Sectoral patterns of innovation and industry dynamics

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Engines of innovation: large or small firms?

Two models of innovation coexist **<u>in different industries</u>**

1) Schumpeter Mark I (Schumpeter 1912)
- innovators: small/new firms
- high degrees of turbulence (entry/exit)
- low concentration
→ 'creative destruction' – widening

2) Schumpeter Mark II (Schumpeter 1942)
- innovators: large/incumbent firms
- low degrees of turbulence (entry/exit)
- high concentration
→ 'creative accumulation' - deepening

Empirical indicators

Entry – % of total 1986-91 patents by firms applying for the first time in a given industry in the period 1986-91

Stability – rank correlation coefficient between hierarchies of firms patenting in 1978-85 and firms patenting in 1986-91

C4 – % of total 1986-91 patents of the top for patenting firms in a given industry

Size – % of total 1986-91 patents accounted for by firms with more than 500 employees in a given industry

Results

- Strong differences across industries within each country
- Strong similarities across countries within each industry

Empirical evidence suggests that industry-specific factors, rather than country-specific factors account for differences in the organization of innovative activies in industries

→ How do we explain that?

The evolutionary approach

Two major forces shaping industry structure:

1) Technology
2) Market selection

The sources and nature of knowledge strongly influence the decisions of firms to innovate / enter into an industry → <u>increase variety</u>

Markets select the firms on the basis of their <u>fitness</u> → <u>reduce variety</u>

Industries evolve through processes of entry, exit, survival and growth of firms.

Technological regime

• <u>Routinised regime</u>: Cumulative learning from sources inside the industry (e.g. in-house R&D), high appropriability and opportunities related to exisiting industrial applications ⇒ **relative advantage for incuments, low entry and high concentration**

• <u>Entrepreneurial regime</u>: High opportunities from sources outside the sector (e.g. academic research), low appropriability and knowledge is pervasive ⇒ **relative advantages for entrants, high entry and low concentration**

The dimensions of a technological regime

- Technological opportunities
  - level/sources/pervasiveness
- Appropriability of innovations
  - level /means
- Cumulativeness of technical advances
- Knowledge base
  - nature of knowledge (tacit, complex, systemic)
  - means of transmission

Expected relationship between technological regime and sectoral patterns of innovation

	Opportunity	Appropriability	Cumulativeness
ENTRY	+	-	-
STABILITY	+/-	+	+
C4	+/-	+	+
SIZE	+/-	+	+

Measuring technological regime

PACE questionnaire survey to 713 European R&D managers

Appropriability: sum of scores on effectiveness of patents and secrecy

Opportunity: sum of scores on importance of external sources of knowledge for innovative activities (universities and PRO, suppliers, users, joint ventures)

Cumulativeness: score on importance of frequent technological improvements in making innovations more difficult to imitate

Knowledge base: score on relevance of applied (specific) and basic (generic) sciences for innovative activities

Inter-industry technology flows: Pavitt's taxonomy

-the largest part (>75%) of new technologies is produced by 'core' industries: chemicals, electronics, machinery, transports

-most innovations produced by 'core' sectors are product innovations, i.e. they are adopted by 'user' industries

-main user sectors are: textiles, food, paper and printing, wood and furniture. User industries also contribute to the development of own process innovations

- Four types of industries: science-based, scale-intensive, specialised suppliers, supplier dominated

Other taxonomies: Pavitt's taxonomy

	Sources of technology	*Type of users*	*Means of appropriation*	*Tech. Trajectories*	*Innovation*	*Size*
Supplier dominated	Suppliers /Big users	Price sensitive	Non-technical	Cost-cutting	Process	Small
Scale intensive	Production engineering; Suppliers; R&D	Price sensitive	Secrecy, know-how, dynamic learning economies	Cost-cutting, product design	Process	Large
Specialised suppliers	Design and development; users	Performance sensitive	Design, knowledge of users, patents	Product design	Product	SME
Science-based	R&D, public science, production	Mixed	R&D, patents, secrecy	Mixed	Mixed	Large /Small

Discussion

- The properties of technology explain who are the engines of innovation (large vs. small firms) in an industry
- There is likely to be a "reverse" causal link going from innovation to market structure
- The nature of technology is therefore expected to shape the organization of an industry: from patterns of innovation to industry dynamics

