NORMS AND THE SHARING OF RESEARCH MATERIALS AND TACIT KNOWLEDGE

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As discussed in Wesley Cohen's chapter in this volume, recent empirical studies have documented that scientists experience increasing difficulty obtaining tangible research materials from other scientists, while they express fewer concerns than many had anticipated about do-it-yourself tools that can be made in the laboratory, even when those tools are patented.[2] In this Chapter I use a rational choice model of social norms[3] to elucidate some factors that affect the likelihood that a research community will adopt a sharing norm. Based on those factors, I discuss some means by which sharing of tangible research materials can be encouraged. The analysis focuses attention on the costs to individual researchers of sharing research materials with others in a research community and suggests that sharing norms will be strengthened by initiatives aimed at i) reducing sharing costs through standardization, ii) spreading sharing costs through central distribution, iii) providing rewards in proportion to the extent to which materials are shared, and iv) reducing the private payoffs of exclusivity. Though motivated by studies of sharing of research materials, the analysis also applies to sharing of extensive datasets and tacit knowledge.

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[2] John P. Walsh, Wesley M. Cohen and Charlene Cho, *Where Excludability Matters: Material versus Intellectual Property in Academic Biomedical Research*, 36 RES. POL. 1184 (2007). *See also* Wesley M. Cohen & John P. Walsh, *Real Impediments to Academic Biomedical Research,* in this volume; JOHN P. WALSH, CHARLENE CHO & WESLEY M. COHEN, PATENTS, MATERIAL TRANSFERS AND ACCESS TO RESEARCH INPUTS IN BIOMEDICAL RESEARCH (Final Report to the Nat'l Acad. of Sci. Committee on Intell. Prop. Rights in Genomic and Protein-Related Inventions 2005).

[3] For overviews of social norm theory, *see, e.g.,* STEVEN A. HETCHER, NORMS IN A WIRED WORLD (Cambridge Univ. Press 2004); ROBERT C. ELLICKSON, ORDER WITHOUT LAW: HOW NEIGHBORS SETTLE DISPUTES (1991); Richard H. McAdams, *The Origin, Development, and Regulation of Norms*, 96 MICH. L. REV. 338, 355-76 (1997).

Scientists who invent research tools are part of a more general category of user innovators motivated by an intention to use, rather than sell, an innovative technology.[4] Case studies suggest that informal collaboration and sharing among innovators – what Allen has called "collective invention" [5] and user innovation researchers often call "free revealing"[6] – is relatively common in communities of user innovators. While research tool sharing norms are illuminated by the user innovation framework, the instability of sharing norms for research materials also provides a cautionary note regarding the potential for collaborative user innovation in communities of competitors.

I. SHARING FAILURE: EVIDENCE OF FAILURE TO SHARE RESEARCH MATERIALS

Increased university patenting, particularly in the life sciences, has inspired fears that research would be significantly slowed or stymied by the need to obtain authorization from tool patentees to perform research. These concerns have given rise to various proposals for strengthened research exemptions.[7] The less-than-anticipated impact of research tool patents suggested by recent empirical studies is not due to any lack of patents on research tools or to widespread patent licensing. Instead, it appears that in most cases patents are simply not being enforced against scientists who make unauthorized use of do-it-yourself research tools and methods.[8] The evidence suggests a social norm of ignoring patents in the context of research.[9]

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[4] *See, e.g.,* ERIC VON HIPPEL, DEMOCRATIZING INNOVATION 3 (2005); Sonali K. Shah, *Open Beyond Software*, *in* OPEN SOURCES 2.0: THE CONTINUING EVOLUTION 339 (Chris DiBona, Danese Cooper & Mark Stone eds., 2005); Katherine J. Strandburg, *Users as Innovators: Implications for Patent Doctrine*, 79 U. Colo. L. Rev. 467, 478 (2008). *See also* Katherine J. Strandburg, *Curiosity-Driven Research and University Technology Transfer*, *in* Advances in the Study of Entrepreneurship, Innovation and Economic Growth: Volume 16 at 93 (Gary D. Libecap, ed., 2005) .

[5] R.C. Allen, *Collective Invention*, 4 J. ECON. BEHAVIOR AND ORG. 1 (1983).

