The 1st round: Multiple Modes of Knowledge Exchange
“Matching the type of scientific human capital with aim of R&D alliances”

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Layout

- Aim of presentation
- Research setting
- Trial Mark I and related research
- Trial Mark II and related research
- Suggestions for future research

Aim of Presentation

- In order to understand the nature of University-industry linkage (UIL) , the viewpoint of multimodal knowledge exchange between academia and the private sector is important.
- Most of the previous studies have relied heavily on limited kinds of data such as scientific papers, patents and licenses.
- Yes, but how can we approach the issues systematically?
- We suggest the efficacy of pairing patent and publication data approach.

Commonly observed assumption: "linear model" (of biotech innovation)

Commercializing science

↓

Knowledge transfer from academic scientists
to corporate researchers.

An indicator of the firm's knowledge capture

↓

The number of research articles written jointly by firm scientists
and discovering "star" scientists.
(Zucker and Darby 1996, 1997, 2001; Darby and Zucker 1999)

Distinctively differentiated assumption: "two way interaction" of advanced materials innovation

Commercializing science

↓

Co-evolution of science and technology:
Importance of user needs
(Meyer-Krahmer 1996, Meyer-Krahmer and Schmock 1998)

Indicator of firms' knowledge capture

↓

Bi-directional knowledge flow
Flow of tacit (scientific) knowledge from university to industry
Flow of tacit (know-how) knowledge from industry to university.

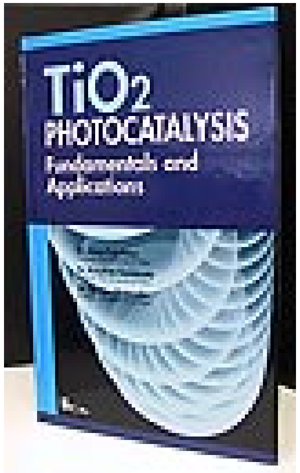
Research setting: Observation on UIL in TiO_2 photocatalyst sector

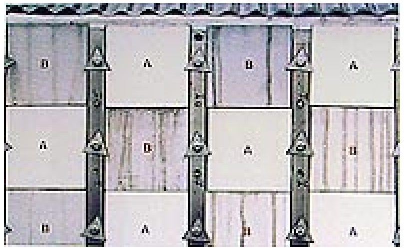
- When TiO2 absorbs UV light, very strong oxidation power is produced, decomposing most organic compounds adsorbed on its surface. Such a photo-induced reaction is called TiO2 photocatalysis (Fujishima, Rao et al. 2000).
  - TiO2-coated materials can achieve clean conditions only with sunlight and rainwater, without using any chemicals.
  - Among the commercialized applications by now: self-cleaning building materials, anti-bacterial ceramic tiles, and anti-fogging window glass (Fujishima, Hashimoto et al. 1997; Fujishima, Hashimoto et al. 2000).

Photocatalysis Applications of Titanium Dioxide Ti0$_2$

TiO2 coated tent material

TiO2 coated glass





TiO2 coated exterior tiles

TiO2 coated interior tiles

Fujishima A., Hashimoto K., Watanabe T. (1999) "*TiO2 Photocatalysis Fundaments and Applications*" BKC, Tokyo

Focal academic scientists:Fujishima and Hashimoto

- Developed in Japan from 1989, thanks to the research work of two outstanding scientists: Fujishima and Hashimoto
  - Fujishima and Hashimoto were ranked first and second in terms of the cumulative numbers of individual applications up to 2002: 119 applications for Fujishima, and 117 for Hashimoto. The number of applications for the next most highly ranked university scientist was 34.
  - Fujishima and Hashimoto have been energetically publishing both original and review papers on photocatalysis with epochal discoveries since the end of the 1960s. Among Japanese scientists, they were ranked second in terms of the cumulative numbers of publication with 191 papers, but were ranked first in terms of the cumulative number of paper citation with 3,228.


Akira Fujishima


Kazuhito Hashimoto

Trial Mark I: *the Role of "Core Researchers" (Baba, Yarime,Shichijo:2010)*

An indicator of firms' knowledge capture in advanced materials

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"Core researchers" in firms.

