How much should society fuel the greed of innovators?

i.e.: Is strong IPR protection always needed for more and better innovations?

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"The protection of intellectual property is important not only for promoting innovation and creativity, but also for developing employment and improving competitiveness"

European Directive 2004/48/EC

"If one wants to induce firms to undertake R&D one must accept the creation of monopolies as a necessary evil"

J.A. Schumpeter, *Capitalism, Socialism and Democracy*, 1943

Outline

Some facts

- patent explosion
- patent expansion
- patent paradox
- increasing costs of the system
- increasing discontent also from innovating (and heavily patenting) firms

The patent explosion

Patents in USA

Year	Pat. applications	Pat. awarded
1963	90,982	48,971
1976	109,580	75,388
1986	132,665	76,862
1996	211,013	121,696
2006	452,633	196,404

Source: United States Patent and Trademark Office (USPTO)

Why the patent explosion?

Possible explanations:

- stronger patent regimes have caused a wave of technological progress
- patents are a symptom of a wave of technological progress
- changes in the legal and institutional framework
  - expansion of the patentability domain
  - patents as intangible assets (Nasdaq “Alternative 2”)
  - strategic use of patent portfolios
  - friendly courts and regulatory capture

Expansion of the patentability domain

In breath:

- software
- algorithms
- business methods
- output of publicly funded research
- less stringent requirements of novelty, non-obviousness and utility

In depth:

- fragments of genetic code
- fragments of algorithms and software
- fragmentation of property rights

But low patent quality

Industry	Median value	Mean value
Chemical	33,856	497,200
Comp. & Commun.	21,287	45,247
Drugs & Med.	12,692	120,419
Electrical/onics	11,928	68,459
Mechanical	8,171	86,033
Others	4,573	38,626

Patent values in 1992 $ and discounted at 10%.

Source: J. Bessen, *The value of US patents by owner and patent characteristics*, Boston University School of Law, WP 06-46.

The "Patent Paradox"

- estimates of patents' value always return low figures
- Surveys of R&D managers (Yale 1983, CMU 1994) seem to indicate patents are not, in general, very effective
- yet patent applications are booming
- If patents are as ineffective as the survey evidence suggests, why the big surge in patenting?

One answer

- Patent portfolios ("thickets of patents") are useful even when individual patents are weak, (especially for defensive purposes)
- Changed legal and institutional context has encouraged patenting also of marginal inventions
- Companies have shifted R&D in a more applied, patent-productive direction (Hall and Ziedonis 2001, Cohen, Nelson and Walsh 2000)

Others problems

- increasing (transaction) costs of the system:
  - administrative costs
  - legal costs (estimated above 25% of total R&D)
  - inefficiency costs
- increasing wide discontent in many industries
- increasing public opinion discontent on controversial issues: patents in genomics, pharmaceutical, software, copyright in art
- weird useless patents (e.g. www.crazypatents.com), examples...

The tragedy of the commons

Collective property is inefficient:

- weak (or null) incentives to investment (positive externalities)
- strong incentives to over-exploitation (negative externalities)
- private property aligns incentive by internalizing all externalities
- however private property introduces a monopoly, which might cause inefficiencies if the resource has no close substitutes

Knowledge is a quasi-public good

- knowledge is non-rival, i.e. one's use does not limit the use of others
- therefore it diffuses quickly and at no cost
- innovative knowledge cannot be easily protected and copies are made at virtually no cost
- the innovator will not appropriate the returns to innovation
- the "market for knowledge" fails

The market failure argument

- competitive markets do not provide incentives to innovation
- knowledge is a valuable good but markets for knowledge cannot function
- unless property rights are assigned and enforced
- thus IPRs are needed to foster innovation and creativity

But IPRs are also a source of inefficiencies

- innovative knowledge is by definition hard to substitute, thus property = strong monopoly power: high prices and inefficient markets
- difficult balance between short-term inefficiencies and long term incentives to R&D investment and innovation