[6] *See, e.g.,* VON HIPPEL, *supra* note 4 at 77-92.

[7] *See* Katherine J. Strandburg, *The Research Exemption to Patent Infringement: The Delicate Balance Between Current and Future Technical Progress*, *in* INTELLECTUAL PROPERTY AND INFORMATION WEALTH 107, 112–15 (Peter Yu ed., 2006) for a review.

[8] Walsh *et al.*, *Where Excludability Matters*, *supra* note 2 at 1185, 1188-91.

[9] Katherine J. Strandburg, *User Innovator Community Norms at the Boundary Between Academic and Industrial Research*, _ FORDHAM L. REV. _ (forthcoming 2009). *See also* Walsh et al, *supra* note 2 at 1200.

While it appears that a sharing norm is functioning reasonably well with respect to do-it-yourself patented research tools and methods (those that can be "homemade" in the lab), there is disturbing evidence of failure to share materials in some cases. Sharing research materials so that published research can be tested, replicated, and followed is a traditional norm in biomedical research. In their survey of 1125 academic biomedical researchers and 563 industry researchers, Walsh, Cho, and Cohen found that 60% of industry scientists and 75% of academics reported having requested such a research input within the last 2 years, while 41% of industry researchers and 69% of academics reported having received such a request.[10] Despite the traditional norm of sharing, however, 19% of academics and 30% of industry scientists reported that their most recent requests for materials were not filled. Moreover, 41% of industry researchers and 19% of academics reported having refused at least one request for materials. There was also evidence that refusals to share materials have approximately doubled in the past five years.

Problems obtaining materials led to research delays and to the abandonment of a significant number of projects. About a third of academic and industry researchers in the study experienced delays of more than one month when requesting materials from academics and about a fifth experienced such delays when requesting materials from industry scientists. About one sixth from both sectors also reported having to abandon projects because of failing to receive requested inputs. Refusals leading to abandoning a project were about equally likely to come from academic or industry suppliers. Importantly for this analysis, academic scientists ranked scientific competition and the cost and effort involved in sharing materials as their primary reasons not to share.

The study also indicated that patenting had little impact on refusals to share materials. Thus, whether or not a material input was patented had no significant effect on whether a request was denied. Whether a formal MTA was requested and whether the

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[10] Walsh *et al.*, PATENTS, MATERIAL TRANSFERS AND ACCESS TO RESEARCH INPUTS IN BIOMEDICAL RESEARCH, *supra* note 2 at 35.

request was for published or unpublished research inputs also were not significantly correlated with whether a request was denied. It seems that the need for a transfer of tangible material is what causes the problems.

II. A RATIONAL CHOICE MODEL OF SCIENTIFIC RESEARCHER SHARING NORMS

II.A A Brief Review of the Rational Choice Theory of Social Norms

The theory of social norms focuses on understanding prescriptions of behavior enforced not by legal means but by informal social sanctions. The rational choice theory of social norms describes how social norms can solve collective action problems (frequently analogized to the "Prisoner's Dilemma"), in which rationally optimal behavior by independently-acting individuals would lead to sub-optimal social results. The theory grounds social norms in the private preferences of community members and explains cooperative behavior in terms of rational utility maximization in close-knit, repeatedly interacting, communities. Social norms enforced by informal imposition of penalties for non-compliance can improve the welfare of a group as long as deviations from the norm can be detected and punished by community members. The informal penalties are often reputational in nature, but may also involve more direct punishment or withholding resources under the group's control.[11]

Of course, social norms are only one mechanism for solving collective action problems. Contractual arrangements, government provision through taxation, government regulation, and other coordination mechanisms may also be exploited. Part III discusses ways in which some of these mechanisms may be used to bolster research tool sharing norms.

II.B. "*Homo Scientificus*" and Research Tool Sharing

[11] *See, e.g.,* references *supra* note 3.

