

Franco Malerba, The Oxford Handbook of Innovation, 2009

Sectoral Systems: How and Why Innovation Differs across Sectors

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Sectoral Systems of Innovation

● Innovation

- the process involving interactions of actors for generating and exchange of knowledge relevant to innovation and commercialization.

● Innovation Systems [1]

- Different actors interact to promote creation of technological innovations
- Facilitates diffusion or applications of technological innovations

● Sectoral Innovation Systems

- Innovation takes place in different sectoral environments
- Focus on certain sectors of the economy

Pharmaceutical



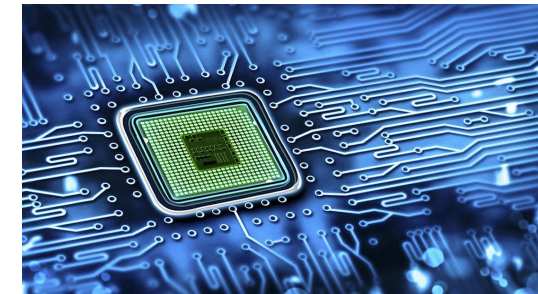
Software



Chemical



Semiconductor^{3/16}



[1] Beije, P. (1998). Technological change in the modern economy: basic topics and new developments.

Differences across sectors

- Innovation differs across sectors in terms of characteristics, sources, actors involved, organization of innovative activities
- Dimensions to understand innovation and its differences
 - Knowledge base
 - Actors involved
 - Links and relationships among actors
 - Institutions

How is it possible to analyze these differences and their effects on sectoral growth and performance?

Previous Literature on Sectoral Differences in Innovation

- International studies by OECD, EU and international organizations
 - High R&D-intensive (electronics, drugs)
 - Low R&D-intensive (textiles, shoes)
- Schumpeterian legacy ^[1,2]
 - Focus on differences in market structure and industrial dynamics

Schumpeter Mark I: creative destruction

- New entrants and new technologies displace previously dominant firms
- E.g., Machinery, biotechnology

Schumpeter Mark II: creative accumulation

- Established firms gradually improve existing technologies
- E.g., Semiconductor, mainframe computers

[1] Schumpeter of Theory of Economic Development (1911, "Schumpeter Mark I")

[2] Capitalism, Socialism and Democracy (1942, "Schumpeter Mark II")

Previous Literature on Sectoral Differences in Innovation

- Technological regimes by Malerba and Orsenigo (1996 and 1997)
 - Technological opportunity
 - ▶ Reflects likelihood of important technological innovations
 - Appropriability conditions
 - ▶ Possibilities of protecting innovations from imitation and obtaining profits
 - ▶ E.g., patents, secrecy
 - Degree of cumulativeness of technological knowledge
 - ▶ Properties that today's innovations lead to future innovations
 - ▶ Knowledge/cognitive factors, organizational or market factors
 - Technological knowledge base
 - ▶ Nature of knowledge underpinning firms' innovative activities
 - ▶ Degree of specificity, tacitness, complementarity, independence

Previous Literature on Sectoral Differences in Innovation

• Scherer et al. (1982)

- Net sources of R&D for other sectors
 - ▶ E.g., Computers and instruments
- Net users of technology
 - ▶ E.g., Textiles and metallurgy

• Robson et al. (1988)

- Core sectors: net sources of technology
 - ▶ E.g., Electronics, machinery, chemicals
- Secondary sectors: secondary role in terms of sources of innovation for economy
 - ▶ E.g., Textiles and metallurgy
- User sectors: services mainly absorb technology

