A general (not complete) definition of knowledge

- Knowledge as
- A correlational structure
  - Knowledge establishes correlations, or connexions, between variables
- A retrieval/interpretative structure
  - Existing knowledge allows agents to retrieve similar knowledge
Units of knowledge

- Defined at different levels of aggregation
- Variables the lowest, but some more aggregate units can be used, such as technological classes in patents, classifications of scientific publications, themes etc.
- Data used: Patents, publications but any text can in principle be used
A representation of knowledge

- Based on the previous definition knowledge can be represented as a network

- Nodes/vertices = units of knowledge (variables, concepts, themes etc)

- Links/edges = correlations /connections/co-occurrence)
Knowledge as a network

Only some variables are correlated
Knowledge dynamics

• New nodes are created as new observables are discovered and as new variables to represent them are created.
• Connections/correlations between different variables are subsequently, and not instantly created.
• The network of knowledge has a variable number of nodes and of links, generally increasing in the course of time.
The knowledge base of firms and organisations

- Knowledge base = collective ((i) and (ii)) knowledge that firms can use to achieve their objectives.
  - (i) it depends both on the elements of knowledge of individual members and on their interactions
  - (ii) same individuals in different organisations ⇒ different outcomes
Rhône Poulenc, Hoechst, Aventis

- Rhône Poulenc and Hoechst were previously mostly chemical firms, but at different times (end of the 1980s- mid 1990s) decided to become life science companies.
- This change in strategy involved a change in their KB
- Aventis was created in 1999 from the merger of Rhône Poulenc and Hoechst. Its strategy quickly became to become a pharmaceutical company.
Example: Rhône-Poulenc 90-92

A61K

Biotech subset

Chemical subset
Example: Rhône Poulenc 96-98
KB Hoechst 90-92

Biotech subset

A61K

Chemical Subset
KB Hoechst 96-98

A61K

Biotech subset

Chemical subset
Aventis summary

• The two firms before the merger changed their KBs in the direction indicated by the change in strategy
• In intermediate phases the KB was segmented with the old part (chemical) very weakly connected to the new part (biological)
• After the merger there was followed an improvement in the integration of the two components of the KB
## Variation of network density

<table>
<thead>
<tr>
<th></th>
<th>Hoechst</th>
<th>Rhône-Poulenc</th>
<th>Aventis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nodes (N)</td>
<td>33</td>
<td>22</td>
<td>31</td>
</tr>
<tr>
<td>Links (L)</td>
<td>55</td>
<td>36</td>
<td>46</td>
</tr>
<tr>
<td>L/N</td>
<td>1.67</td>
<td>1.64</td>
<td>1.48</td>
</tr>
</tbody>
</table>
Monsanto (1)

- From foundation (1901) until end of 1970s = diversified chemical company (agricultural chemicals, polymers, fibres etc)
- End of 1970s important start of strategic reorientation away from chemistry
- The search for new fields included plants genetics, pharmaceuticals, products for electronics, fluid technology etc
- Amongst these possible fields plant genetics emerged as the dominant one
Monsanto (2)

- 1980s acquisition of knowledge and competencies in 3rd generation biotechnology by alliances and collaborations, M&amp;A
- Initially life science company (wide range of products belonging to different markets by common (transversal) knowledge base, biotechnology
- Later, abandoned the life science company strategy & focused on agrochemistry
Organic compounds -- part of the class 532-570 series

Liquid purification or separation

Synthetic resins or natural rubbers -- part of the class 520 series

Fabric (woven, knitted, or nonwoven textile or cloth, etc.)

Plant protecting and regulating compositions

Compositions: coating or plastic
Monsanto 2\textsuperscript{nd} Period, 1980-1985, Agrochemistry, Plant Biotechnology

Plant protecting and regulating compositions

Synthetic resins or natural rubbers

Stock material or miscellaneous articles

Drug, bio-affecting and body treating compositions

Organic compounds

Polymers, plastics & fibers
Monsanto, 3rd period 1986-1996 Life Sciences, Plant Genetics

Compositions

Organic compounds

Drug, bio-affecting and body treating compositions

Chemistry: natural resins or derivatives; peptides or proteins; lignins or reaction products thereof

Multicellular living organisms and unmodified parts thereof and related processes