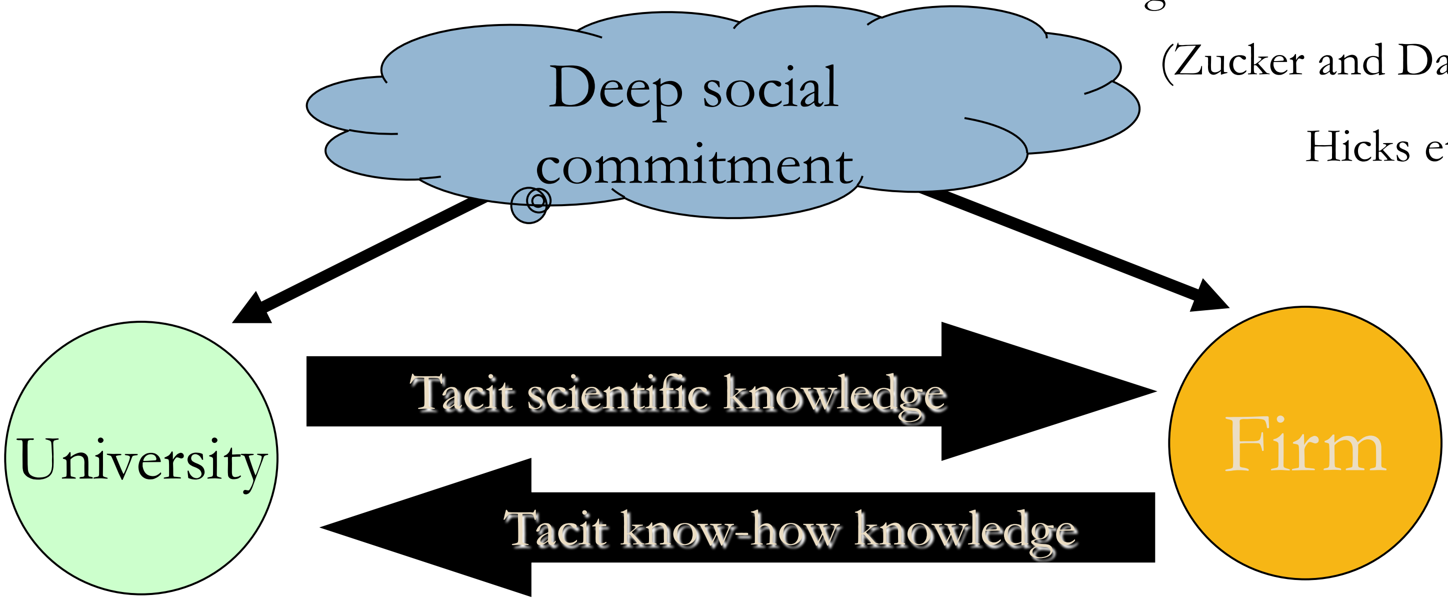
Emergence of "core researcher" in firms

↓

Positive impact on firms' R&D productivity.

Function of core researchers (1)

- Observed by co-authoring of academic papers



Eg. Personal exchanges

(Zucker and Darby 2001;

Hicks et.al. 1995)

