Funding Conditions, the Public-Private Research Portfolio & the Disclosure of Scientific Knowledge

Joshua Gans
University of Melbourne
Fiona Murray
MIT Sloan School of Management

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Public vs. Private Funders of Research Projects

- Nelson (1959) articulates the critical role of public funding in shaping the portfolio of research projects undertaken by scientists.

- Recent scholarship emphasizes several criteria as critical to scientists' project choice(see Aghion, Dewatripont & Stein 2008):
  - Type of research (control over **freedom**)
  - Type of disclosure (control over **openness**)
  - And (less well explored) control over **commercial benefits**

QUESTION:

- How do different funding criteria (specifically disclosure) shape the portfolio of projects and the mix of those projects between public & private funders (particularly those undertaken in universities)?

Research Agenda

- **Examine the impact of disclosure conditions attached to public vs. private funding of research (in universities):**
  - *Publication and dissemination requires*
  - *Patenting*
  - Commercial payments
  - Exclusive and non-exclusive licensing

- **Explore impacts on outcomes**:
  - Number of projects funded
  - Type of projects funded
  - Commercial exploitation of research output
  - Scientific disclosure of research output

Approach to the micro-economic foundations of disclosure

- EMPIRICAL: Grounded in an empirical understanding of the rich context in which disclosure choices are made – and the wide range of disclosure choices actually made.

- THEORETICAL: Disclosure as a negotiation between scientists & those who fund them – often subject to key disagreements in preferences.

- FUTURE RESEARCH AGENDA

Empirical Insights into Disclosure

- Shaped at a variety of levels & through a variety of mechanisms – informal norms & formal contracts
  - Traditional Emphasis: communities & regulations
    - Communities guided by norms, reinforced by formal rules of Journals & Societies (e.g. David & Dasgupta 1994)
    - Federal regulations – specifically Bayh-Dole 1980 (e.g. Mowery et al, 2005)
  - Further Source of Influence: formal requirements of funders for current and future funding
    - Public (government) funding agencies as defined through their grant terms with individual scientists and their universities as well as their informal expectations.
    - Private (for-profit firms) funders through contractual agreement with scientists negotiated with their universities.

Basic disclosure practices allows for two forms of disclosure

- Publishing & patenting:
  - Can use both forms of disclosure for the same research project (Murray 2002; Gans, Murray & Stern 2008)
  - Many scientists take advantage of both by filing patent-paper pairs (Azoulay, Ding & Stuart 2007; Montobbio & Guena 2008; Thursby & Thursby 2009)

Consequences
Patent-Paper Pairs from Public Funding

Discovery of fullerenes by Smalley and colleagues at Rice University funded by the Department of Energy

Doping Bucky: Formation and Properties of Boron-Doped Buckminsterfullerene

Ting Guo, Changming Jin, and R. E. Smalley*

Rice Quantum Institute and Departments of Chemistry and Physics, Rice University, Houston, Texas 77251
(Received: April 11, 1991)

Laser vaporization of a graphite pellet containing boron nitride powder was found to produce fullerenes in which one or more atoms of the hollow carbon cage was replaced by a boron atom. The clusters were probed as isolated positive and negative ions by ion cyclotron resonance techniques. The boron-doped carbon clusters were demonstrated to be fullerenes by the absence of odd-numbered clusters, and relative prominence of the clusters with 50, 60, and 70 atoms, and the fact that they fragment by the successive loss of C_2, resulting in a shrinking of the cage. The boron-doped clusters were found to act as Lewis acids, readily chemisorbing one ammonia molecule per surface boron atom.

United States Patent [19]

Smalley et al.

[54] **ELECTRIC ARC PROCESS FOR MAKING FULLERENES**

[75] Inventors: **Richard E. Smalley; Robert E. Haufler**, both of Houston, Tex.

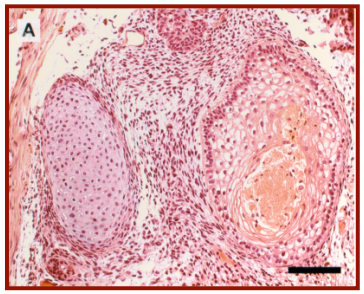
[73] Assignee: **William Marsh Rice University**, Houston, Tex.

[21] Appl. No.: **771,741**

[22] Filed: **Oct. 4, 1991**

[51] **Int. Cl.**[5] **C01B 31/00**
[52] **U.S. Cl.** **204/173**; 423/445
[58] **Field of Search** ..... 423/446, 445, 445 B, 423/460; 156/DIG. 68; 204/172, 173

[56] **References Cited**



Consequences
Patent-Paper Pairs from Private Funding

Stem cell research funded by Geron Corporate at the University of Wisconsin disclosed as patent and paper.

