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- EX LABORE FRUCTUS -

Economics of Science

Economics of Innovation

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Science as a quasi public good

- Competitive markets provide poor incentives for the production of a public good.
- The non-excludable nature of public goods invites free-riders and consequently makes it difficult for providers to capture the economic returns. Thus, incentives for provision are not present.
- The non-rivalrous nature of public goods means that if and when public goods are produced, the market will fail to provide them efficiently where marginal cost equals marginal revenue since the marginal cost of an additional user is zero.
- Such observations regarding the provision of public goods, however, relate to incentives that are market based.
  - An important contribution of the sociologists of science and the economists who have extended their work is the demonstration that a <u>non-market reward system has evolved in science</u> that provides incentives for scientists to produce and share their knowledge, thus behaving in socially desirable ways.

Dasgupta & David, 1994 / Merton, 1973
[*cf.* Sauermann and Stephan, 2013]

- Focus on the nature of the individuals undertaking R&D projects and on the nature of the knowledge produced by these individuals
- Two types of individuals undertaking R&D are identified
  - Scientists
  - Technologists

Priority in scientific discovery

- Sort of intellectual property right
- The scientist aims at being the first in discovering new knowledge
  - Recognition in place since centuries
- This priority gives prestige and fame to the scientist

Form of recognition

- Eponymy: link the name of the scientist to the discovery
  - Copernicus
  - Pitagora
  - Higgs boson
- Awards
  - Nobel

Mechanisms to priority recognition

- Publication
  - Main mechanism to gain recognition in scientific community
- Publishing give visibility to the work of scientists
- The higher the quality of the article, theoretically, the higher the level of visibility and recognition of the academic scientist

Compensation in science

"Rosovsky (1990) recounts how, upon becoming dean of the Faculty of Arts and Sciences at Harvard, he asked one of Harvard's most eminent scientists the source of his scientific inspiration. The reply (which "came without the slightest hesitation") was "money and flattery." (p. 242) " (Stephan 2010, p. 223)

Compensation in science (2)

- Two forms of remuneration:
  - Fixed part
  - Part linked to scientific productivity (measured mostly in terms of publications)
    - Does this quite recent approach favour or hamper the output of scientific research? 20 years debate (see Dasgupta and David, 1994; Nelson and Rosenberg, 1994; David, 1997)
- Number of publications, quality of the outlet, number of citations/impact
  - Career progress
  - Research projects and funds
  - Conferences, consultancies, research contracts, andso on

Scientific research

“Research often provides answers to unposed questions. Consequently, the risk associated with such research can be lessened by shifting goals during the course of research. Nelson (1959) argues that this strategy is more appropriate for scientists working in a nonprofit-based environment than for scientists working in the profit sector because the former can more easily capture the rewards regardless of where the research leads. On the other hand, companies having a broad technological base can benefit from research that is not directed to a specific goal. At the time General Electric developed synthetic diamonds, for example, it was the most diversified company in the United States.” (Stephan 2010, p. 233)

Scientists

- Curiosity for science and the search for prestige and fame are the main means to professional growth (Dasgupta-David 1994); priority confers this prestige (Stephan, 1996):
  - Aim of the scientist who produce new knowlegde is the maximum diffusion of this knowledge, and the main mechanims is the publication
- Incentives and returns are mostly of a non-monetary form, directly. Monetary returns appear to mostly be indirect, although present (recall Rosovsky quote)

Technologists

- Industry R&D works differently
- Priority may be important, but what is central is the profit the new knowledge can render
- Technologists don’t aim at diffusion, but at secret: the less the new knowledge get diffused the higher its advantage are appropriable by the inventor (company)
- Technologists are rewarder in relation to the profits the company gain from the new knowledge

Moreover

Arora and Gambardella, 1994:

- Academic knowledge tend to be more abstract and seek to derive comprehensive theory from specific phenomenon
- Industrial knowledge tend to be more specific and aim at creation prototypes without much consideration to scientific underlying principles
  - Produce specific applications of new knowledge

University vs Industry R&D

	Orizzonte temporale della ricerca svolta	Orientamento alla diffusione	Orientamento allo sfruttamento
Università	Principalmente di lungo termine	Alto	Basso
Imprese	Principalmente di breve termine	Basso	Alto

Fonte: Piccaluga (2001)

University vs Industry Institutional Logics differences

- Grounding on Institutional Logics theory (evolution of Neo-Institutionalism):
  - Nature of the work
  - Characteristics of the workplace
  - Characteristics of the workers
  - Disclosure of research results

- How would you characterise open source software?
  - Incentives
  - Returns
  - Characteristics of individuals participating in os

Real Effects of Academic Research

Adam Jaffe, 1989

Jaffe, 1989 - Introduction

- It is conventional wisdom that "Silicon Valley" near San Jose, California and Route 128 around Boston owe their status as centers of commercial innovation and entrepreneurship to their proximity to Stanford and MIT.
- Several other areas of the country, such as San Antonio/ Austin in Texas and Raleigh/Durham in North Carolina have tried explicitly to build new centers of high-technology industry around their universities.
- It is certainly plausible that the pool of talented graduates, the ideas generated by faculty, and the high quality libraries and other facilities of research universities facilitate the process of commercial innovation in their neighborhood, but there has been very little systematic empirical analysis of this phenomenon.

Jaffe, 1989 – Introduction (2)

- Knowledge is, after all, a public good.
  - There has been much recent interest in “spillovers” of research among firms.
- There is even more reason to believe that spillovers exist from universities to firms, since the former have less incentive to try to keep research secret.
- For none of these spillover phenomena are the “transport” mechanisms understood.
  - If the mechanism is primarily journal publications, then geographic location is probably unimportant in capturing the benefits of spillovers. If, however, the mechanism is informal conversations, then geographic proximity to the spillover source may be helpful or even necessary in capturing the spillover benefits.