Deep social commitment

University

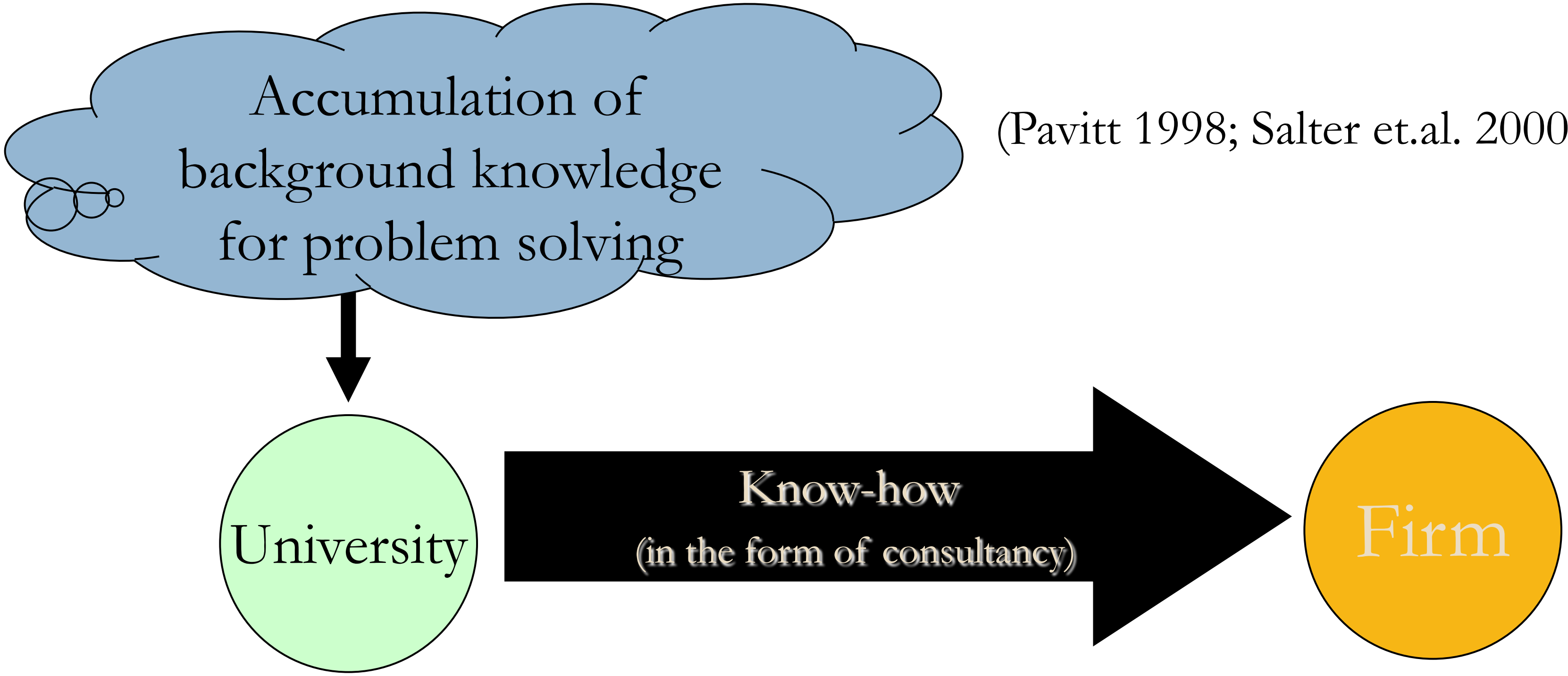
Tacit scientific knowledge

Tacit know-how knowledge

Firm

Function of core researchers (2)

- Observed by co-invention of patents



Accumulation of background knowledge for problem solving

(Pavitt 1998; Salter et.al. 2000)

University

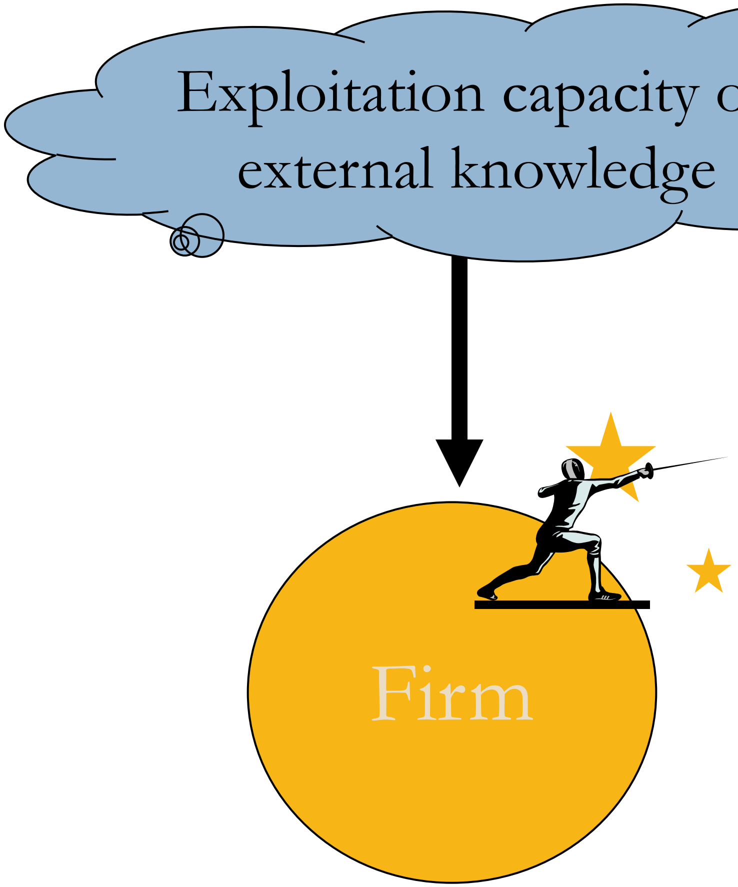
Know-how

(in the form of consultancy)

Firm

Function of core researchers (3)

- Observed by firms' applying more than 10 patents



Exploitation capacity of external knowledge

Cohen and Levinthal 1998

Firm

Definition of core researchers

(i) jointly apply at least one patent with university scientists

(ii) jointly publish at least one research article with university scientists

(iii) apply more than 10 patents independently at firms.

