Economic Development, Catching up and Sectoral Systems

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GLOBELICS ACADEMY
May 2011
THIS LECTURE

- Economic development and catching up
- The relevance of the sectoral dimension
- The learning environment: technological regimes
- Sectoral systems of innovation and production
- Catching up in different sectoral systems
Catching up, lagging behind and forging ahead

The macro view

The meso and micro view: the growth of local knowledge and the changing productive and innovative structure of the economy.

Catching up does not mean imitation or cloning. Catching up means a process through which emerging countries learn and accumulate knowledge, and develop products, processes and technologies that may differ more or less from the ones of advanced countries.

The focus on learning and knowledge implies the possibility of different trajectories of knowledge accumulation, innovation and production specialization with respect to the leading countries.
FOCUS ON MESO AND MICRO

The focus on meso and micro implies that catching up:

- may take place in industries that can be different from country to country and that may change in importance over time

- means that the learning processes and the factors that affect the catching up may greatly differ from one industry to another
Why sectoral innovation systems?

1. Innovation in sectors is the result of different learning processes, of the use of different knowledge and of the interaction of different actors

2. Major differences across sectors exist

What do we know about these issues?
IN ORDER TO EXAMINE CATCHING UP IN INDUSTRIES

- I will considered industries as systems
- In doing that I will create a link between evolutionary theory (focus on learning, capabilities and heterogeneity) and the innovation system perspective (focus on interactive learning among different actors)
The learning and knowledge environment that affect innovation differs across sectors
FROM CONCEPTS AND THEORIZING TO MEASUREMENTS AND ECONOMETRICS

F. Malerba L. Orsenigo  Industrial and corporate change 1997

S. Breschi F. Malerba L. Orsenigo  Economic Journal  2000

Castellacci F. Technological regimes and sectoral differences in productivity growth  Industrial and Corporate Change 2007
TECHNOLOGICAL REGIMES

- Opportunities (scientific and technological)
  - Level
  - Sources (R&D, universities, research institutes, ...)
- Appropriability of innovations
  - Level
    - Instruments (patents, secrecy, ...)
  Incentive vs efficiency effect
- Cumulativeness of technical advance
- Cognitive base underpinning innovative activity in a sector
  Nature of knowledge: some simple distinction
    - Complex / Simple
      - Tacit / Codified
    - Independent / Part of a system

Malerba and Orsenigo, ICC 1997
Breschi, Malerba and Orsenigo, EJ 2000
THE RELATIONSHIP BETWEEN TECHNOLOGICAL REGIMES AND SCHUMPETERIAN PATTERNS

BASIC RELATIONS from Malerba and Orsenigo (1997) and from Breschi, Malerba and Orsenigo (2000)

\[ \text{CONC} = f(\text{OPP, APP, CUM, Kbasic, Kapplied}) \]

\[ \text{STAB} = f(\text{APP, CUM}) \]

\[ \text{ENTRY} = f(\text{OPP, CUM, KBA, KAP}) \]
The Effects of Technological Regime and Market Structure on SCHUMP

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>(1) OLS†</th>
<th>(2) OLS†</th>
<th>(3) Logit‡</th>
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<td>Intercept</td>
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<td>(4.432)</td>
<td>(1.995)</td>
<td>(2.891)</td>
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<td>APPROPIABILITY</td>
<td>0.058***</td>
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<td>0.153***</td>
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<td></td>
<td>(5.703)</td>
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<td>(4.899)</td>
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<td>CUMULAT</td>
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<td>0.095***</td>
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<td>0.181**</td>
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<td>(3.243)</td>
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<td>(2.183)</td>
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<td>OPPORTUNITY</td>
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<td>(-2.292)</td>
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<td>(-1.377)</td>
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<tr>
<td>DUKingdom</td>
<td>0.093</td>
<td>0.074</td>
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<td>-0.139</td>
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<td>(0.860)</td>
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<td>Adj. R²</td>
<td>0.120</td>
<td>0.072</td>
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<td></td>
<td>10.88***</td>
<td>6.69***</td>
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<td>χ²(6)</td>
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<td>39.19***</td>
<td>19.14***</td>
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Notes: † Heteroskedasticity-robust t values in parentheses;
‡ Heteroskedasticity-robust asymptotic t values in parentheses.
* Significant at 0.10 level.
** Significant at 0.05 level.
*** Significant at 0.01 level.
TECHNOLOGICAL REGIMES AND DIFFERENCES IN PRODUCTIVITY GROWTH