REPORTS

Embryonic Stem Cell Lines Derived from Human Blastocysts

James A. Thomson,* Joseph Itskovitz-Eldor, Sander S. Shapiro, Michelle A. Waknitz, Jennifer J. Swiergiel, Vivienne S. Marshall, Jeffrey M. Jones

Human blastocyst-derived, pluripotent cell lines are described that have normal karyotypes, express high levels of telomerase activity, and express cell surface markers that characterize primate embryonic stem cells but do not characterize other early lineages. After undifferentiated proliferation in vitro for 4 to 5 months, these cells still maintained the developmental potential to form trophoblast and derivatives of all three embryonic germ layers, including gut epithelium (endoderm); cartilage, bone, smooth muscle, and striated muscle (mesoderm); and neural epithelium, embryonic ganglia, and stratified squamous epithelium (ectoderm). These cell lines should be useful in human developmental biology, drug discovery, and transplantation medicine.

www.sciencemag.org SCIENCE VOL 282 6 NOVEMBER 1998

(12) **United States Patent**
Thomson

(54) **PRIMATE EMBRYONIC STEM CELLS**

(75) Inventor: **James A. Thomson**, Madison, WI (US)

(73) Assignee: **Wisconsin Alumni Research Foundation**, Madison, WI (US)

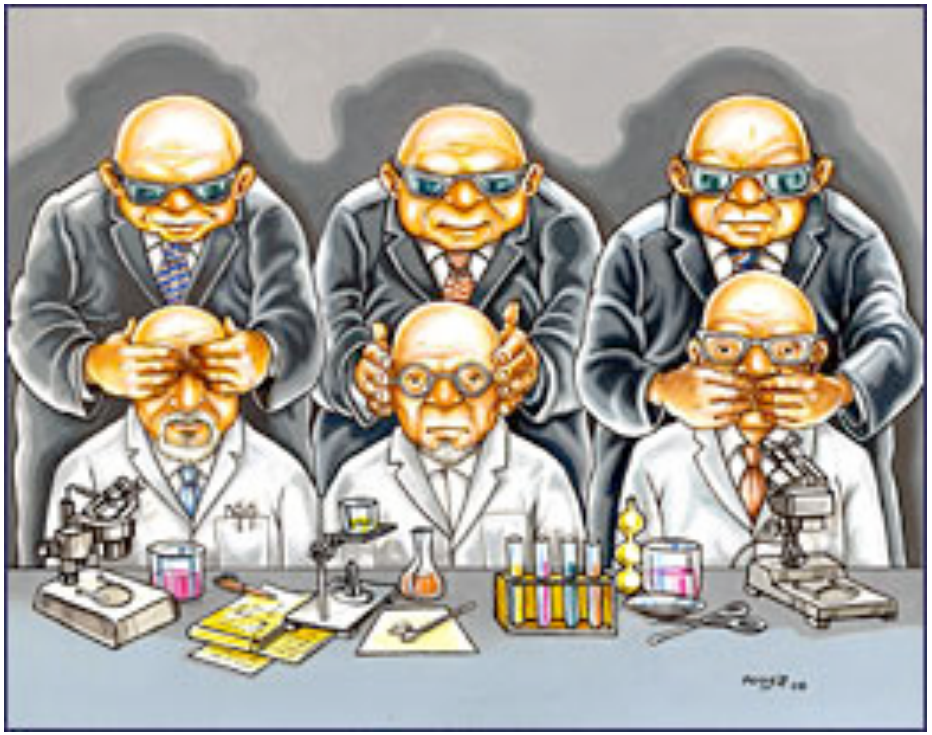
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **09/106,390**

(22) Filed: **Jun. 26, 1998**

Rich set of influences over scientific disclosure



The Three Wise Men and the Three Monkeys by Raul de la Nuez.
Courtesy of Raul de la Nuez

Considerable variation remains particularly as imposed by funders:

- Disclosure obligations
- Disclosure timing
- Scope of disclosure

Publication under Public vs. Private Funding

Table 1: Federal Agencies' Policies on Disseminating Research Results

Agency	Policy	Citation
Agriculture	The principal investigator is expected to publish or otherwise make publicly available the results of the work conducted under this award.	Cooperative State Research, Education, and Extension Service General Terms and Conditions
Defense	Publication of results of the research project in appropriate professional journal is encouraged as an important method of recording and reporting scientific information.	Office of Naval Research Research Terms and Conditions
	The recipient is expected to publish or otherwise make publicly available the results of the work conducted under this agreement.	Air Force Office of Scientific Research Grant Terms and Conditions
Education	Grantees are encouraged to publish the results of the work conducted under this award.	Individual grant agreements[a]
Energy	Recipients are encouraged to disseminate results promptly to the scientific community.	Office of Science, Grant Application Guide Reporting Requirements
EPA	EPA encourages the independent publication of the results of its extramural research in appropriate scientific journals.	National Center for Environmental Research Terms and Conditions
NASA	NASA requires prompt public disclosure of the results of its sponsored research and, therefore, expects significant findings from supported research to be promptly submitted for peer reviewed publication.	Guidebook for Proposers Responding to a NASA Research Announcement
NIH	[P]rincipal investigators and grantee organizations are expected to make the results and accomplishments of their activities available to the research community and to the public at large. Starting with the October 1, 2003, receipt date, investigators submitting an NIH application seeking $500,000 or more in direct costs in any single year are expected to include a plan for data sharing or state why data sharing is not possible.	NIH Grants Policy Statement and Final NIH Research Tools Policy (Dec. 23, 1999) Final NIH Statement on Sharing Research Data (Feb. 26, 2003)
NSF	Investigators are expected to promptly prepare and submit for publication ... all significant findings from work conducted under NSF grants. Investigators are expected to share with other researchers ... materials created or gathered in the course of work under NSF grants. Grantees are expected to encourage and facilitate such sharing.	NSF Grants Policy Manual

Sources: Agriculture, Defense, Education, Energy, EPA, NASA, NIH, and NSF.

GAO Report 04-031 University Research

Patenting under Public vs. Private Funding

Public funders (in the US but not elsewhere) oblige scientists to disclose their research through **patents** (under the Bayh-Dole Act (Federal Register ([35 U.S.C. § 200 et seq.]).