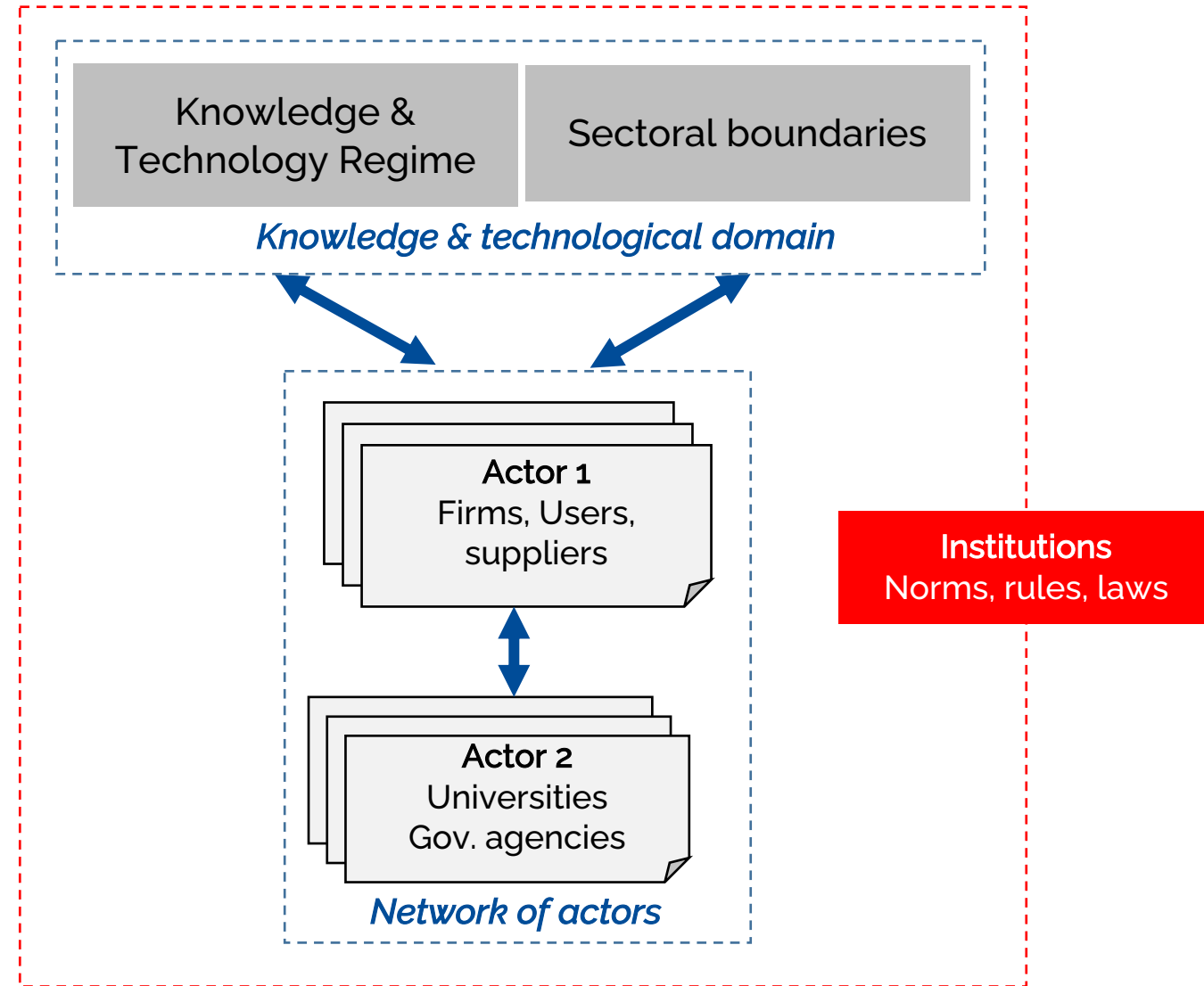
Previous Literature on Sectoral Differences in Innovation

- Pavitt et al. (1984) propose four types of sectoral pattern for innovative activities

Sectors	Example	Innovation focus	Source of innovation	Appropriability
Supplier-dominated	<ul style="list-style-type: none"> • Textile • Services 	<ul style="list-style-type: none"> • New components • Equipments 	<ul style="list-style-type: none"> • Learning-by-doing • Learning by-using 	
Scale-intensive	<ul style="list-style-type: none"> • Autos • Steel 	<ul style="list-style-type: none"> • Process 	<ul style="list-style-type: none"> • Internal R&D • learning-by-doing • external equipment producers 	<ul style="list-style-type: none"> • Secrecy • Patents
Specialized suppliers	<ul style="list-style-type: none"> • Equipment producers 	<ul style="list-style-type: none"> • Performance improvement • Reliability • Customization 	<ul style="list-style-type: none"> • Tacit knowledge • Experience of skilled technicians • User-producer interaction 	<ul style="list-style-type: none"> • Localized and interactive nature of knowledge
Science-based	<ul style="list-style-type: none"> • Pharmaceuticals • Electronics 	<ul style="list-style-type: none"> • High rate of product and process innovations 	<ul style="list-style-type: none"> • Science • Internal R&D • Scientific research at universities & public research lab 	<ul style="list-style-type: none"> • Patents • Lead-times • Learning curves • Secrecy

