# Economics and Policy of Innovation

## Academic year 2015/2016

Lecture 5: March 7th, 2016

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# Change in timetable

As communicated on Moodle:

- Tomorrow 8th of March: my tutoring hours will be 14:30-16:30
- Tuesday 15th of March: no tutoring of mine

Additional information:

- **Lecture on the 16th of March is cancelled!**
- Lectures on the 9th and 14th of March will be held by Prof Torbianelli

# Innovation Processes
# [part II]

(Chapter 4)

# Let’s recall some concepts

- Innovation process
- Vs. Process innovation
- Vs. Product innovation
- Technological routines
- Path dependency and technological lock-in

# The innovative firm in the evolutionary theory

Main concepts:

- Technological learning and routines
- Path dependence and technological lock-in
- **Absorptive Capacity**
- **Technological paradigms and trajectories**

# Absorptive Capacity

The concept of **Absorptive Capacity** (AC) has been put forward by Cohen and Levinthal (1989 and 1990) → usually measured with the level of R&D.

One of the reasons to invest in R&D is to develop firms' ability to evaluate and exploit knowledge generated somewhere else (e.g. by competitors, providers, or extra-industry sources).

AC is needed for acquiring, adapting/improving imported technology (e.g. ***reverse engineering***).

# Absorptive Capacity (2)

"Imitation" (as we have seen) has been considered a key factor for the technological catching-up process of countries like Japan (after World War II, see chapter 2.5) or China (more recently).

However, if the distance between top countries (e.g. the US) and these catching-up countries is too big, no real imitation is possible.

# Absorptive Capacity (3)

In fact, the catching-up subject (country or firm) needs internal capabilities to "understand" what has been done by the leader subject; and to "absorb" this knowledge generated outside.

Therefore, a firm R&D not only generates new information, but also enhances the firm ability to identify, assimilate and exploit knowledge from the environment (absorptive or learning capacity).

# Absorptive Capacity (4)

The firm's R&D division has an important monitoring function: in order to understand the potential relevance of knowledge generated outside the firm, it is necessary to already be actively engaged in a related research programme.

The motive behind R&D is that what a firm sees in its environment, and thereby the opportunities it is able to exploit, is conditional on its existing capability, the problems it is currently trying to resolve and the opportunities it is already aware of.

# Absorptive Capacity (5)

Thus, the difficulty of appropriating a full return on a particular item of knowledge is not normally of overriding concern to a firm.

The firm's R&D contributes to its ability to learn.

The more technologically competent firm is also better able to gather relevant knowledge from its environment and to use it in productive applications that are not well understood or not perceived so quickly by lesser able competitors.

# Technological paradigms and trajectories

- A **technological paradigm** has been defined (Dosi, 1982) as a "model and a pattern of solution of selected technological problems, based on selected principles derived from natural sciences and on selected material technologies".
- A **technological trajectory** is the pattern of "normal" problem solving activity on the ground of a technological paradigm.

"The identification of a technological paradigm relates to generic tasks to which it is applied (e.g, amplifying and switching electrical signals), to the material technology it selects (e.g. semiconductors), to the physical/chemical properties it exploits (e.g. the "transistor effect"), to the economic dimensions it focuses upon".

Dosi has drawn on work in the philosophy of science to argue for the existence of technological ‘paradigms’, representing **broad fields** understood to be effective for progress

**e.g. Newton vs Einstein in physics**

In his view, ‘Trajectories’ were the specific outcomes of applying paradigms to immediate circumstances

- but this meant confronting with the economic and social context
- importance of economic factors, social/ political (‘social shaping of technology’), actor networks