Private funding to universities comes with a similar ***obligation*** to file for IP or at least file invention disclosures.

e.g. NSF Provision 38. Sharing of Findings, Data, and Other Research Products

c. *Invention Disclosure, Election of Title and Filing of Patent Applications by Grantee*

1. The **grantee will disclose each subject invention to NSF** within two months after the inventor discloses it in writing to grantee personnel responsible for the administration of patent matters. … The disclosure shall also identify any publication…
2. The grantee will elect in writing whether or not to retain title to any such invention by notifying NSF within two years of disclosure to NSF. …

f. *Grantee Action to Protect Government's Interest*

1. The grantee agrees to execute or to have executed and promptly deliver to NSF all instruments necessary to: (i) establish or confirm the rights the Government has throughout the world…
2. The **grantee agrees to require, by written agreement, its employees**, … **to disclose** promptly in writing to personnel identified as responsible for the administration of patent matters and in a format suggested by the grantee **each subject invention made under this award …**

Other disclosure dynamics

- More complex than typically articulated in debates over data withholding
    - Ambiguous funders' rights to knowledge produced under different funding regimes
    - Incentives for secrecy on the part of funders

Funders have few “rights” for knowledge disclosure & scientists seek to have their scope limited

Shelby Amendment (provision of Public Law 105-277 introduced in 1999)

> “…the Director of OMB amends Section __.36 of OMB Circular A-110 to require Federal awarding agencies to ensure that all data produced under an award will be made available to the public through the procedures established under the Freedom of Information Act."

In practice…

> c) The Federal Government has the right to (1) obtain, reproduce, publish, or otherwise use the data first produced under an award, and (2) authorize others to receive, reproduce, publish, or otherwise use such data for Federal purposes. In addition, in response to a Freedom of Information Act (FOIA) request for data relating to published research **findings produced under an award that were used by the Federal Government in developing policy or rules**, the Federal awarding agency shall, within a reasonable time, obtain the requested data so that they can be made available to the public through the procedures established under the FOIA…

Funders also attempt to ensure secrecy at times: Invention Secrecy Act

- Code of Federal Regulations Title 37, Volume 1 Revised as of July 1, 1998 Sec. 5.2 Secrecy order.

- In the US alone over 5000 patents are currently covered by secrecy orders (Marks, 2005 *The New Scientist; Sabing 1997*)
  - At least 10% of secrecy orders cover "John Does" – patents filed by non-government employees (irrespective of funding)

> (a) When notified by the chief officer of a defense agency that publication or disclosure of the invention by the granting of a patent would be detrimental to the national security, an **order that the invention be kept secret** will be issued by the Commissioner of Patents and Trademarks.
> (b) Any request for compensation as provided in 35 U.S.C. 183 must not be made to the Patent and Trademark Office, but directly to the department or agency which caused the secrecy order to be issued. [24 FR 10381, Dec. 22, 1959, as amended at 62 FR 53203, Oct. 10, 1997]

Most consistent use of invention secrecy occurred in the Manhattan Project

- Under Vannevar Bush the Office of Scientific Research & Development (OSRD) ensured that "as much patent control as possible resided in the hands of the government" (Bush-Conant File , Folder 147).
- Filed over 1200 patents as part of the Manhattan Project (almost 2% of patents in that period) - well over 80% subject to secrecy orders.
- Special Committee on Atomic Energy (1946) after questioning Captain Lavender (officer in charge of the patent program) commented:

> *"I didn't dream, frankly, up until this point, that there was a patent application down there showing how the bomb was put together" (Chairman, Senator Brien MacMahon quoted in Wallerstein 2008, p. 58).*

Development & control of Atomic Energy [PL 585, Section 11(a)] "**no patent shall hereafter be granted for any invention or discovery which is useful solely in the production …or in the utilization of fissionable material…for a military weapon**"

Publications also maintained secret in wartime in the US and UK (via statue)

- Manhattan project
- British advances in cryptography
- Penicillin crystal structure:

  "But detailed public information on the penicillin [crystal structure] results were delayed because 'all of the information secured during the period of active collaboration bore a high security classification" (Clarke et al. 1949 cited in Cranswick 2008)