Going back to the work of sociologist Robert Merton, the norms of the scientific community traditionally have been identified as universalism, communalism, disinterestedness, and organized skepticism.[12] A norm of sharing research tools and materials would be an example of communalism. In the traditional view, "the rationale of all these norms is to further the institutional goal of science, which is the progress of knowledge."[13] Professors Arti Rai and Rebecca Eisenberg, among others, have argued that the traditional norms of science might be threatened by the increasing emphasis on and availability of proprietary rights in research results and by technology transfer initiatives.[14] Rai further argued that law could and should fruitfully be adapted to support the traditional norms. Here I assume that research tool sharing is socially desirable because it increases the pace of scientific progress and produces positive social spillovers. I then use a more detailed exposition of social norm theory to suggest policies to promote sharing, especially in light of the empirically observed discrepancy in sharing of do-it-yourself research tools and tangible materials.

Scientists, like other people, vary in their preferences and values. But, just as a model of human beings as rational wealth maximizers is often useful in understanding both average and collective behavior, a model of a typical scientist may be used to understand and predict the behavior of the scientific community and its response to legal and social changes. The viability of a sharing norm depends on the preferences of the members of the community, which determine the perceived costs and benefits of sharing. I model the non-profit researcher as an individual, *homo scientificus*, say, with strong preferences for 1) performing scientific research and participating in the scientific discourse; 2) exercising autonomy in choosing the topic and direction of his or her

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[12] ROBERT K. MERTON, THE SOCIOLOGY OF SCIENCE (1973).

[13] Arti Kaur Rai, *Regulating Scientific Research: Intellectual Property Rights and the Norms of Science*, 94 NW. U. L. REV. 77, 91 (1999).

[14] *See ,e.g.,* Rebecca S. Eisenberg, *Proprietary Rights and the Norms of Science in Biotechnology Research*, 97 YALE L. J. 177, 230-31 (1987); Rai, *supra* note 13 at 109-11.

research; and 3) learning the collective results of research in his or her field.[15] It seems plausible that life scientists in particular are also substantially motivated by a desire to contribute to society. The analysis here demonstrates, however, that there is no need to assume that scientists are particularly public-spirited to account for sharing norms using a rational choice theory.

Empirical evidence supports this preference model. In a survey by the American Association for the Advancement of Science, scientists placed a very high value on intellectual challenge and autonomy in their work, ranking both substantially higher than salary and prestige on a scale of job aspects.[16] This evidence of preferences is bolstered by surveys indicating that academic scientists make significantly lower salaries than industry scientists: a 2001 National Science Foundation survey shows a nearly $30,000 median salary gap between academic and industry doctoral scientists.[17] While this salary differential conceivably could reflect lower demand for scientists who end up in academia, in fact it is well known that academic positions are coveted. Indeed, a comparison of salary offers to specific individuals showed that scientists essentially "pay" to do academic research.[18] Surveys also indicate that academic scientists are more satisfied with their careers than industry scientists, again suggesting that something other than salary is a major source of utility for these individuals.[19]

Despite somewhat increased industry funding,[20] the size of the academic research community is limited primarily by the amount of public funding. The availability of higher paying jobs in industry for individuals with virtually the same skill set as these

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[15] Strandburg, *Curiosity-Driven Research*, *supra* note 4.

[16] Constance Holden, *General Contentment Masks Gender Gap in First AAAS Salary and Job Survey*, 294 SCIENCE 401 (2001) (reporting results of survey of life scientists).

[17] Thomas B. Hoffer, *Employment Sector, Salaries, Publishing, and Patenting Activities of Science & Engineering Doctorate Holders* (Nat'l Sci. Found., InfoBrief No. 04-328, June 2004) (comparing results of 1995 and 2001 surveys of doctoral scientists), *available at* http://www.nsf.gov/statistics/infbrief/nsf04328/nsf04328.pdf.

[18] Scott Stern, *Do Scientists Pay to Be Scientists?*, 50 MGMT. SCI. 835 (2004) .

[19] Holden, *supra* note 16.

[20] Hoffer, *supra* note 17.

scientists provides a mechanism for selecting out those who place a high value on the particular type of research traditionally practiced in universities -- characterized generally by an emphasis on autonomous choice of research direction and on scientific interest.