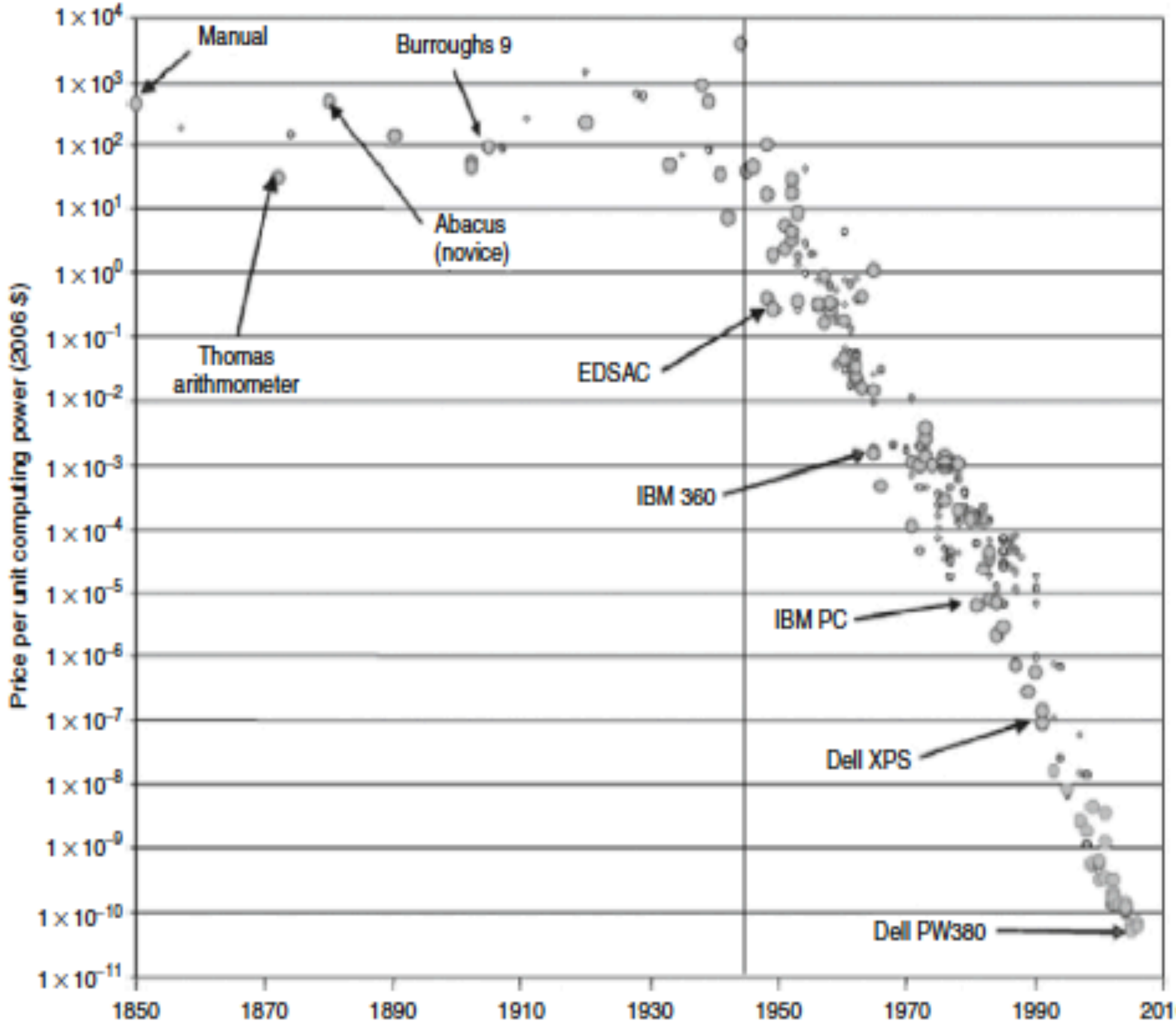
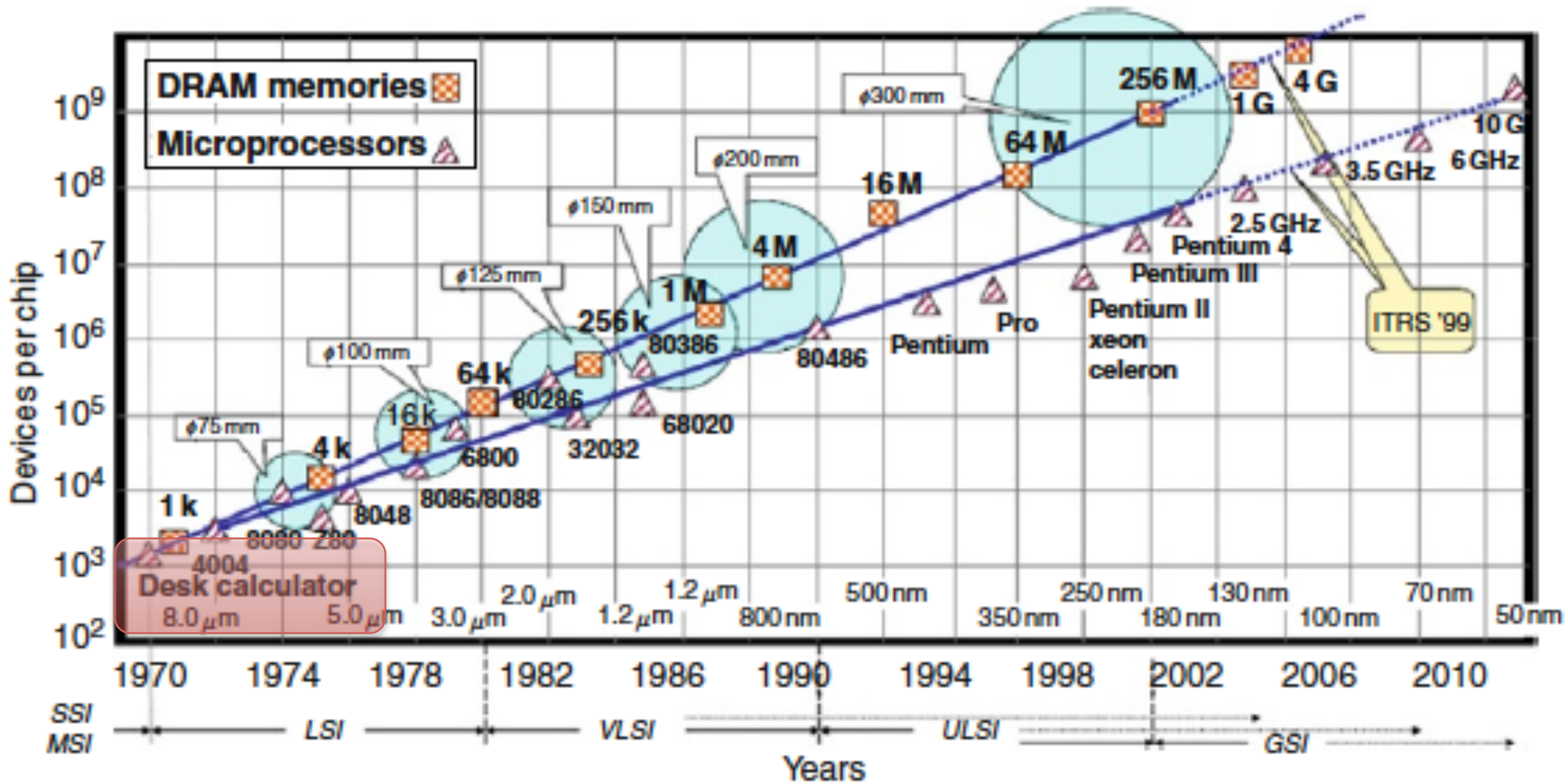