Drug, bio-affecting and body treating compositions

Chemistry: molecular biology and microbiology

Synthetic resins & related
Monsanto 4th period, after 1996
Seeds, genetics, agriculture

Plant protecting and regulating compositions
Drug, bio-affecting and body treating compositions
Multicellular living organisms and unmodified parts thereof and related processes
Chemistry: molecular biology and microbiology
Synthetic resins or natural rubbers -- part of the class 520 series

Organic compounds
Monsanto summary

- $\Delta$ strategy $\rightarrow \Delta$ KB (minus classes corresponding to 'old' products + new technological classes corresponding to pharmaceuticals & agricultural chemistry (life science company))

- Only agrochemicals survive now (Seeds & complementary herbicides)

- Q: How was knowledge used to create new products?

- Q: vs competitors?
Applications

- Useful to study:
- Firm strategy
- Firm organization
- Mergers and acquisitions
- Divestitures
- Innovation networks
Network of IPC technological classes, biotechnology, 1981-1985
Network of IPC technological classes, biotechnology, 1986-1990
Network of IPC technological classes, biotechnology, 1991-1995
Network of technology classes for biotechnology, 1996–2000
KB properties

• Coherence

• Variety (Knowledge): related (intra-group) and unrelated (inter-group)

• Cognitive distance
Variety of the knowledge base of biotechnology
Coherence of the knowledge base of biotechnology
Cognitive distance of the knowledge base of biotechnology
• A pronounced structural change occurring

  – (i) the emergence of new technological classes linked to biology and partly to physics,
  – (ii) the disappearance or gradual loss of importance of classes linked to the previous knowledge base, organic chemistry,
  – (iii) the gradual rise in strength of the links between A61K and the emerging classes and the gradual fall in strength of the links between A61K and the older classes,
  – (iv) a growth in the number of important nodes and of important links, corresponding to an overall process of diversification of the knowledge networks
  – (v) the persistence of A61K, showing that the new knowledge is used to attain market objectives similar to the past ones in the pharmaceutical, industry.
Applications

• Test of concepts such as technological paradigms, trajectories, exploration, exploitation

• Technology life cycles, from random to organized search

• Identify knowledge discontinuities, their evolution and their impact on firm behaviour and performance

• Compare different firms (firm strategies)

• Compare networks of firms and networks of technological alliances
References


# IPC Technological classes

## biotechnology

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A01H</td>
<td>new plants or processes for obtaining them; plant reproduction by tissue culture techniques</td>
</tr>
<tr>
<td>A61K</td>
<td>preparations for medical, dental, or toilet purposes</td>
</tr>
<tr>
<td>C02F</td>
<td>treatment of water, waste water, sewage, or sludge</td>
</tr>
<tr>
<td>C07G</td>
<td>compounds of unknown constitution</td>
</tr>
<tr>
<td>C07K</td>
<td>peptides</td>
</tr>
<tr>
<td>C12M</td>
<td>apparatus for enzy-mology or microbiology</td>
</tr>
<tr>
<td>C12N</td>
<td>micro-organisms or enzymes; compositions thereof</td>
</tr>
<tr>
<td>C12P</td>
<td>fermentation or enzyme-using processes to synthesise a desired chemical compound or composition or to separate optical isomers from a racemic mixture</td>
</tr>
<tr>
<td>C12Q</td>
<td>measuring or testing processes involving enzymes or micro-organisms; compositions or test papers thereof; processes of preparing such compositions; condition-responsive control in microbiological or enzymological processes</td>
</tr>
<tr>
<td>C12S</td>
<td>processes using enzymes or micro-organisms to liberate, separate or purify a pre-existing compound or, processes using enzymes or micro-organisms to treat textiles or to clean solid surfaces of materials</td>
</tr>
<tr>
<td>G01N</td>
<td>investigating or analysing materials by determining their chemical or physical properties</td>
</tr>
</tbody>
</table>
# IPC classification

- **A** Human Necessities
- **B** Performing Operations; Transporting
- **C** Chemistry; Metallurgy
- **D** Textiles; Paper
- **E** Fixed Constructions
- **F** Mechanical Engineering; Lighting; Heating; Weapons; Blasting
- **G** Physics
- **H** Electricity
IPC classification (2)

- Site for more detailed IPC classification
  - http://www.wipo.int/classifications/ipc/ipc8/?lang=en