The mechanisms for entry to and exit from the academic research community reinforce the *homo scientificus* preference profile. Present members of the community play an important gatekeeping role, through recommendations, peer review, and collaboration, which selects for members whose preferences match their own. Scientific progress is incremental and scientists depend heavily on other scientists' work to satisfy their own tastes for research. Further, most scientific research is collaborative. An individual scientist's ability to enjoy a fruitful collaboration is heavily dependent on both the talents of her collaborators and their willingness to put in long hours and intense intellectual effort. Researchers who gain high utility from conducting research are desirable community members in part because they are likely to be more productive.

To the extent that tastes are endogenous, it is also likely that years of training under the direction of academic scientists for the doctoral degree also serve to mold preferences toward academic research. As non-profit scientists become involved in industry collaborations, obtain industry funding, and otherwise interact with commercial researchers, the inculcation of these preferences may be less effective, of course. Indeed, studies have shown that, for better or worse, the propensity to engage in patenting or other entrepreneurial activity is increased by association with those who already are involved in such activities.[21] If the social environment of universities increasingly rewards entrepreneurial and applied research, the preferences of younger researchers may be influenced accordingly. Such changing preferences might affect the relative values that researchers place on obtaining access to research tools invented by others and

[21] *See, e.g.,* Karen Seashore Louis, David Blumenthal, Michael E. Gluck & Michael A. Stoto, *Entrepreneurs in Academe: An Exploration of Behaviors among Life Scientists*, 34 ADMIN. SCI. Q. 110 (1989) ; Toby E. Stuart & Waverly W. Ding, *When Do Scientists Become Entrepreneurs? The Social Structural Antecedents of Commercial Activity in the Academic Life Sciences*, 112 AM. J. SOC. 97 (2006).

maintaining exclusive control over their own research tool innovations. I do not address this possibility in detail here, except to note that industry funding accounted for less than 4.9% of overall university research funding in 2004[22] and patent royalties make a very small contribution to most research budgets.[23] If industry funding reflects points of overlap between the non-profit and industry research communities, the effects of commercial interaction on preference molding may be concentrated on a few academic scientists and relatively minor for others. Nonetheless, the potential for shifting preferences is worthy of further study, particularly in light of the fact that the overlap between communities may be much greater than the amount of industry funding reflects.

In seeking to satisfy their preferences, scientists confront resource scarcities that lead to competition with other scientists. To satisfy the preferences of "*homo scientificus*," two primary scarce resources are needed: research funding and the attention of other scientists. Indeed, scientists in the AAAS survey ranked availability of resources and opportunities for collegial exchange immediately below intellectual challenge and autonomy as important factors in job satisfaction. While scientists are interested in reputation and esteem, recognition and prestige ranked far below most other factors in importance. Thus, arguably, the primary importance of reputation for "*homo scientificus*" is as a currency with which to acquire funding and attention.[24]

Research funding is a crucial resource for preference satisfaction for scientists, not only because it directly facilitates research, but because control over funding may (depending upon the source of the funding) provide autonomy in research direction and

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[22] Alan I. Rapoport, *Where has the Money Gone? Declining Industrial Support of Academic R&D* (Nat'l Sci. Found., InfoBrief No. 06-328, Sept. 2006), *available at* http://www.nsf.gov/statistics/infbrief/nsf06328/nsf06328.pdf.

[23] Jerry G. Thursby & Marie C. Thursby, *Knowledge Creation and Diffusion of Public Science with Intellectual Property Rights, in* INTELLECTUAL PROPERTY RIGHTS AND TECHNICAL CHANGE (K. Maskus ed., Elsevier Publishers 2007).

[24] *Cf.*, F. Scott Kieff, *Facilitating Scientific Research: Intellectual Property Rights and the Norms of Science - A Response to Rai and Eisenberg,* 95 NW. U. L. REV. 691, 696 n. 34 (2001) (pointing out that "kudos can take many forms," including the award of research grants along with less tangible benefits, but not drawing out the distinction between reputation *per se* and resources for pursuing scientific work).

