  - experience goods
  - high returns to scale
  - quasi-public goods
- thus information is rarely sold in competitive markets
  \( p = MC \)
Price discrimination

- **first degree discrimination:**
  - a different price for each consumer
  - firms can appropriate all consumer surplus
  - requires full monopoly power

- **second degree discrimination:**
  - setting different prices for different goods (first-run movies vs. pay-per-view vs. DVDs; hardback vs. paperback)
  - firms can appropriate part of consumer surplus

- **third degree discrimination:**
  - setting different prices for different categories of users (Saturday stay over for airlines)
Market features

- high network externalities
- high switching costs
- lock-in and path-dependence
- implications for markets:
  - intense competition for new users
  - price discrimination
  - price discrimination between new and current users
- government intervention:
  - creation and dissemination of information
  - development, regulation, and usage of information infrastructure (including standards)
  - legal and institutional framework