Figure 1. The progress of computing measured in cost per computation per second deflated by the price index for GDP in 2006 prices. Source: Nordhaus (2007).



DRAM memories
Microprocessors
Devices per chip
$10^2$
$10^3$
$10^4$
$10^5$
$10^6$
$10^7$
$10^8$
$10^9$
1 k
4 k
16 k
64 k
256 k
1 M
4 M
16 M
64 M
256 M
1 G
4 G
4004
8080
Z80
8048
8086/8088
6800
80286
32032
68020
80386
80486
Pentium
Pro
Pentium II
xeon
celeron
Pentium III
Pentium 4
2.5 GHz
3.5 GHz
6 GHz
10 G
ITRS '99
ϕ75 mm
ϕ100 mm
ϕ125 mm
ϕ150 mm
ϕ200 mm
ϕ300 mm
Desk calculator
8.0 μm
5.0 μm
3.0 μm
2.0 μm
1.2 μm
1.2 μm
800 nm
500 nm
350 nm
250 nm
180 nm
130 nm
100 nm
70 nm
50 nm
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
SSI
MSI
LSI
VLSI
ULSI
GSI
Years

To avoid technological determinism and to confront actual economic circumstances, Freeman & Perez extended the notion of technological paradigms to **techno-economic paradigms**.