- Technological regimes (APP, OPP, CUM)
- External sources of opportunities (cooperation, users, science and suppliers)
- Industry specific characteristics
  - Skills and training
  - Openness
  - Market size
- Country specific factors

Castellacci, ICC 2007
Table 3  Results of econometric estimation

<table>
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<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
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<tbody>
<tr>
<td>APPROPR</td>
<td>0.089 (2.11)**</td>
<td>0.074 (1.90)*</td>
<td>0.075 (1.95)*</td>
<td>0.077 (2.04)**</td>
<td>0.067 (2.04)**</td>
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<td>CUMUL</td>
<td>0.048 (1.90)*</td>
<td>0.025 (0.77)</td>
<td>0.001 (0.04)</td>
<td>-0.002 (0.07)</td>
<td>0.010 (0.30)</td>
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<td>OPPORT</td>
<td>0.290 (1.71)*</td>
<td>0.660 (1.52)</td>
<td>0.963 (1.95)*</td>
<td>0.901 (1.96)*</td>
<td>-0.013 (0.02)</td>
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<td>COOP</td>
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<td>0.014 (0.31)</td>
<td>0.008 (0.20)</td>
<td>0.018 (0.45)</td>
<td>-0.041 (0.93)</td>
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<tr>
<td>COOP-OPPORT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.013 (1.43)</td>
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<td>SKILLS</td>
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<td>0.083 (3.28)**</td>
<td>0.084 (3.70)**</td>
<td>0.082 (3.65)**</td>
<td>0.079 (3.64)**</td>
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<td>TRAIN</td>
<td>-</td>
<td>0.057 (1.98)**</td>
<td>0.047 (1.68)*</td>
<td>0.058 (2.15)**</td>
<td>0.058 (2.23)**</td>
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<td>TRAIN-OPPORT</td>
<td>-</td>
<td>-</td>
<td>-0.011 (1.31)</td>
<td>-0.010 (1.37)</td>
<td>0.013 (1.70)*</td>
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<tr>
<td>EXP</td>
<td>-</td>
<td>-</td>
<td>0.636 (2.18)**</td>
<td>0.634 (2.33)**</td>
<td>0.071 (1.94)*</td>
</tr>
<tr>
<td>EXP-OPPORT</td>
<td>-</td>
<td>-</td>
<td>0.219 (1.65)*</td>
<td>0.209 (1.78)*</td>
<td>-0.084 (1.01)</td>
</tr>
<tr>
<td>MARKETSIZE</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.253 (2.11)**</td>
<td>0.239 (2.14)**</td>
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<td>MARKETSIZE-OPPORT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.047 (1.42)</td>
<td>0.040 (1.32)</td>
</tr>
</tbody>
</table>

Country dummies: Yes, Yes, Yes, Yes, Yes

$R^2$ 0.474 0.550 0.600 0.615 0.631

N 175 156 146 146 146

Base results
Heteroskedasticity-robust $t$-values in parentheses.
***Significance at 1% level; **Significance at 5% level; *Significance at 10% level.
The differences in the innovation and production systems across sectors: sectoral systems
SECTORAL SYSTEMS OF INNOVATION AND PRODUCTION

Innovation and production take place in sectoral systems that are characterized by:

- a knowledge base
- firms
- other actors relevant for generating or supporting learning and innovation in a sector such as suppliers, users, universities, public research organizations, the government, financial organizations;
- links and networks among the different actors;
- institutions;
- processes of interaction, cooperation, and selection