All with some loss of reputation/kudos

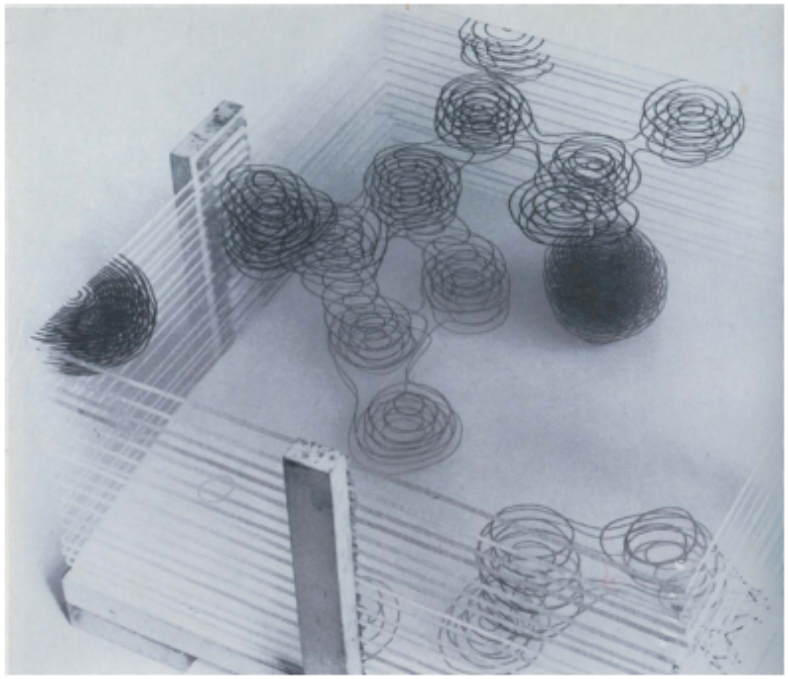


Figure 6
From the 1949 penicillin monograph: photograph of electron-density contours drawn on sheets of perspex showing the thiazolidine and β-lactam of potassium benzylpenicillin (Crowfoot *et al.*, 1949*a*). Owing to urgency created by the '*extreme importance of penicillin as a military weapon*' in WWII, determining the crystal structure of penicillin involved the first crystallographic use in Britain of a Hollerith computer; with Dorothy Hodgkin-Crowfoot as lead crystallographer and with Leslie J. Comrie's Scientific Computing Services Ltd developing the computing

Secrecy over publications also imposed by private funders (via contracts)

Olivieri case at the University of Toronto:

- PI conducting a trial for pediatric thalessemia patients using drug Deferiprone funded by drug company Apotex
- PI publishes in NEJM that the drugs not only are not effective but have significant negative clinical outcomes.

The New England
Journal of Medicine

VOLUME 339 AUGUST 13, 1998 NUMBER 7

LONG-TERM SAFETY AND EFFECTIVENESS OF IRON-CHELATION THERAPY WITH DEFERIPRONE FOR THALASSEMIA MAJOR

NANCY F. OLIVIERI, M.D., GARY M. BRITTENHAM, M.D., CHRISTINE E. MCLAREN, PH.D., DOUGLAS M. TEMPLETON, PH.D., M.D., ROSS G. CAMERON, M.D., PH.D., ROBERT A. MCCLELLAND, PH.D., ALASTAIR D. BURT, M.D., AND KENNETH A. FLEMING, D.PHIL., M.B., CH.B.

Not simply a binary outcome – negotiations also take place over timing & scope of disclosure

Timing of disclosure

- Publication & patent delay by public & private funders
- Rapid release of knowledge (esp data) e.g. Bermuda Rules

Scope of disclosure

- Expanding scope of disclosure E.g. Crystallography debates (NIH guidelines)
- Contracting scope of access to disclosed materials and methods E.g. Access to tissue samples from Multiple Myeloma

Timing of Disclosure
Secrecy Orders for over fifty years!

- *The longest <u>known</u> delay under a secrecy order is **nearly sixty years**.*
- *Patent, filed in September 1945 was not granted until July 2004 - for chemical process research done at Oak Ridge during the war.*

US006761862B1

(12) **United States Patent**
Brusie

(10) **Patent No.: US 6,761,862 B1**
(45) **Date of Patent: Jul. 13, 2004**

(54) **METHOD OF DETERMINING THE EXTENT TO WHICH A NICKEL STRUCTURE HAS BEEN ATTACHED BY A FLUORINE-CONTAINING GAS**

(75) Inventor: **James P. Brusie**, Oak Ridge, TN (US)

(73) Assignee: **The United States of America as represented by the United States Department of Energy**, Washington, DC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **02/618,355**

(22) Filed: **Sep. 24, 1945**

OTHER PUBLICATIONS

Mellor, "Inorganic and Theoretical Chemistry", vol. 15, p. 406, Published by Longmans, Green, and Co.,London, (1936) Copy in Division 59.

Primary Examiner—Jack Keith
(74) *Attorney, Agent, or Firm*—Emily G. Schneider; Paul A. Gottlieb

(57) **ABSTRACT**

The method of determining the extent to which a nickel structure has been attacked by a halogen containing gas to which it has been exposed which comprises preparing a quantity of water substantially free from dissolved oxygen, passing ammonia gas through a cuprammonium solution to produce ammonia substantially free from oxygen, dissolving said oxygen-free ammonia in said water to produce a saturated aqueous ammonia solution free from uncombined

Timing of disclosure
Private funders seek time restrictions on disclosure

- Sponsored research contracts specify publication delays
- GAO (2003) survey found that "3 universities…do not permit any publication delays, while 160 allow a sponsor to review a manuscript prior to publication (typically from 30 to 90 days). 10 universities allow a longer period of up to either 120 days or 180 days, and 1 university allows up to 365 days (GAO 2003)

PUBLICATIONS. M.I.T. will be free to publish the results of the Research after providing the Sponsor with a thirty (30) day period in which to review each publication to identify patentable subject matter and to identify any inadvertent disclosure of the Sponsor's proprietary information. If necessary to permit the preparation and filing of U.S. patent applications, the Principal Investigator may agree to an additional review period not to exceed sixty (60) days. Any further extension will require subsequent agreement between the Sponsor and M.I.T.

Standard MIT contract allows 30 days but in larger contracts e.g. DuPont-MIT Alliance, PI has "an obligation to send DuPont a copy of the publication 60 days prior to publication" which "can be delayed for no more than an additional 90 days from the time of receipt by DuPont to file a patent".

Timing of Disclosure
Bermuda Rules imposed by public funders

- Traditional norms of disclosure of gene sequences allowed PIs long discretionary period prior to disclosure of sequencing data.
- Following entry of Celera, funders (NIH, DOE & Wellcome Trust) set our principles agreed at the International Strategy Meeting on Human Genome (Bermuda Rules):

  "requiring grantees to deposit newly identified sequence in the public GenBank database within twenty-four hours" (Eisenberg 2006, p. 1025 and see http://www.gene.ucl.ac.uk/hugo/bermuda.htm)

Scope of Disclosure
Required by public funders but with few "teeth"

www.nature.com/nature Vol 442 | Issue no. 7098 | 6 July 2006

Illuminating the black box

Note to biologists: submissions to *Nature* should contain complete descriptions of materials and reagents used.