Each wave of radical innovations requires radical changes not just in the technologies but in the wider economic, social, organizational and political system, including:

- new technological regimes
- new product mixes
- new forms of organization and management
- new infrastructure
- changes in education and training
- changes in intellectual property regimes (appropriability)
- 'creative destruction' - changes in innovation leadership of firms and countries

| *Technical and organizational innovations* | *Dates* | *Key inputs* | *Managerial and organizational changes* | *'Carrier' industries* |
|---|---|---|---|---|
| Water-powered mechanization of industry | 1780s-1848 | Iron, raw cotton, coal | Factories, entrepreneurs, partnerships | Cotton spinning, iron products, bleach |
| Steam-powered mechanization of industry and transport | 1848-1895 | Iron, coal | Joint-stock companies, subcontracting | Railways, machine tools, alkalis |
| Electrification of industry, transport and the home | 1895-1940 | Steel, copper, alloys | Professional management, Taylorism, giant firms | Electrical equipment, heavy engineering, heavy chemicals |
| Motorization of transport, civil economy and war | 1941-?? | Oil, gas, synthetics | Mass production, Fordism, hierarchies | Automobiles, aircraft, refineries |
| Computerization of entire economy | ?? - ?? | Integrated circuits | Networks | Computers, telecoms, biotechnology |

# Firm selection and industry evolution

Predictions on the likelihood of survival and growth rates of surviving new firms:

- Lower survival of new firms in industries with large scale economies, but higher growth of surviving firms
- Higher survival of larger firms, but lower growth rates
- Both firm growth and the likelihood of survival greater in high-growing sectors
- Lower survival of new firms under the entrepreneurial regime, but higher growth of surviving firms

However, as firms gain experience in the market, they learn: learning process and capabilities as persistent source of **heterogeneity**

# Heterogeneity

All the differences we have seen (e.g. in terms of AC or technological trajectories, as well as in the evolution of industries/sectors) confirm the **heterogeneity** of innovation processes.

In chapter 4.3.4, Pavitt relates heterogeneity to:

- Path dependency;
- Specialisation in specific fields of knowledge;
- Firm size.

# Dimensions of technological regimes

- A technological regime is a particular combination of appropriability conditions, opportunities, degree of cumulativeness of technological knowledge and characteristic of the knowledge base
- These variables explain the patterns of innovation across technologies and industries
  - Low cumulativeness and appropriability, high importance of applied science ➔ Schumpeter mark I
  - High cumulativeness and appropriability, high importance of basic science ➔ Schumpeter mark II

# Firm selection and technological regimes

Linking technological regimes to start-up and selection

- Entrepreneurial regime ***(remember Schumpeter Mark I)***:

  - new firm start-ups play an important role; small firms account for the bulk of innovative activity

  - frequent innovation associated with higher uncertainty on technology and demand: likelihood to be able to survive decreases

  - new entrants have greater likelihood of innovating and are less likely to decide to exit

- Routinized regime ***(remember Schumpeter Mark II)***:

  - large incumbents account for most of the innovative activity; low propensity to new firms to be started

  - innovative advantage of incumbents tends to increase the propensity to exit the market for new entrants

# Multi-technology (4.4.3)

In reality, firms are no more bound to a single technology of field of knowledge. Because:

- A large firm can be a multi-technological one (even without operating in multiple sectors);
- Firms can sub-contract parts of their production process to other firms with a different technological base (and need to develop AC to assimilate it);
- The innovation process itself might require disintegration and modularisation.

# R&D / Innovation collaboration

The Innovation (or even the R&D) process can be based on collaboration among different actors. It can be "balanced" if these actors are similar, or if they have the same power, or not.