Modeling spillovers from university research

- Knowledge production function *a la* Griliches:

$$\log(P_{ikt}) = \beta_{1k}\log(I_{ikt}) + \beta_{2k}\log(U_{ikt}) + \beta_{3k}[\log(U_{ikt})\log(C_{ikt})] + \epsilon_{ikt}$$

- where *i* indexes the unit of observation (states, in this case), *k* indexes technological areas, and *t* indexes time. *P* is corporate patents, a proxy for new economically useful knowledge; *I* is R&D performed by industry and *U* is university research. ϵ_{ikt} is a stochastic error whose properties will be discussed below. The variable *C* is a measure of the geographic coincidence of university and industrial research activity within the state. Allowing the potency of university spillovers to depend on *C* is intended to mitigate the arbitrariness of states as observation units.

Results and conclusions

- The analysis of state-level corporate patent activity provides some evidence of the importance of geographically mediated commercial spillovers from university research.
- The effect is statistically strongest in Drugs, slightly smaller and less significant in Chemicals, and smaller but quite significant in Electronics, etc.
- There is only weak evidence that spillovers are facilitated by geographic coincidence of universities and research labs within the state.
- It is interesting that the effect comes through more clearly within technical areas than it does in the total across areas. This suggests that the spillovers are limited to specific areas and not just the diffuse effect of a large research university.

Follow up

- The work by Jaffe is not only about academic research, it also is about geography of innovation

- Various work on the geopgraphical proximity of knowledge spillovers. For example:
  - Seminal work by Audretsch and Feldmann (1996). R&D Spillovers and the Geography of Innovation and Production» American Economic Review
  - Anselin et al., (1997). «Local Geographic Spillovers between University Research and High Technology Innovations» Journal of Urban Economics
- Various critics to this model: we will possibly explore them

Further research topics

- Agglomeration economies
- Knowledge spillovers and their geographical dimensions
- Consequences of agglomeration economies and R&D expenditure on the economic system (municipality, region, country, etc)
- …

Third mission of universities

The shifting organisation and institutionalisation of knowledge production

Gibbons et al. *The New Production of Knowledge,* 1994

- Two different modes of knowledge production can be clearly identified in history – Mode One and Mode Two;
- Mode Two is a new mode of knowledge production;
- Mode Two is becoming the dominant mode of knowledge production

Mode 1 and Mode 2 Knowledge Production

Mode 1	Mode 2	Significance of shift
Academic context	Context of application	No gap between knowledge production and application
Disciplinary	Transdisciplinary	Outputs of interactions not reducible to disciplines
Homogeneity	Heterogeneity	Proliferation of knowledge producing organisations and modes of interaction
Autonomy	Reflexivity / social accountability	Researchers more aware of the social context and potential impacts of their research
Traditional quality control (Peer review)	Novel quality control	Traditional judgements of ‘good science’ supplemented with economic, social, political criteria

Universitiy third mission

- Ratio: research results remain on shelves → if they are brought on the market, there will be a higher diffusion of innovation
- Need of an incentive: give the property of the research results (patent) to the university
- Increase rewards for universities and increased impact of the university on the economic development (through innovation)
  - After few years the only rationale remained was about the impact on economic growth

Third mission of university

- Bay Dole Act, 1980: law that shift the property of academic patent from a national office to the university
  - Enormous increase in patenting activity of universities
    - Is it all due to Bay Dole Act? NO: also biotech industry emergence and strength of patent system
- Strong policy effort toward favouring third mission activities
  - Since the ‘80s in US, ‘90s in UK, 2000 in EU

TTOs

- Emergence of Technology Transfer Offices
  - UK: early ‘90 institutionalization of already existing formal and private technology transfer offices
  - Continental Europe: creation of TTOs from 2000
    - Mostly of public ownership (of the University)
- Nowadays virtually all universities have a technology transfer office
- Other variety of policy implemented

Critical issues

- Universities evaluated on the number of patent and academic spin-offs
- Effort of universities of creating higher number of patents and of academic spin-offs
- Spin-offs poorly perform, many exit the market soon after creation
- Patent increased in numbers but probably the average quality decreased
- Imitation of policies: Continental Europe and Anglo-Saxon countries have very different context and research systems (age and specialization of universities)

A debate on this topic

- Does the conduction of third mission activities positively or negatively relate to scientific productivity?
- Do scientist engaging with industry to a higher extent publish more paper or are cited more often?

Positive factors

- Knowledge of relevant industrial problems
- Funds to for equipment and other research activities
- Networking assets building
- …

Negative factors

- Less time to dedicate to teaching
- Less time to dedicate to research

Build a small dataset

- Essentials
  - Measure of individual/university sicentific productivity output
  - Measure of individual/university engagement

- https://www.timeshighereducation.com
- https://www.topuniversities.com/university-rankings/world-university-rankings/2019
- Unfortunately there is no export/download function available here, but easily duable by hand

Explore the data:

- Relationship across universities: do universities that have higher score in industry income have also higher score in research? And in teaching?
- By time: do universities that increased their score in industry income also increased their research score? And the teaching score?
- By country: are these patterns similar between for example US and Continental Europe? And how do UK behave, closer to the US or Europe?

Drive conclusions

- Discuss the relationships/results chosen to present
- Relate the findings to the theoretical background (or to the literature review, as in this example)
- Advance policy implications if results provide