- National Research Council Committee on Responsibilities of Authorship in the Biological Sciences called on authors to include "the data, algorithms, or other information—that is, whatever is necessary to support the major claims of the paper and would enable one skilled in the art to verify or replicate the claims" (National Research Council, 2003: 5).
- NIH followed with material sharing guidelines etc. but widespread violations (e.g. Blumenthal 1998, Cohen et al. 2007).

Scope of Disclosure
Better enforcement for crystal coordinates

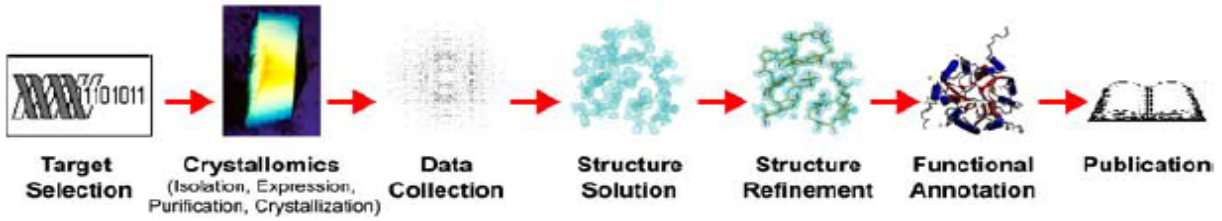


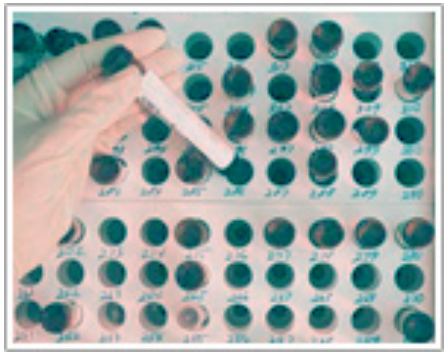
Fig. (1). The steps involved in X-ray crystal structure determination, from target selection to publication.

- Protein Data Bank (PDB) (Berman *et al., 2000)* created in 1970s as a repository for the results of crystal structure analyses.
- Formal set of guidelines established the rules by which data would be publicly available (International Union of Crystallography, 1989)
  - Scope - required deposition of **all coordinates**
  - Timing - allowed for a "hold" on data release one year beyond publication.

Scientists & funders also limit the scope of disclosure in terms of who gains access

"The MMRC Tissue Bank is the only resource of its kind that integrates myeloma tissue samples with corresponding genomic and clinical data" (over 1,900 samples with matching peripheral blood samples).

- Only available to researchers at "Member Institutions nationwide" – PIs from about 15 universities.
- Funder effectively excludes others from these key research disclosures.



Variations in commercial payments as defined by funders

- In general commercial payments to scientists made at the discretion of their universities not predetermined by funders (may be international variation)
  - Takes place via requirements for patenting & patent ownership.
  - Typically title held by universities with licensing revenues shared with scientists (~30%)

Model Set-Up

- Project space
  - (b,v) on $[0,1]\times[0,1]$
  - b: scientific kudos/future spillover (if publication)
  - v: immediate use value (if commercialised)
  - k: required capital (Fund if $b + v \geq k$)
  - Each project requires 1 scientist (no outside option)
- Commerce:
  - Duopoly possible – realise v and firms get share 2β
  - Monopoly outcome – realise $(1-\delta)v$ and firm gets share μ
  - Commercialisation cost, θ (distributed $U[0,1]$); removed if scientist has a commercial interest
  - Publication defrays cost by d
  - Patent increases cost (on non-patent holder) by λ