may indirectly provide the ability to associate and collaborate with other scientists, either through affiliation with a research institution or by doling out funds to colleagues, postdoctoral research associates and graduate students. The importance of research funding to academic scientists is evidenced by a survey of university technology transfer officials who suggested that faculty would place "sponsored research" at the top, ahead of royalties, of a list of potential payoffs from patenting and industry collaboration[25] and from studies showing that faculty members often re-invest their profits from commercialization projects in further research.[26]

The attention of other researchers is a scarce and important resource for several reasons. First, it is an important factor in obtaining funding from the peer review process, which is the primary allocator of basic research funding. But it is also of more direct importance. Most scientific researchers work collaboratively -- both as a means of increasing their personal research productivity and because part of the utility they derive from doing and consuming science is derived from being part of the ongoing conversation between researchers. Participating in this conversation requires getting the attention of other researchers -- and the better the other researchers involved, the more rewarding the conversation.

Because both funding and attention are scarce, there is competition between scientists for these resources. Funding and attention are separately important for satisfying scientists' preferences; while funding can attract a certain amount of scientific attention and *vice versa*, no amount of funding can garner attention for the results of research about which there is no interest in the scientific community. Because researchers benefit from collective progress yet compete for scarce resources, collective

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[25] Jerry G. Thursby & Marie C. Thursby, *University Licensing and the Bayh- Dole Act,* 301 SCIENCE 1052 (2003) .

[26] *See, e.g.,* Joanna Poyago-Theotoky, John Beath & Donald S. Siegel, *Universities and Fundamental Research: Reflections on the Growth of University- Industry Partnerships*, 18 OXFORD REV. ECON. POL'Y 10 (2002).

action problems are likely to arise. Scientists collectively exercise significant control over allocation of these resources, however, and can deploy them to enforce social norms.

II.C. A Model of the Tool Sharing Collective Action Problem

Having formed at least a tentative idea of the preference structure of the "typical" academic researcher, we can now turn to a discussion of how these individual preferences affect the viability of sharing norms for research tools and materials. At the outset, we can see that these preferences explain why researchers might prefer to share at least some research tools, methods, and materials, despite the fact that they compete with one another for reputation and the associated scarce resources of funding and attention.
To fulfill their preferences, scientists seek not only their own advancement relative to other scientists but also the advancement of science. There are thus tradeoffs between competition and the benefits of sharing. Just as members of a competitive tennis club might enjoy the games more if all players improve or have access to better equipment; scientific researchers enjoy having more complete scientific knowledge and better research tools even if they are shared with the scientific community.

The general situation can be parameterized by a simple model. Assume that all members of a researcher community are equivalent in their production and use of research tools and also equally able to benefit from refusing to share their tools and using them exclusively. Assume also that sharing an invention means sharing it with the entire group, as it will if, for example, the mechanism of sharing is publication.

Scientific researchers are generally "user innovators;" they both invent and use research tools and methods and research input materials just as they both produce and consume research results.[27] The marginal investment in developing user innovations is often relatively small since many user innovations are developed as a result of knowledge gained through use. The comparatively lower investment required for user innovation is

[27] Strandburg, *Users as Innovators*, *supra* note 4.

reflected in empirical studies showing that scientists make a majority of research tool innovations, especially those that improve functionality.[28] I therefore assume, based on the realities of scientific research and the user innovation mechanism, that all members of the research community invent new research tools, *i.e.,* that a strategic decision not to invest in inventing new tools is not an option. There is thus no need to account explicitly for such investment in the model.

The benefits of using a research tool are reflected in three parameters. Let U be the value of non-exclusive use of a research tool invented by another scientist. U is assumed to be the same for all community members and for all inventions. Non-exclusive use benefits may arise from a number of sources. For example, researchers may gain intrinsic enjoyment from doing research using new tools; they may derive direct satisfaction from the advancement of the field made possible by new tools; and they may use a non-exclusive tool to make the minimal scientific advances necessary to keep them "at par" with other researchers and involved in the community.

Of course, even if a tool is shared so that other researchers can use it, the scientist who developed it may retain some advantage in its use as a result of skill, tacit knowledge, tailoring of the tool to her private research agenda or similar first mover advantages. Let first mover advantage be denoted M. The value of using one's own tool invention non-exclusively is thus U+M, while the value of using someone else's invention is simply U.