Major differences exist among sectoral systems
A sectoral system approach for the study of innovation in sectors:

- Is not a straight jacket, but broad, flexible and adaptable: it points to a system view of sectors, key variables and fundamental relationships
- It has a link with theory
- It enables quantitative analyses
- It allows for different levels of aggregation, depending on the purpose of the analysis
- It allows for comparative analysis across industries and across countries
- It provides a framework for policy
SECTORAL SYSTEMS OF INNOVATION
IN THE UNITES STATES AND EUROPE

F. Malerba  Sectoral systems of innovation Cambridge University Press 2004

F. Malerba Sectoral systems of innovation and production Research Policy 2002

SECTORAL SYSTEMS
AND ECONOMIC DEVELOPMENT

- F. Malerba and S. Mani “The structure and evolution of sectoral systems in developing countries” Elgar 2009

Pharmaceuticals, telecommunications, ICT, software, aeronautics, motorcycle, salmon farming, machine tools, bio-fuels

Various countries examined.
Major insights

Understanding the specificities of the relevant sectoral system is fundamental in order to identify the source of innovation in development.

The so-called traditional sectors may have a process of major transformation and be highly innovative.

The separation of research from development and production capability can be very harmful for innovation and development.

The type of network that emerge in a sector is strongly associated with the specific knowledge base of that sector.

Vertical interdependencies and local demand may foster in some cases or impair the full development of a sector.
PROGRESS IN THE ANALYSIS OF SECTORAL SYSTEMS HAS BEEN RELEVANT BUT OFTEN HAS MAINTAINED A STATIC FLAVOUR

Progress has been made in the analysis of the main dimensions, features and structure of sectoral systems and their effects on innovation.

However this analysis often has been static, mainly centred on the actors, linkages and attributes and not on the evolution of the system.

There is a major need to move to the dynamics.

The broad theme of catching up in industries is an attempt to focus on this aspect.
CHALLENGE FOR RESEARCH - 1

EXPAND OUR KNOWLEDGE TO ECONOMIC DEVELOPMENT AND TO SECTORS OTHER THAN MANUFACTURING

The specificity of sectors in economic development

Services

Traditional or low tech sectors

CHALLENGE 2

DEVELOP TAXONOMIES OF SECTORAL SYSTEMS
CHALLENGE 3

UNDERSTAND THE DYNAMICS AND EVOLUTION OF SECTORAL SYSTEMS IN THE PROCESS OF ECONOMIC DEVELOPMENT

Are there unique paths of sectoral trajectories and organizations? Or not?

Understanding the emergence of new sectors, the transformation of sectors, the trajectories of a sector, lock-ins, development blocks, self reinforcing mechanisms in sectors

Examine the specific co-evolutionary processes at the base of change and growth in sectors

CHALLENGE 4

PROGRESS ALONG COMPLEMENTARY METHODOLOGICAL TRAJECTORIES THAT FEED ONE WITH THE OTHER

1. Case studies on actors, structure and evolution of sectoral systems
2. Appreciative theorizing
3. Quantitative-econometric analyses
4. Modelling

Link 1-2-3-4 together!
CATCHING UP IN SIX SECTORAL SYSTEMS

A project coordinated by F. Malerba and R. Nelson
Forthcoming as a book by Elgar

The “PASTAS” Project

**Pharmaceuticals**: India and Brazil  
*S. Ramani* and *S. Guennif*

**Agro-food**: China, Brazil, Nigeria and Costa Rica  
*S. Gu*, *J. Adeoti*, *A. Castro*, *J. Orozco*

**Software**: India, Brazil, Russia, Philippines...  
*G. Niosi*, *S. Athreye*, *T. Tschang*

**Telecommunications**: Korea, China, Brazil  
*K. Lee*, *S. Mani*, *Q. Mu*

**Auto**: Korea, China, Brazil  
*R. Quadros*, *Y. Huyn*, *Y. Wang*

**Semiconductors**: Korea, China, Malaysia  
*R. Rasiah*, *X. Kong*, *Y. Lin*
THE PASTAS PROJECT

- Motivation: understanding factors affecting learning by firms and catching up in a sector across different countries
- Analysis of several sectors and of the commonalities and differences
- Historical and descriptive analysis and appreciative theorizing