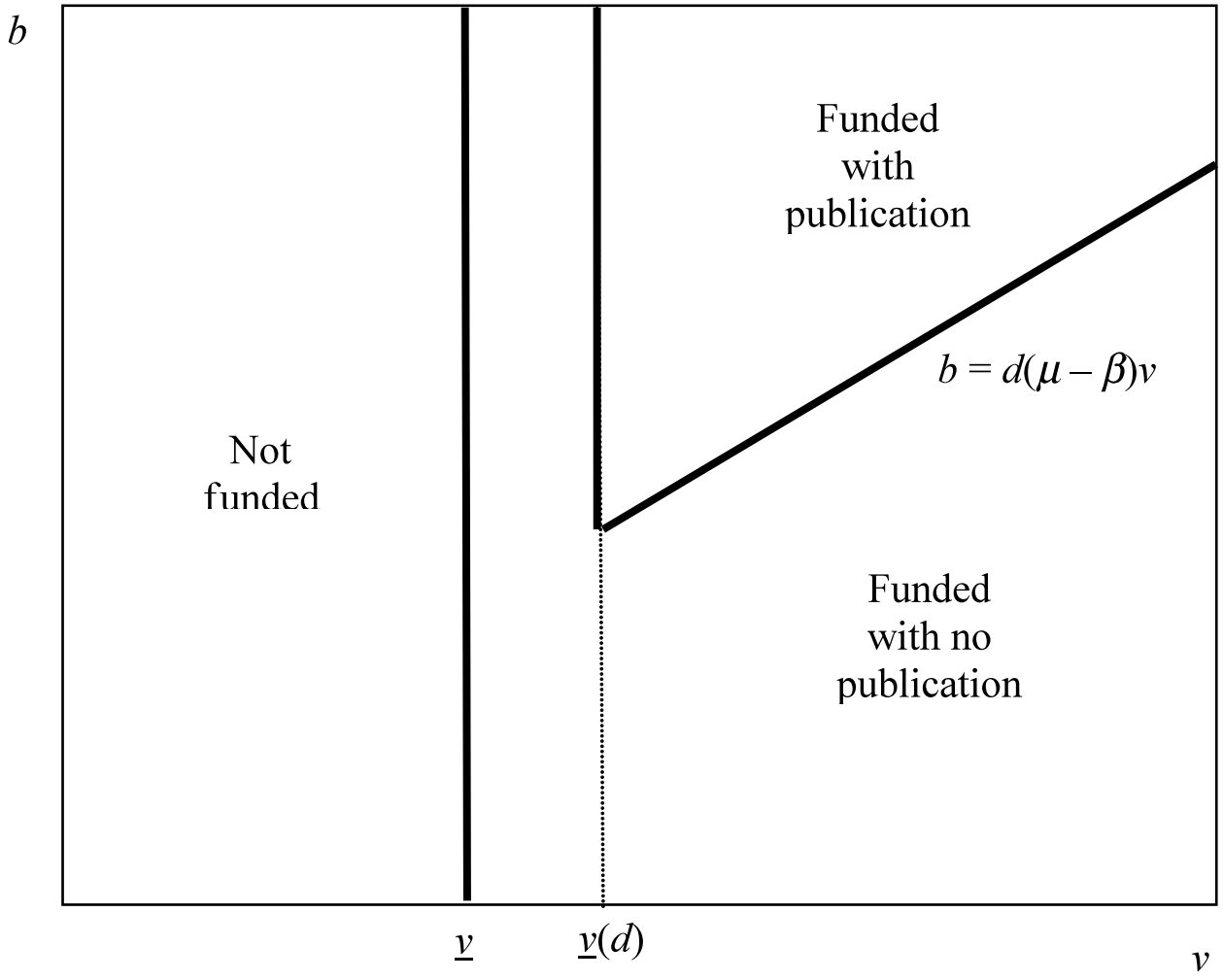
Negotiations

- Continuum of potential private funders
  - Require expected profit to cover capital costs and any payment to scientist
- Single scientist for each project
  - Scientist has all of the bargaining power
  - Scientists are wealth constrained so cannot contribute to capital of project
- Choices
  - Whether to disclose or not
  - Payment, if any, to scientist
  - Whether to accept public funding or not

Pure Private Funding

- Suppose there is no public funding
  - $\underline{v}$ = minimum v with positive profits (no pub)
  - $\underline{v}(d)$ = minimum v with positive profits (pub)
  - $\underline{v} < \underline{v}(d)$
- Scientist has commercial interest and patent is held with exclusive licensing