Rather than share his or her tool with others, a scientist might choose to use it exclusively. Exclusive use of a tool will ordinarily provide a competitive advantage in pursuing research objectives. We may define E to be the increase in a tool's value to a researcher when she uses it exclusively; the total value to a scientist of exclusive use of a tool is U + E. In the model, E is the *net* additional benefit of exclusive use. It reflects

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[28] William Riggs & Eric von Hippel, *Incentives to Innovate and the Sources of Innovation: The Case of Scientific Instruments*, 23 RES. POL'Y 459 (1994).

both the costs and the benefits of exclusivity. In principal, it is possible that for some research tools E is negative. Some research tools may be less valuable if they are not shared, perhaps as a result of a need for standardization, In other cases, the costs of maintaining exclusivity outweigh the benefits of exclusive use.

The final two parameters in the model reflect the costs and benefits of sharing a research tool with the scientific community. Let C be the cost of sharing a research tool (for example, by publication). I will have more to say about sharing costs below. Let R be any reward that a scientist receives in return for sharing a tool invention other than access to tools invented by other scientists. The reward R might, for example, include reputational benefits or intrinsic enjoyment of contributing to community discourse.

Assume there are N members of the research community. A member (who we will call A) will make a strategic choice of whether to share a new tool based on what other members are expected to do. In making that choice in our simplified model, scientist A will assume that the N-1 other scientists, faced with identical incentives, will make identical choices. In this symmetric situation, the "payoffs" that scientist A would expect in light of how the others might behave will look like this:

		Other Scientists: Share	Other Scientists: Don't Share
Scientist A	Share	NU+M+R-C	U+M+R-C
	Don't Share	NU+E	U+E

If all scientists share (the upper left hand corner above), Scientist A has access to N-1 research tools from the other scientists. Because Scientist A shares, her own tool is worth U + M to her (she gets a first mover advantage, but no exclusivity advantage) and she receives the rewards of and incurs the costs of sharing. Her net payoff is thus NU+M+R-C. If none share (the lower right hand corner), Scientist A is restricted to using her own research tool exclusively and her payoff is U+E. If scientist A shares and the others do not (the upper right hand corner), scientist A receives only the benefit of using her own tool non-exclusively, $U+M$, along with the rewards and costs of sharing. If scientist A does not share and the other scientists do (lower left hand corner), A benefits non-exclusively from all the other tools, $(N-1)U$, and exclusively from her own, $U+E$. In choosing her own course of action, scientist A will consider her prospective payoffs in light of either course of action by the rest of the community.

Inspecting the matrix one can see that sometimes there may be no need for a sharing norm. If the first mover advantages, M, and other rewards for sharing bestowed by the community, R, are large enough and sharing is relatively cheap, the benefits of exclusivity may be outweighed by the rewards of sharing, i.e., $M+R-C > E$. In this case, Scientist A will prefer to share her tool, regardless of what the others do. Because all scientists are identical in the model, all will share. In this happy situation there is no need for a social norm to enforce sharing.

However, a less felicitous situation may arise. It may be that the rewards for sharing are not enough to motivate Scientist A (and all her identical colleagues) to share unless she can be sure that everyone else will share as well. Thus, if $M+R-C < E$, Scientist A will not make an independent choice to share. Indeed, no one will share and everyone will receive only the benefit of exclusive use of his or her own tool, $U+E$. This is an unfortunate situation for the scientific community (indeed, it is a classic collective action problem) if the benefit to each scientist of sharing all of the tools would have outweighed the advantage of using her own tool exclusively. Thus, if $(N-1)U+M+R-C > E > M+R-C$, all scientists would benefit from a means to ensure that all share their tools. In this situation, a social norm of sharing is desirable. Such a norm is viable as long as failing to share can be detected by the group and a sufficient penalty imposed at relatively low cost. Professor Richard McAdams has argued, for example, that esteem penalties are costless to impose.[29] In any event, as long as the cost of the penalty is low enough, the group will be willing in principle to impose it. (I do not deal here with the question of the mechanism by which such a norm becomes established.)