Methodology: each sectoral analysis is conducted together by various authors knowledgeable of the sector and of different countries

Aim: to develop an integrated dynamic comparative view of catching up in a sector that takes into account the sectoral specificities but also the institutional differences related to the national institutional frameworks.
COMMON FACTORS ACROSS SECTORS AFFECTING POSITIVELY CATCH UP

1. Accumulation of domestic capabilities

2. Access to foreign knowledge and international links

3. Development of advanced human capital

4. Active government policy

In successful countries, these factors work together in a dynamic complementary way: learning and capability building, knowledge access, advanced human capital
SECTOR-SPECIFIC FACTORS (1)

a) INDUSTRIAL STRUCTURE

- Scale and large size vs entry of new small firms
- Presence of local clusters
- Role of multinational corporations (global value chains vs licences to local firms vs competent local branches)

These differences are the result of the working of

- different technological regimes, of different scale, scope and modularity of production and of different demand
- dynamic elements such as industry life cycle and the time of catch-up
b) DEMAND CONDITIONS:
- Different role of exports, domestic demand, demand segmentation and user-producer links.
- Often a dynamic relationship between demand and economic performance has been present.

c) OTHER SECTORAL SYSTEM ELEMENTS
- Universities and public research organizations (pharma and telecom).
- Finance: venture capital vs internal finance (software vs telecom and auto).
- Diversity in the types of government policy (relevant in telecom vs software vs pharma), with different dynamic effects over the short run and the long run.
AGAIN, THESE FACTORS ACT TOGETHER IN COMPLEMENTARY WAYS

SOFTWARE: entrepreneurship, local clusters, links with customers

TELECOM: large firms, active government support for domestic firms R&D

SEMICOND: entrepreneurship, specialization

PHARMA: university research, relaxation of IPR

AGRO-FOOD: development of market institutions, diffusion policies, development of a knowledge infrastructure
A KEY ISSUE:
THE ROLE OF THE NATIONAL INNOVATION SYSTEMS

The role of national systems in terms of national institutions and government policy has been significant across sectors.

For example: government policy in Korea has supported learning and capability accumulation by large firms, in Taiwan new small firms and in Brazil has been favorable to multinationals.

This has affected also the sectors of a country catching up.

There has been a two-way dynamic relationship between national and sectoral variables: national policies have affected specific sectors that in turn have pushed for specific national policies.
IN CONCLUSION

For catch up “One size does not fit all”.

The same “learning/knowledge/industrial structure/ innovation/ institutions/dynamics” link does not fit all sectors in the same way.

Diversity is relevant across SECTORS.

Major DIFFERENCES exist across sectors in the learning processes, knowledge accumulation, structure, dynamics and transformation.
The sectoral dimension mediates between the MICRO analysis of learning and knowledge within firms and by firms and the MACRO relationship between knowledge and economic growth.

Sectors affect the MICRO dimension of firms learning and capability accumulation because of sectors’ specific knowledge base, structure and institutional context and the MACRO analysis of knowledge and economic growth in terms of the changing structural base of knowledge accumulation.
THE WAY AHEAD

This is just the beginning of a more systematic analysis of the dynamics of sectoral systems, catch up and industry evolution.