Conclusion

- Emergence of core researchers increases firms' R&D productivity measured by the number of granted patents.
- Firms' collaboration with star scientists exerts negative impact on their R&D productivity in advanced materials
- UIL working as central conduits for interaction of tacit knowledge (scientific and know-how)

Related research: ”Bridging Scientists” in biotechnology (Gittelman and Kogut,2003)

- Since the evolutionary logic that selects out “better” patents is different than that which selects the most influential papers, we do not expect influential papers to lead to influential patents.
- Individual scientists who inhabit both the world of open science and the world of technology creation, by bridging the worlds of discovery and innovation, are able to reconcile these two conflicting logics more effectively than those specializing in either science or technology.
- Those bridging scientists play an important role in transforming scientific ideas into useful innovations

Trial mark II :the role of “Pasteur scientists” (Baba,Shichijo,Sedita:2009)

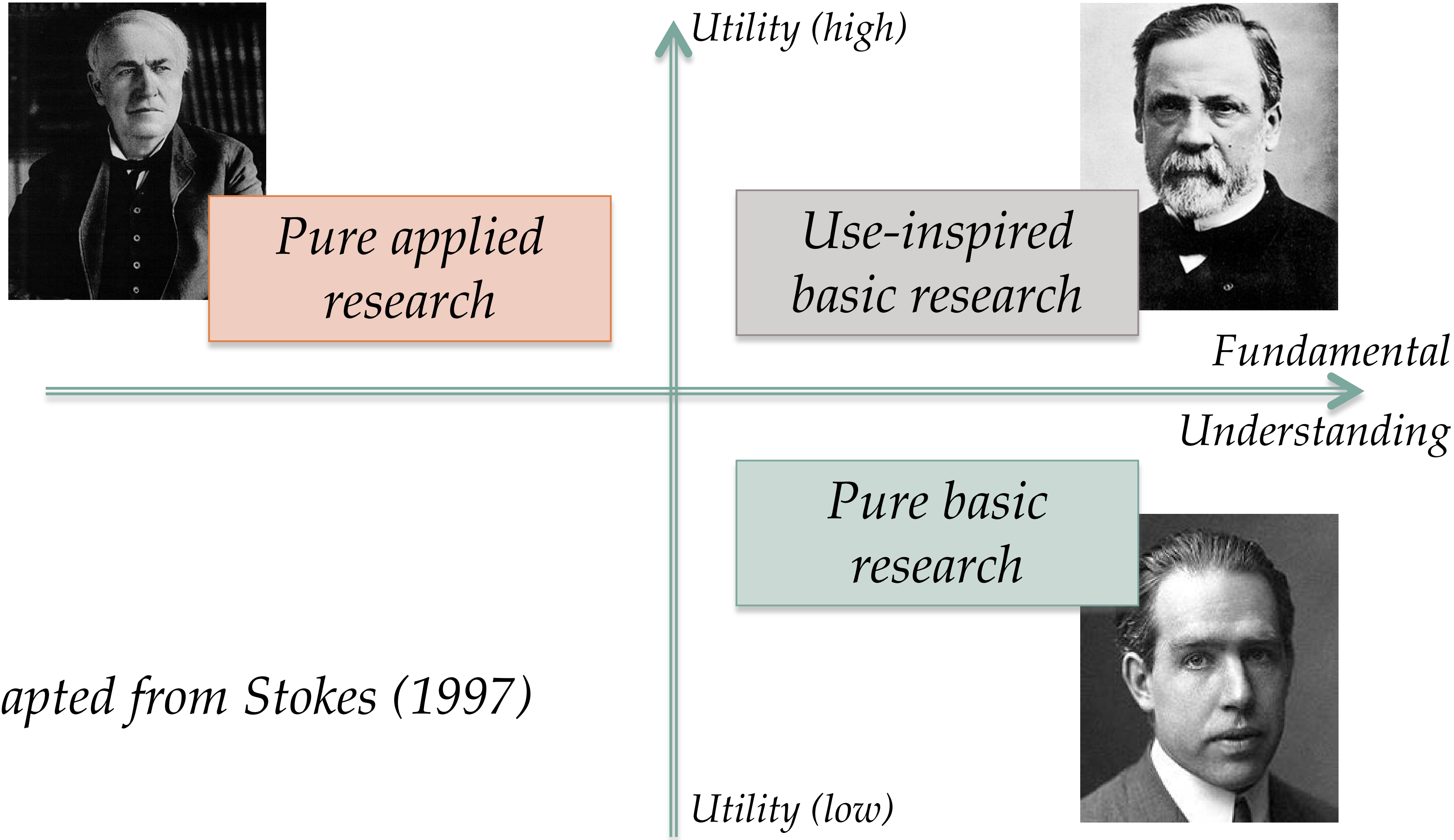
- What type of scientific human capital is more likely to be conducive of successful knowledge interactions with R&D alliances in advanced materials?
- What types of UIL, by means of co-patenting with corporate researchers, are more influential in transforming scientific knowledge into technological achievements, and thus, for increasing firm’s R&D productivity?