A deeper look

- The idea that a positive and uniform relation between innovation and strong IPR protection is based on a standard market-failure, positive externalities argument, which implies:
  1. a specific representation of knowledge and its nature: knowledge = codified information (Arrow, 1962), i.e. non-rival, hardly excludable and easily transferred
  2. a specific representation of markets and their functioning: perfect competition model = price competition on homogeneous products
  3. the assumption that property rights are the only effective way of appropriating returns to knowledge (internalize knowledge externalities) and thus of providing ex-ante incentives to produce knowledge
  4. an assumption of rationality of innovators who anticipate the erosion of returns and thus do not engage in innovative activities

The problem

- . . . but points 1, 2 and 3 contrast with (most of) what we know on the economics of technological change and most of empirical evidence; on point 4 we know almost nothing.

Our thesis

- if we start from a richer picture of knowledge and competition the economic foundations of IPRs become less clear:
  1. the features of knowledge and competition have a strong impact on appropriability regimes and IPRs' dynamic efficiency
  2. characteristics of knowledge and competition are highly technology-, industry-, and firm-specific: variety of appropriability regimes

The failure of Market failures

- The classical argument for strong IPRs in the form of legally enforced rights is based on the idea of market failure:
  1. Knowledge is a (to a large extent) public good: it will be underproduced and it will receive insufficient investments.
  2. An artificial scarcity is thus created to amend non rivalry and non excludability in such a way that an appropriate degree of appropriability of returns from R&D investments is set.
- The problem then becomes that of balancing out the detrimental effect of deadweight loss implied by a legally enforced monopoly and the beneficial effect of knowledge creation and investment in R & D.

Many questions about knowledge

- knowledge does not present any problem of over-exploitation
- knowledge = information?
  - tacitness and non-codifiability;
  - imitation is costly (Mansfield) and requires absorptive competencies and assets (Cohen-Levinthal);

Many questions about knowledge II

- knowledge = quasi public good?
  - is non-rivarly the appropriate category? significant important differences with public goods
  - need to distinguish between disembodied ideas (non-rival) and knowledge embodied in products (rival) (Boldrin-Levine, Quah)
  - rivarly vs. expansibility (David)
  - the “problem” is not in the good but in the production technology

Many questions about knowledge III

- "innovation" as a well-defined, discrete event?
  - complementary knowledge, physical and organizational assets not available at competitive prices (Teece)
  - cumulative/sequential knowledge (Bessen-Maskin, Scotchmer)
- complexity and interdependencies in knowledge (patent thickets, tragedy of anti-commons, and more in general non separabilities)
- technological opportunities:
  - where do they come from? (exogenous vs. endogenous opportunities)
  - to what extent are determined by incentives?

Some consequences

- imitation and diffusion is costly and problematic
- appropriability more general than IPRs
  1. patents
  2. secrecy (and Trade Secrets)
  3. complementary assets
  4. lead time
- technology-, industry-, and organization- specific knowledge dimensions: complexity, cumulativeness, opportunities
- interdependencies limit the efficiency of the property rights / market solution to the coordination problem

Markets and their functioning

- the benchmark is the static efficiency of resource allocation in the perfect competition model
- however:
  - this notion is hardly relevant in terms of empirical and descriptive adequacy
  - markets are also places in which novelty is (imperfectly) produced, (imperfectly) tested and (imperfectly) selected (variation + selection)
  - product innovations often create quasi-independent sub-markets and competitive processes are displaced before they settle into an “efficient” equilibrium

Some consequences

- IPRs do not only determine a hypothetic static efficiency but also the dynamic path of innovation
- IPRs have an influence on technological opportunities as they drive the new product generation mechanism
- IPRs set constraints to which paths can be followed, as some of them are blocked by patents
- . . . especially if knowledge is “complex”, i.e. complementary or interdependent
- e.g. patent thickets, tragedy of anti-commons

Effectiveness of the Mechanisms

- Surveys of R&D managers (Yale 1983, CMU 1994) seem to indicate patents the least effective of the four mechanisms
- large differences among industries
- patents score high in pharmaceutical low in aircraft