Sectoral System Framework

- Propose dynamic view of innovation in sectors
- Three dimensions of sectors
 - Knowledge and technological domain
 - Actors and networks
 - Institutions



Sectoral system undergoes processes of change and transformation through coevolution of its elements

Knowledge and Technological Domain

Knowledge &
Technological Regime

- **Degrees of accessibility**
 - Opportunities of gaining knowledge
 - Scientific breakthroughs in universities
 - Advancements in R&D, equipment, instrumentation
 - Suppliers or users
- **Cumulativeness: generation of new knowledge based on current knowledge**
 - Learning process and generate new knowledge
 - Firms and its organizational capabilities
 - Feedbacks from markets

Sectoral boundaries

- **Affected by knowledge base and technologies**
- **May change rapidly over time due to**
 - Dynamic processes related to transformation of knowledge
 - Evolution and convergence in demand
 - Changes in competition and learning by firms

Actors, Relationships and Networks

• Propose dynamic view of innovation in sectors

- Generate, adopt and use new technologies
- Have specific knowledge base, experience, learning process



interact



Non-firm organizations

- Support innovation, technological diffusion
- Role differs among sectoral systems

- Universities
- Financial orgs
- Gov. agencies
- Local authorities

*Demand from various actors
drives innovation, and
boundaries of sectoral
system*



Emergence of new
actors over time based
on industry life-cycle

*Venture capital companies for
start-ups in new high-tech
sectors*

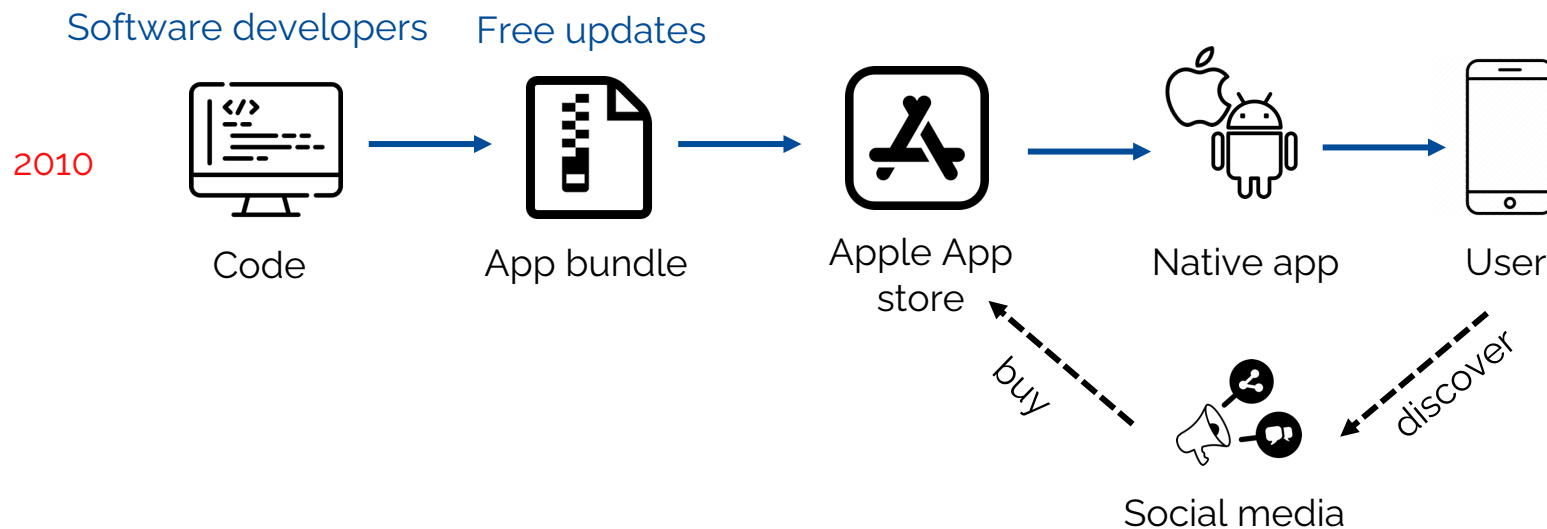
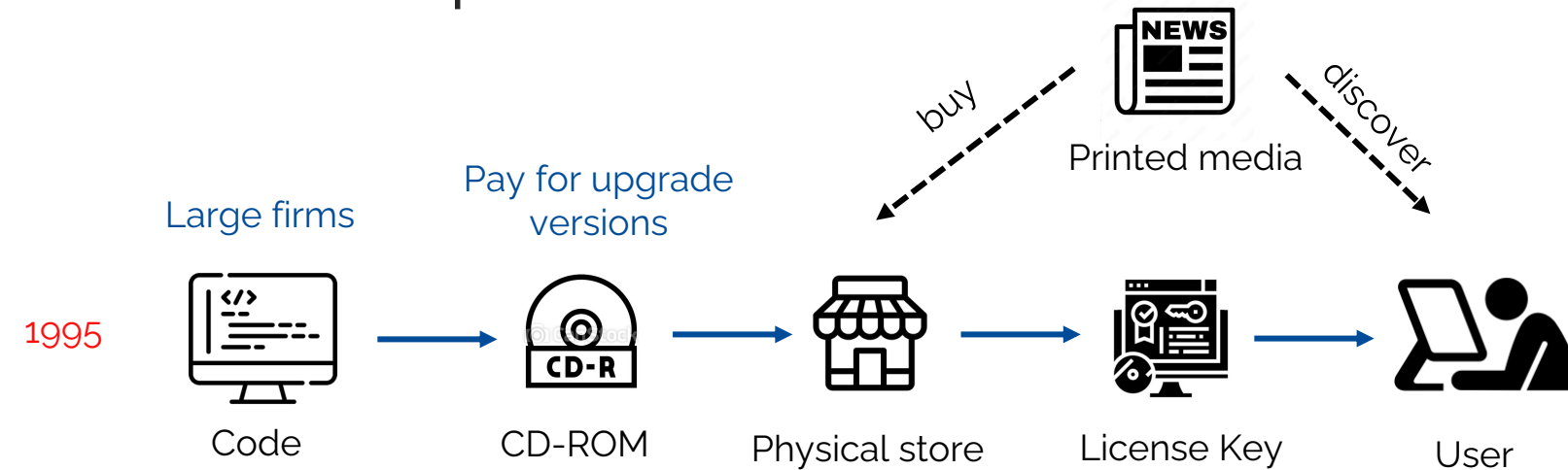
Types and structures of relationships and networks different greatly in sectoral systems, based on knowledge base, learning processing, basic of technologies, characteristics of demand.