Future work has to systematically develop empirical evidence, build taxonomies, do quantitative analyses and develop empirically-grounded models in a complementary and interactive way.
AUTO
R. Quadros Y. Huyn Y. Wang

SECTORAL SYSTEM

Scale is critical
Local manufacturing (but not necessarily by domestic firms)
De-maturation of product-process technologies
Vertical links and the role of supplier networks (local vs MNC)
Modularization and outsourcing
Platforms for product innovation
Key role of MNCs;
Learning through licencing and joint ventures
Local demand vs export
CASES: KOREA, CHINA AND BRAZIL

Different trajectories

**KOREA:** Independent model development
  - National champions and exports

**CHINA:** Adaptation, reverse engineering and new models;
  - JV and Chinese brands; Growing domestic market

**BRAZIL:** Local development of new models by local MNCs
  - Component suppliers are also MNCs; increasing R&D and skills (engineers) in product development; increasing design and development of entire new cars, not necessarily only for emerging countries
PHARMACEUTICALS
Shyama Ramani and Samira Guennif

SECTORAL SYSTEM
Drugs, vaccines and diagnostics. Active pharmaceutical ingredients, bulk drugs and formulation
Key role of MNCs
Internal vs international demand
The increasing role of science
IPR and TRIPS and the re-engineering use of Western innovations.
Different health care systems
PHARMACEUTICALS (2)

THE CASES OF INDIA AND BRAZIL

INDIA: process patents for a number of years, but no product patents. Cost reducing innovations. Research by the public sector affected private firms. Increasing competitiveness of domestic firms. TRIPS did not have a major effect on domestic capabilities, but on the access to medicine.

BRAZIL: it did not have IPR for many years. Persisting culture of investing in product differentiation and not of innovation. Dependence on foreign MNC. Active public sector in research and technology development, and links to public firms. “Generic Act” strengthened local firms in generics.
TELECOMMUNICATION EQUIPMENT INDUSTRY

Keun Lee     Sunil Mani      Q Mu

SECTORAL SYSTEM

From digital switches
Integration between R&D and production
Role of government research institutes
Access to foreign knowledge base
Domestic demand

To mobile telecommunications
The transition process: barriers to latecomers
TELECOMMUNICATION EQUIPMENT INDUSTRY (2)

CASES

KOREA AND CHINA: success in capability building and in transition to mobile telecom

BRAZIL: dominance by MNC
role of Public research lab in the fixed telecom era
lack of competences by Brazilian companies in mobile phones
SEMICONDUCTORS

R. Rasiah     X. Kong     Y. Lin

SECTORAL SYSTEM

Vertical links with software and process machinery

Various types of products and specialization: integrated companies, foundries or fabless. Back end vs front end. Therefore different types of capabilities and trajectories

Active role of the government: attraction of MNC and in the same time development of domestic capabilities

Role of export markets

Various types of outsourcing and role of MNC

IPR has not blocked the emergence of new activities in developing countries
SEMICONDUCTORS (2)

CASES

CHINA: upgrading to wafer fabrication and R&D
market protection and promotion of domestic capabilities

TAIWAN: upgrading to wafer fabrication and R&D
ASICs and DRAMs
networks and mobility of skilled people

MALAYSIA: always assembly and testing – attraction for MNC
COMPUTER SOFTWARE

George Niosi     Suma Athreye     Ted Tschang

SECTORAL SYSTEM

Upstream and downstream linkages with applications
Different products and trajectories: embedded software, business processing outsourcing (BPO) and information technology enabled services (ITES)
Outsourcing
Human capital and training
Limited role of government policies
A VARIETY OF DIFFERENT CASES

Established off-shoring countries: INDIA, IRELAND AND ISRAEL and their capability development (broadening and deepening)

New off-shoring countries: CHINA, RUSSIA, BRAZIL and PHILIPPINES
AGRO FOOD

Shulin Gu   John Adeoti   Ana Castro   Jeff Orozco

From passive to dynamic role in economic development

SECTORAL SYSTEM

Role of GPT and process technologies, technologies for quality control and distribution, and for food processing
Small farms vs large scale farms
Distribution and international channels
Government policy, public R&D and institutional changes
Export oriented crops: coffee – COSTA RICA; Soybean – BRAZIL;

Domestic consumption: Vegetables–CHINA; Cassava–NIGERIA