Previous research

- The key actors of the U-I knowledge transfer
  - Star scientists (Zucker and Darby, 1995, 1996, 2001; Zucker et al., 1998, 2002)
    - biotechnology
  - Core scientists (Furukawa and Goto 2006a, 2006b)
    - pharmaceutical and electronics industries
- Testing a new concept

  -using Quadrant model of Stokes(1997) to categorize individual scientists, not just areas of science
  - Pasteur scientists
    - Advanced materials, medical device

Quadrant model by Stokes(1997)



Utility (high)

Pure applied research

Use-inspired basic research

Fundamental Understanding

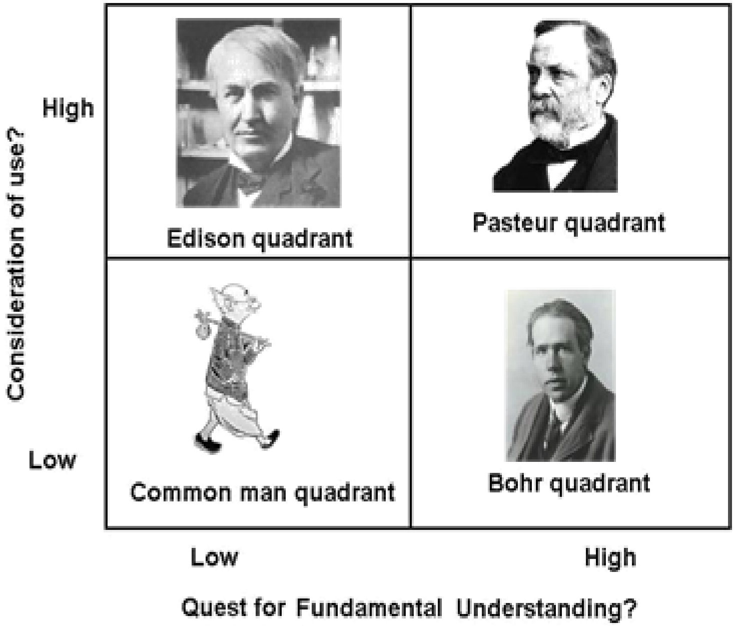
Pure basic research

Utility (low)

Adapted from Stokes (1997)

Operationalization of the model

- Operationalization of the concept of *Quadrant model* (Stokes 1997)
    - Citations to their papers to measure contribution to fundamental understanding
    - Patents to measure contribution to social utility (body of practice)