Institutions

- Affect the rate of technological change, organization of innovative activity and performance
 - Emerge as result of planned decision by firms or unpredicted consequences of agents' interaction
 - National institutions have different effects on sectors
 - ▶ **Pharmaceuticals:** National health systems and regulations have played major role in affecting the direction of technological change
 - Institutional Review Board (IRB) review and approval of research involving FDA-regulated product
 - ▶ **Software:** standards, and standard organizations are important,
 - International Organization for Standardization (ISO) for *System and Software Quality Requirements*

Dynamics and Transformation of Sectoral System

Transformation process in software sector



- Changes in knowledge base
- Technologies
- Market competition
- Market structure
- Behavior transformations
- Actors & relationships

Policy Implications

- Understanding following dimensions is a prerequisite for any policy addressed in specific sectors
 - Knowledge and boundaries, Heterogeneity of actors and networks, Institutions and transformation
- For fostering innovation and diffusion in a sector, technology and innovation policies may not be enough
 - Supplemented by science policy, industrial policy, policies related to standards and IPR, etc.
- Policy has to consider coexistence of different geographical dimensions of sectoral systems
- Sectoral perspective provides a tool for policy makers to
 - understand the differences in innovation systems
 - identify specific actors that should be influenced by policy

Conclusion

- Sectoral framework provides a way to examine innovation in sectors through different dimensions
- Challenges
 - Geographical boundaries to be considered in analyses of sectoral systems
 - ▶ Sectoral systems are highly localized and define specialization of local areas
 - Differences across countries have affected countries international performance.
 - ▶ Cannot mimic the features of sectoral systems without appropriate set of actors, links and institutions
- Future Work
 - Coevolution of various elements of a sectoral system
 - Analyses of relationship between presence and strength of elements of sectoral systems and international performance of countries to be developed

Thank You.

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