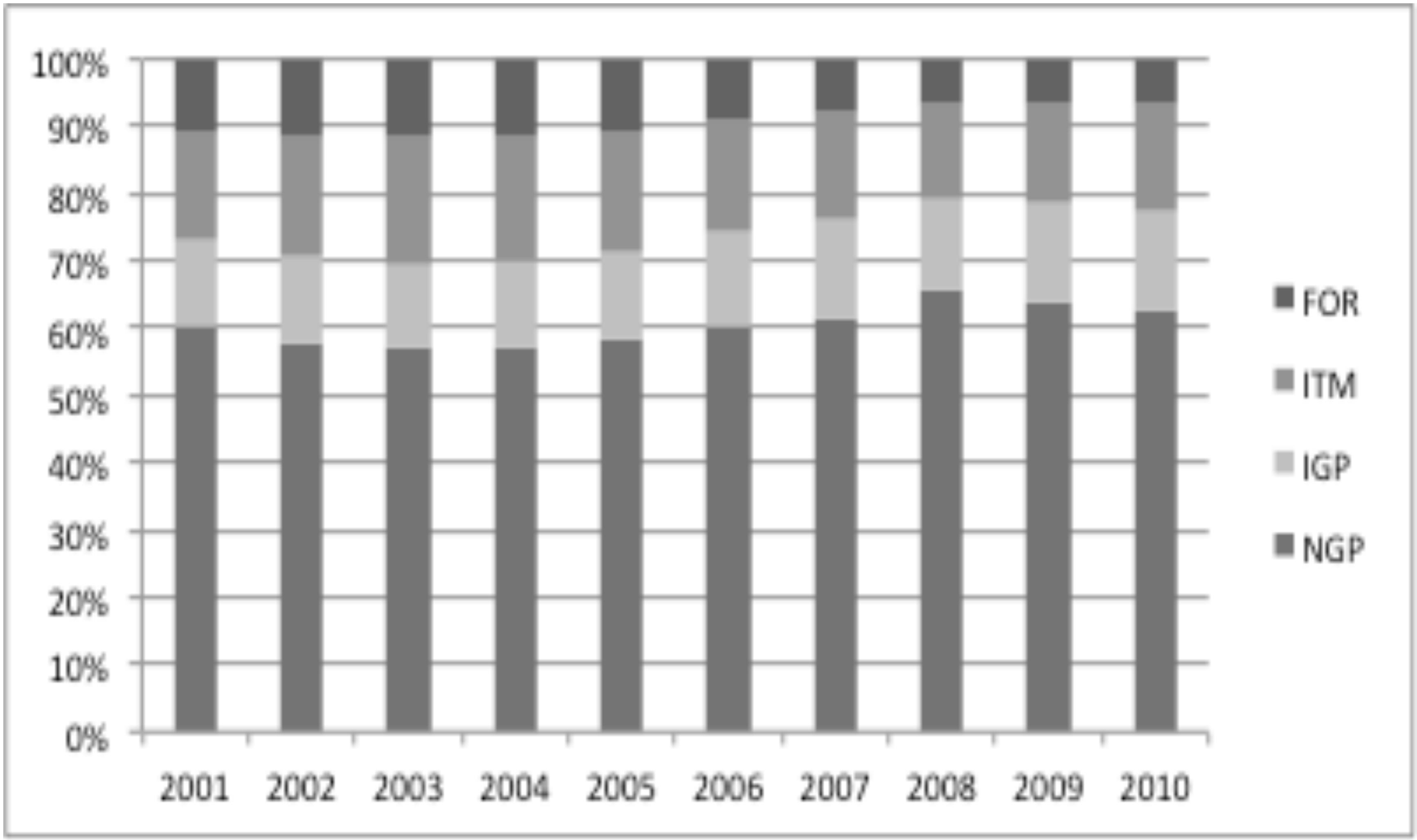
Examples:

- Inter-firm collaboration:
  - at the same level (2 large firms, 2 SMEs…)
  - At different levels (e.g. in a Value-chain logic)
- Intra-firm collaboration (e.g. Between the Parent Company and one of its subsidiaries)
- University-Industry collaboration (4.3.3)

# R&D collaboration: the Italian case

- Data coming from the Italian R&D survey (***RS1***) conducted by the Italian Bureau of Statistics (***ISTAT***)
- The survey follows a ***census approach***
- ***2001-2010*** unbalanced panel of R&D performers active in Italy
- ***13,675 firms*** performing R&D (in at least one year), ***subdivided by firm typology***: Italian Firms Not belonging to a Group (***NGP***), Italian firms belonging to a Domestic Group (***IGP***), Italian Multinationals (***ITM***), Affiliates of Foreign MNEs (***FOR***).
- Data on ***internal R&D*** and on ***R&D contracting out (Extra-muros) and technical collaborations***