Data and sampling procedure: Patent data

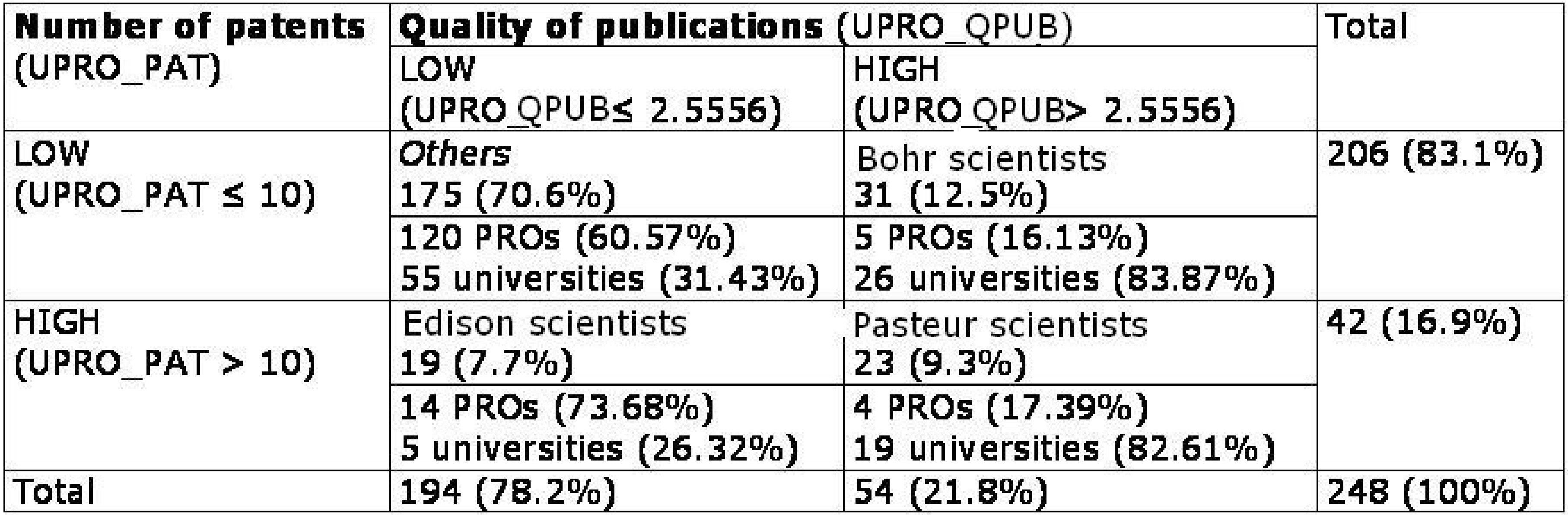
- Main source of data is the Japanese Patent Office (JPO)
- Full-text search by supplying the keyword “Photocatalyst” in the PATOLIS-J database
  - 19,784 patent applications from 1970 to 2006 (97,2% from Japan).
  - 6,749 inventors from 3,207 organizations (2,994 firms, 109 PROs and 104 universities)
    - The affiliations of 956 inventors are unidentified.
    - For corporate inventors, affiliation was identified by address (basically, the corporate name and address are listed in the “place of inventor” field in the patent gazette).
    - For university and PRO researchers, affiliation is not always indicated in patent journal descriptions.
      - Directory Database of Research and Development Activities (ReaD) - the Japanese Science and Technology Corporation (JST) - and Database of Grants-in-Aid for Scientific Research - the National Institute of Informatics
    - By incorporating acquisition and merger or change and variation of corporate names, we identified 2,726 distinct firms.
- we identified the number of patent applications co-invented with researchers affiliated with PROs and universities. In this sample, 10.3% are classified as UI co-inventorship.

Data and sampling procedure: Publication data

- Main source of data is the bibliographic database of academic articles prepared by Thomson Scientific Inc. (called SCI-EXPANDED)
- Full-text search to extract photocatalyst-related articles.
  - 6,992 articles published from 1970 to 2004
  - 9,801 individual researchers from 2002 organizations.
    - 26.8% of articles (1,873) are authored or co-authored by Japanese researchers (including researchers affiliated with firms, PROs, and universities).
      - we counted the number of papers and the number of citations (the sum of citations eventually received by all the papers the organization has ever published)