Patents may inhibit innovation

- The patent thicket
  - problem of contracting when many inputs are essential – high transaction costs lead to breakdown
  - Large numbers of patents in a given area, impossibility of adequate search
  - Ex post holdup by patent holder after costs are sunk
  - Given litigation costs, even “invalid” patents can be enforced
  - Increases the risk of innovation
  - Discourages entry (increases sunk costs)

Patents may help competition

- Increases dynamic competition by facilitating entry
  - Useful for securing financing in knowledge – intensive industries (where there are few tangible assets)
- Can lead to competition – enhancing vertical disintegration by facilitating trade in technology (specialization; interface standardization)
  - Chemicals – Arora, Fosfuri, Gambardella
  - Semiconductor design firms - Hall and Ziedonis

A useful taxonomy of industries

- "discrete" product industries
  - food, textiles, chemicals including oil and plastics, pharmaceuticals, metals, and metal products
  - patents used to exclude, and sometimes for licensing; also to prevent litigation
- "complex" product technologies
  - machinery, computers, software, electrical equipment, electronic components, instruments, and transportation equipment
  - patents used in negotiations (cross licensing and other), and to prevent litigation

- In general, patents more important for appropriability in discrete product industries
- Strategic uses (cross licensing, negotiations) greater in complex product industries

Some policy implication

- need to separate incentive problem from exclusion: property is not the correct legal framework
- compulsory licensing on continuous auction basis?
- avoid downstream restrictions in use
- legal and institutional reforms: restricting the domain of patentable, sharpening patentability conditions, decreasing depth and breath of patents, etc.

Towards a more realistic model

Main features:

- product innovation, where products are complex systems of interdependent components (complex product space);
- innovation can generate new products weakly (or not at all) competing with existing ones if enough differentiated in the product space (sub-markets)
- imitation is costly and problematic (complex /interdependent systems cannot be usually imitated "piecewise")

Products and firms

- **products** are made of many component: $\{x_1, x_3, \ldots, x_n\}$.
- each component can take one out of a countable set of values $x_j = \{0, 1, \ldots\}$, i.e. progressively better components
- a product's is a function $f : X \mapsto R^+$, possibly non-linear and/or non-monotonic: a complex product space
- products diversity may be measured horizontally (number of diverse components) and vertically (distance between components)

Products and firms

- single product firms
- **prices**: at each time step innovators and a few randomly chosen firms can set prices at profit maximizing level, under the assumption that competitors do not react
- **R&D investment** is a boundedly rational routinized decision subject to adaptive learning (cf. models of Schumpeterian competition *à la* Nelson and Winter)
- firms decide the amount of innovative R&D and imitative R&D and scope of R&D as a share of profits.
- **innovation**: random draw of new components in the neighborhood of the current product. R&D investment determines how many different components can be modified and the size of steps. Firm can be specialized (search only on few components) or generalists (broad search on all components)

Consumers

Maximize utility, which depends upon

- product price
- product technological performance
- product characteristics: each consumer has idiosyncratic preferences for a specific product profile
- at each time step only a share of consumers can modify choice, all the others repeat previous purchasing decision

Patents

Patent regimes are defined by:

- patentability standards (required to get a patent)
- patent amplitude (required to sell a product)

Patentability standards

- patent life
- vertical breadth: required minimum distance on single components
- horizontal breadth: minimum number of components which must differ
- patent “coarseness”: can we patent whole products, modules or single components?

Patent amplitude

- vertical amplitude: required minimum distance on single components
- horizontal amplitude: minimum number of components which must differ
- patent “coarseness”: on how many components do we measure vertical and horizontal amplitudes?

Some preliminary results

- **product complexity**:
  - If product complexity is low strong patent regime increases social welfare: higher prices and concentration is more than compensated by higher innovation and product quality.
  - If product complexity is high, a strong patent system, in addition to leading to higher prices and concentration, is also a cause of lower rates of innovation and product quality growth.
- **patent coarseness**:
  - if patents are granted single components they generate long run inefficiencies even in environments characterized by low complexity
  - granting finer patents selects firms with excess R&D specialization