Industrial organization (IO)

- **Object of study**

- How productive activities are organised
- What determines industry performance

- **Theoretical approaches**
  - Static analysis
  - Dynamic analysis

Measures of industry structure/dynamics

- **Market structure**

- Size distribution of firms / Mkt concentration

- **Turnover of firms**

- Entry: greenfield investment and diversification
- Exits: closure and disinvest

- **Mobility of firms**
  - Size growth (internal and external)
  - Market shares volatility

Stylised facts

- **Size distribution**
  - Stable over time
  - Highly skewed
- **Turbulence**
  - High rates of entry and exit
  - Turbulence at the “fringe” of the industry
- **Persistence and heterogeneity**
  - Differences across companies persistent over time
  - Industry-specific differences

Traditional approaches to IO

- **Structuralist (Bain, 1956)**
  - Structural entry barriers
  - Technology → cost asymmetries
- **Rationalistic (Tirole, 1990)**
  - Strategic interactions (game theory)
  - Technology → structure of the game

Both approaches share a rather <u>static view</u> of industry structures

Entry: An evolutionary approach

• Traditional view of entry not consistent with stylised facts

• Evolutionary-based explanation of entry

- Agents have knowledge whose economic value uncertain
- Information asymmetry → divergence in evaluation
- Entry as a way to test economic value of knowledge

Implication: the nature of knowledge is likely to affect the decision to enter the industry → technological regime

Technological regime and market entry

• One expects high rates of new firm startups in an industry where the nature of technology favours small firms → entrepreunerial regime

• One expects low rates of new firm startups in an industry where the nature of knowledge favours incumbent firms → routinised regime

Results

• **Entry of new firms**
- high where small firms' share of innovations is high
-not deterred by high K intensity and economies of scale

• **Survival of new firms**
- low in industries with high K intensity and economies of scale
- high in industries where small firms' share of innovations is high
- increasing with firm size and age

• **Growth of surviving firms**
- higher in industries with high K intensity and scale economies
- higher in industries with higher rates of innovation (and uncertainty)

Implications

⇒ New firm start-ups more prevalent where knowledge favours small firms
⇒ New firms start at sub-optimal scale, if successful grow if unsuccessful exit from the industry

⇒ In industries where MES is high, surviving firms grow faster, but the probability of surviving is lower
⇒ In industries where the probability of innovating is greater, one would expect higher rates of new firm formation, higher growth rates of surviving firms, but lower likelihood of survival

Models of industry dynamics

• Are there models capable to explain the overall dynamics of an industry in terms of entry, exit, growth, size distribution, product and process innovation?

• Simulation models (history-friendly models)

• Industry-life cycle model (ILC)

• Traditional version of the ILC model based upon the notion of a **dominant design**

• Steven Klepper's model

Industry life cycle

	Exploratory	*Development*	*Mature*
Turbulence	High	Medium	Low
Survival	High	Low	Low++
Innovation	Radical / product	Incremental / product+process	Incremental / process
Equipment	General purpose / production inefficient	Specialised / segmentation	Large scale plants / automation
Concentration	Low	Medium	High
Entry barriers	Low	High	High++
Competition	Functional performance / new products	Price / product differentiation	Low / collusion

Why should industries evolve according to ILC?

• Early entrants that are able to introduce successful product innovations tend to grow

• These firms have also greater incentives to engage in process R&D (that reduces costs)

• Incumbents' growth and entry push the price down

• Entry becomes more difficult given the cost advantage of incumbents → **shakeout**

• As the number of firms reduces, product diversity reduces as well, whereas the importance of process innovations tends to increase → **dominant design**

ILC is powerful in explaining structural dynamics in specific industries, e.g. consumer durables

<u>HOWEVER</u>

a) The sequence product>>>process does not hold in capital intensive industries, e.g. plastics, petrochemicals
b) Where demand is customised (e.g. industrial machinery), product innovations are always prevailing
c) In some industries (e.g. semiconductors, microprocessors), the emergence of a dominant design led to new techological discontinuities and several dominant designs
d) In some cases, the technological discontinuity which originates the industry is associated with an incumbent and not with a newcomer