Classification of scientists

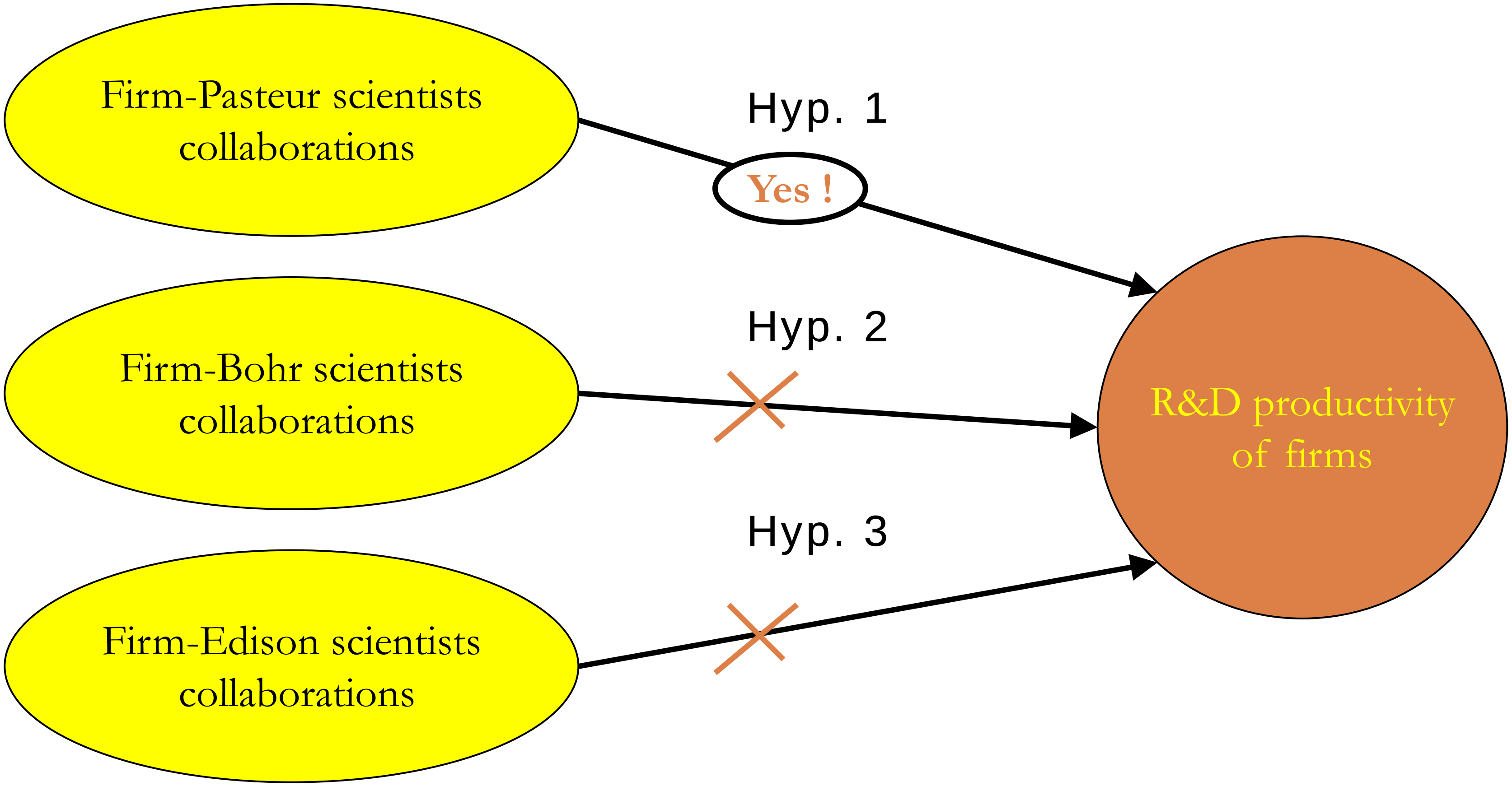
UPRO_QPUB counts the average quality of the publications of the universities and PROs (Number of citations divided by number of publications).
UPRO_PAT counts the number of patent applications reported by the universities and PROs.



Number of patents (UPRO_PAT)	**Quality of publications** (UPRO_QPUB)		Total
	LOW (UPRO_QPUB≤ 2.5556)	HIGH (UPRO_QPUB> 2.5556)	
LOW (UPRO_PAT ≤ 10)	*Others* 175 (70.6%)	Bohr scientists 31 (12.5%)	206 (83.1%)
	120 PROs (60.57%) 55 universities (31.43%)	5 PROs (16.13%) 26 universities (83.87%)	
HIGH (UPRO_PAT > 10)	Edison scientists 19 (7.7%)	Pasteur scientists 23 (9.3%)	42 (16.9%)
	14 PROs (73.68%) 5 universities (26.32%)	4 PROs (17.39%) 19 universities (82.61%)	
Total	194 (78.2%)	54 (21.8%)	248 (100%)

Note: *2.5556 is the mean value of the distribution of the variable* UPRO_QPUB
10 is the mean value of the distribution of the variable UPRO_PAT

Testable hypotheses



Firm-Pasteur scientists collaborations

Firm-Bohr scientists collaborations

Firm-Edison scientists collaborations

R&D productivity of firms

Hyp. 1

Yes !

Hyp. 2

Hyp. 3

Conclusions

- Collaborations with Pasteur scientists have a positive and significant impact on the firm’s innovative performance.
    - Hyp.1 is supported, it’s important for corporate managers to select university partners with high scientific value and technological experience.
- Collaborations with Bohr scientists are not significant in improving the firm’s innovative performance.
    - Hyp. 2 is supported, being a star scientist is not a sufficient condition to engage in a two-way knowledge interaction process with corporate researchers conducive to innovation.
- Collaborations with Edison scientists have a lower, but still positive and significant impact on firm’s innovative performance.
    - Hyp. 3 is rejected, being an inventor not well respected in the scientific community is not a sufficient condition to provide firms with the appropriate knowledge base to develop new products incorporating cutting edge science.

Theoretical implications

- The concept of Pasteur scientists was tested empirically first by the authors, to deepen the present understanding of industrial heterogeneity in innovation processes and to offer new insights for the formulation of corporate innovation strategies.
- Our findings strongly support the importance of consulting as mean for knowledge re-combination and tacit knowledge flows between firms and universities through the contribution of Pasteur scientists,who work as boundary spanners, combining their science-based background with the knowledge, mainly ingrained into practice and trial-and-error procedures, of corporate researchers.