- Allow publication if:
  - $b \geq d(\mu - \beta)v$
  - $v \geq \underline{v}(d)$
- Otherwise fund with no publication if:
  - $v \geq \underline{v}$

Figure 2: Pure Private Funding



Remarks

- Suppose ironclad patent
  - No cost to publication as entry is blocked
  - Gans, Murray and Stern (2009)
- Scientist payment
  - Reduced if there is greater scientific kudos
  - Stern (2004)

Public Funding

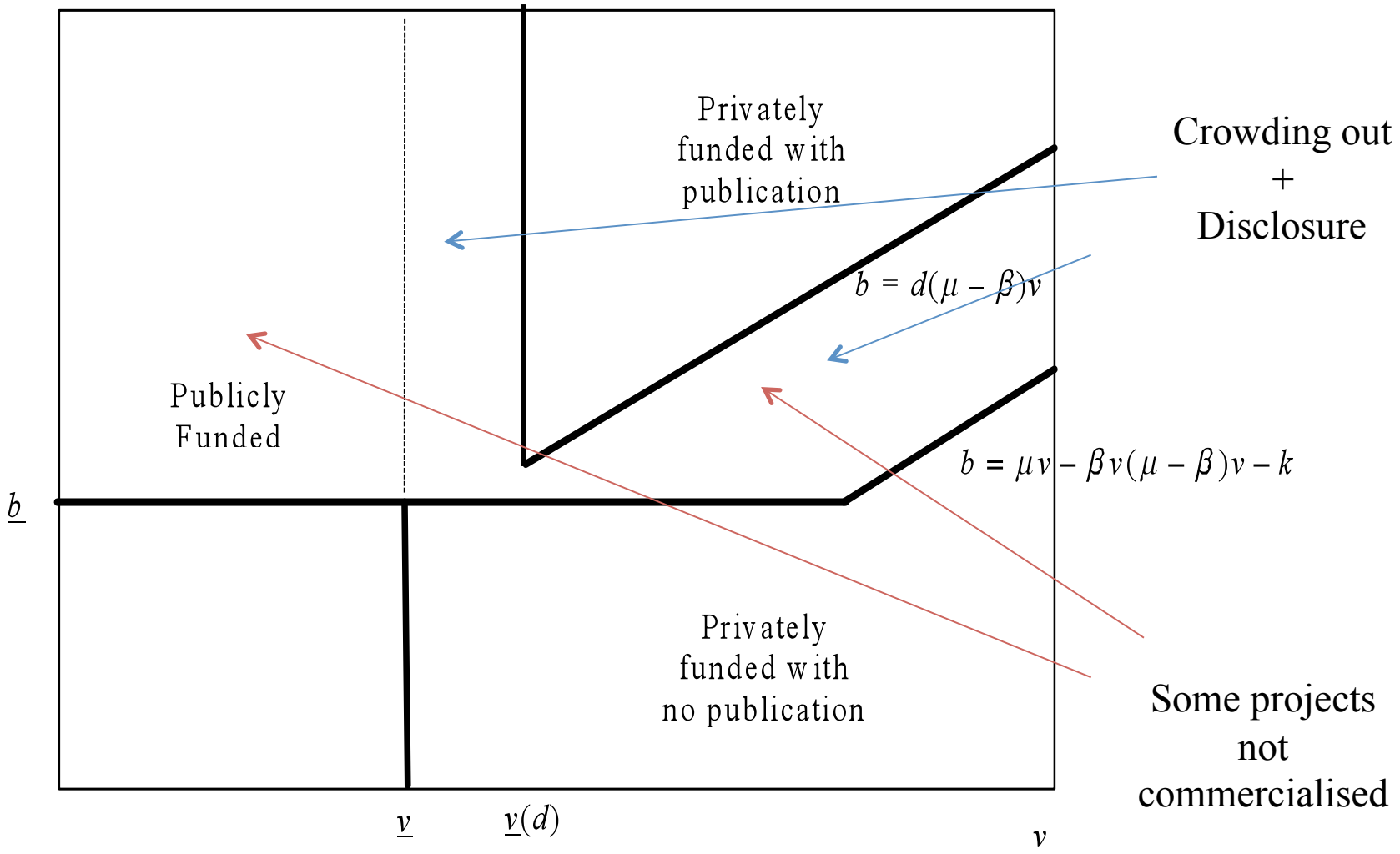
- Total available funding
  - $K < k$
  - Budget constraint
- Project selection criteria
  - Assume can only observe b
  - Choose to fund b above a threshold, $\underline{b}$
- Funding conditions
  - No patent/commercial payments
  - Patent/open licensing
  - Publication requirements
  - No conditions