# Distribution of firms



# Descriptives

| | NGP | IGP | ITM | FOR |
|---|---|---|---|---|
| Number of firms | 8,770 | 2,279 | 1,509 | 864 |
| Size (Average number of firm employees) | 87.90 | 245.30 | 837.42 | 656.56 |
| Average Intra-muros R&D expenditure per firm (in thousand euro) | 592.04 | 2,588.27 | 5,380.03 | 6,706.96 |
| Labour Productivity (in thousand euro, average 2008-2010) | 71.12 | 70.43 | 81.76 | 91.92 |
| Average Extra-muros R&D expenditure per firm (in thousand euro) | 90.64 | 704.17 | 1311.43 | 992.29 |
| Share of firms involved in R&D Cooperation | 28% | 38% | 45% | 50% |

**Table 1 – Description of main RS1 variables, by typology of firm (data on expenditure expressed in thousand Euros)**

| | | ING | IGP | FOR |
|---|---|---|---|---|
| **Number of total R&D performers** | Year 2010 | 3,775 | 1,742 | 393 |
| | *Growth rate* | ***250.6%*** | ***218.5%*** | ***140.8%*** |
| **Average size of firms (number of employees FTE)** | Year 2010 | 88.33 | 499.33 | 619.08 |
| | *Growth rate* | ***-1.6%*** | ***-4.2%*** | ***-3.6%*** |
| **Total intra-muros R&D expenditure** | Year 2010 | 2,170,501 | 6,397,387 | 2,011,355 |
| | *Growth rate* | ***12.1%*** | ***6.8%*** | ***-1.7%*** |
| **Total R&D Employees (Head Counts)** | Year 2010 | 51,941 | 82,154 | 19,263 |
| | *Growth rate* | ***13.7%*** | ***8.3%*** | ***-1.1%*** |
| **Total R&D Employees (Full Time Equivalent)** | Year 2010 | 17,267 | 44,251 | 12,953 |
| | *Growth rate* | ***4.8%*** | ***2.8%*** | ***-4.4%*** |
| **Average Intra-muros R&D expenditure per firm** | Year 2010 | 574.97 | 3,672.44 | 5,117.95 |
| | *Growth rate* | ***1.3%*** | ***-2.1%*** | ***-5.4%*** |
| **R&D / R&D employees** | Year 2010 | 41.79 | 77.87 | 104.42 |
| | *Growth rate* | ***-1.4%*** | ***-1.4%*** | ***-0.6%*** |
| **R&D / R&D employees FTE** | Year 2010 | 125.70 | 144.57 | 155.28 |
| | *Growth rate* | ***7.1%*** | ***3.9%*** | ***2.9%*** |
| **Average Extra-muros R&D expenditure per firm** | Year 2010 | 125.56 | 752.93 | 518.45 |
| | *Growth rate* | ***22.8%*** | ***10.0%*** | ***-12.2%*** |
| **Share of firms cooperating, on total firms** | Year 2010 | 29.7% | 39.8% | 42.2% |
| | *Growth rate* | ***9.7%*** | ***6.8%*** | ***1,4%*** |
| **Share of firms cooperating with university, on total firms** | Year 2010 | 12.9% | 19.1% | 16.0% |
| | *Growth rate* | ***11.2%*** | ***6.1%*** | ***-1.5%*** |

Cozza&Zanfei, *Journal of Technology Transfer*, 2015

# Summary of results (1)

- ***Intra-muros R&D*** (a proxy of "***primary absorptive capacity***") explains a large fraction of firms' propensity to collaborate, more than other measures;
- Once controlled for "primary absorptive capacity", there remains a substantial premium associated to ***group belonging*** (relative to independent firms) that might reflect networking advantages;
- The premium is higher for firms belonging to ***multinational groups*** that have relatively more extensive and richer networking → ***network based absorptive capacity***;
- Hence ***MNEs do exhibit a higher propensity to R&D collaboration*** relative to local firms, taken as a whole, and relative to firms not belonging to a group in particular.

# Summary of results (2)

However:

- *Premia* are particularly high for firms belonging ***to Italian owned multinational groups*** that are less affected by institutional and cultural barriers than foreign MNEs;
- Differentials between foreign Multinationals and independent firms are much lower in the case of knowledge ***collaboration with universities***. Considerable differences persist between Italian owned MNEs and local independent firms
- The latter results might reveal that SMEs needing to access knowledge will face lower appropriability issues when dealing with local universities, while foreign MNEs encounter greater institutional barriers.
- Hence there are difference also across MNEs → ***local MNEs better off than foreign MNEs at knowledge collaborating***.