Related research: “Pasteur bridging scientists” in biotechnology (Subramanian,et.al.:2013)

- Innovation impact on a focal firm depends upon the composition of the firm’s scientific human capital and how that human capital interacts with the type of external R&D alliances
- Pasteur bridging scientists substitute for academic R&D partners, and therefore interact negatively with the UI R&D alliances
- Edison bridging scientists complement the firm’s R&D alliances with university partners and therefore exhibit a positive interaction term

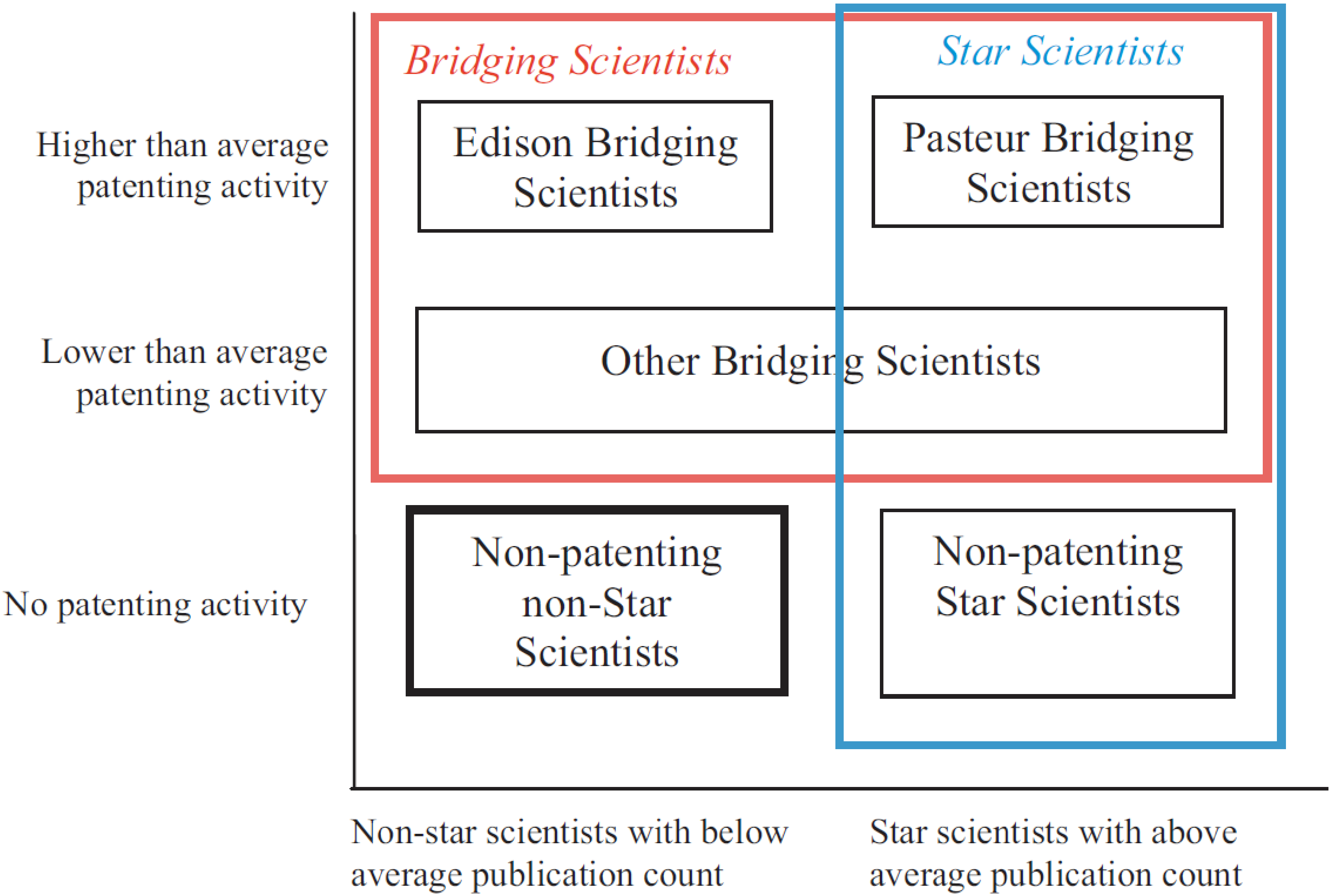


Fig. 1. Types of scientists.