No patent/commercial pay

- If accept public funding
  - Must publish to get scientist participation
  - Forgo monopoly profits
  - Incur commercialisation costs as scientist has no interest in defraying them
- Conditional on positive profits from commercialisation, accept public funding if:

$$\min\{b, d(\mu-\beta)v\} \geq \mu v - \beta v(\mu-\beta)v - k$$

Figure 3: Public Funding (No Commerce/Patent)

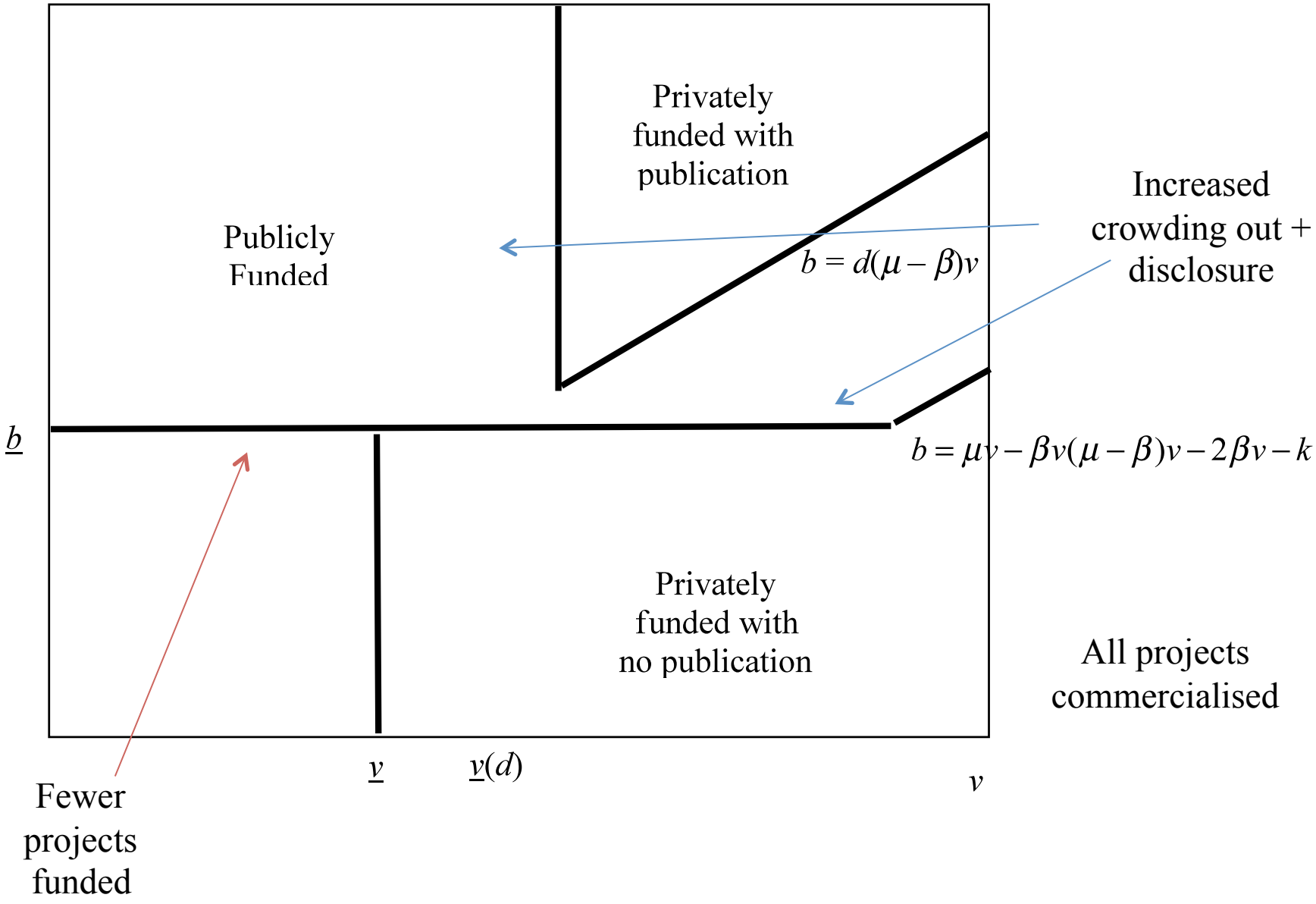


Open Licensing/Payment

- Suppose there is a patent but licensing is required to be open
  - If no commercial interest, same outcome as no patent
  - If commercial interest, commercialisation costs defrayed and there is a duopoly
- Public funding accepted if (positive profits):

$$\min\{b, d(\mu-\beta)v\} \geq \mu v - \beta v(2-(\mu-\beta)v) - k$$

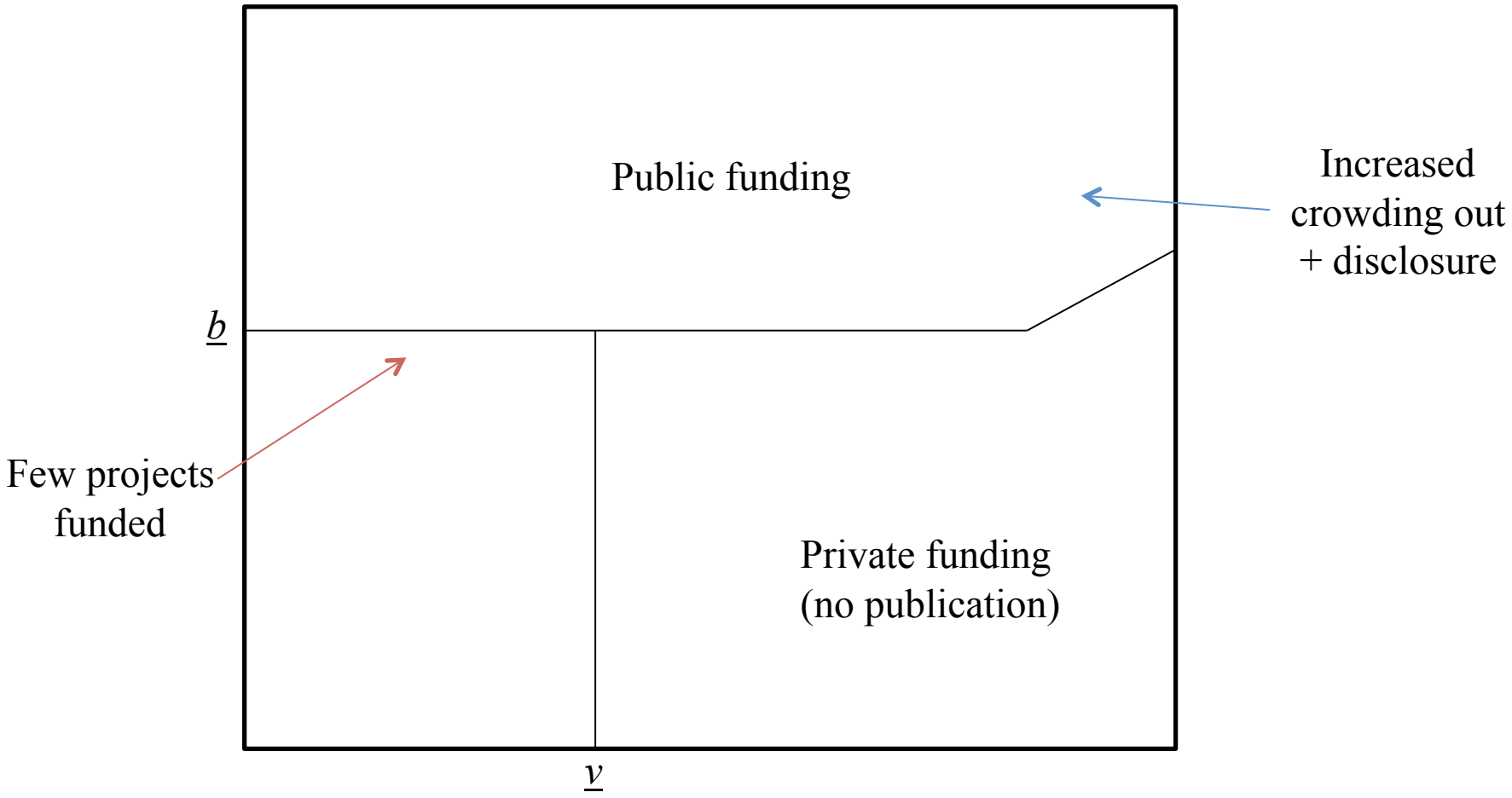
Figure 4: Public Funding (Open Licensing)



Exclusive Licensing

- Only condition is publication
  - All projects where $b \geq d(\mu - \beta)v$ request public funding
- Publicly funded projects may lead to monopoly

No commercial restrictions



Extensions

- Placing weight on immediate use
  - Should public funders do this?
- Multi-stage research projects
- Public goals for secrecy