To summarize, depending on the values of U, M, R, C, and E, there are three regimes:

Regime I: $M+R-C > E$, the benefits of sharing one's own tool are enough to induce sharing regardless of what others do; no social norm is necessary;

Regime II: $(N-1)U+M+R-C > E > M+R-C$, sharing is preferable as long as everyone shares; a social norm is desirable to coordinate sharing

Regime III: $E > (N-1)U+M+R-C$, the exclusivity payoff outweighs the benefits of sharing; scientists will not share.

The viability of research tool sharing norms thus depends on the scientist preference structure already discussed, which determines the relative values of U and E, on the rewards bestowed for sharing, and also, importantly, on the costs of sharing, which depend on the nature of a given tool invention. In particular, norms of sharing are much more tenable when the costs of disseminating a tool are relatively low.

II.D. Sharing Norms for "Do-It-Yourself" Research Tools

Research tool sharing norms are most likely to emerge for "do-it-yourself" research tools, by which I mean tools that may be employed by other researchers relatively easily after they read about them in a scientific journal or hear about them at a conference. Publication is rewarded in the non-profit research context. It affects reputation (both directly and through citation), access to funding, career advancement, and collaboration opportunities and is virtually the lifeblood of academic science. Because publication costs relatively little, provides reputational and other rewards, and is

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[29] McAdams, *supra* note 3 at 357-58.

necessary to obtain the scarce resources of attention and research funding, $R - C$ is likely to be positive for do-it-yourself research tools and often will be strongly so.

Moreover, *homo scientificus* values the overall advancement of science and enjoys doing research, meaning that scientists are likely to be able to benefit significantly from using new research tools, even when other scientists are also using them. Researchers are also highly skilled, so that they have high "absorptive capacity"[30] and low "do-it-yourself" costs. These factors suggest that U will tend to be relatively large.

Finally, within the non-profit research context, scientists' ability to profit from using research tools exclusively is limited by the possibility of independent invention by other researchers and, more importantly, by the difficulty of preventing the diffusion of do-it-yourself research tools throughout the community. Non-profit research laboratories are relatively open, and research often involves visitors, postdoctoral research associates, and graduate students who come and go, taking their knowledge of research tools and methods along with them. Confidentiality agreements are unlikely in this context, where the focus is on training graduate students and postdoctoral researchers to carry on independent research elsewhere. Thus, although a researcher will often retain a first mover advantage even after sharing a research tool or method, the potential for exclusivity is limited, *i.e.,* $E-M$ tends to be small.

These factors combine to favor sharing. Indeed, it may often be that $M+R-C > E$ (Regime I) and a norm is not even needed to coordinate sharing. Even if $M+R-C < E$, the benefits of sharing, $((N-1)U + M + R - C)$, will almost always outweigh the benefits of exclusivity, E, meaning that a norm is desirable to induce everyone to share.

Assuming that a sharing norm is desirable, its viability depends on whether it can be effectively enforced. Enforcing a norm of sharing in a non-profit research community should not be particularly difficult since that community is tightly knit and involves repeated interactions. The community can easily impose reputational and shunning penalties. The preferences of *homo scientificus* mean that such penalties are likely to be highly effective. Many traditional scientific practices help to enforce sharing norms. Most importantly, publication traditionally requires a sufficient description to enable replication of results, at least where it is possible to replicate the results using generally available materials (more on this point later).

The availability of patent protection *per se* may not change this picture substantially.[31] While patenting makes it possible in principle to obtain the reputational benefits of publication while retaining the benefits of exclusive use, those benefits are limited in the non-profit context, as already discussed. Thus, a sharing norm is likely to persist among scientists in a non-profit context even when patents are available.

When patents are available, a sharing norm can take the form either of a norm of non-patenting or of a norm of non-enforcement. Despite the fact that university patenting has drastically increased in the past thirty years, sharing research tools and methods without patenting is still probably the most common norm.[32] Where researchers do choose to patent, however, the same result can be obtained, and generally is obtained in the non-profit context, by forbearing to sue other researchers.[33] The choice to patent a

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[30] Wesley M. Cohen & Daniel A. Levinthal, *Absorptive Capacity: A New Perspective on Learning and Innovation*, 35 ADMIN. SCI. Q. 128 (1990).
[31] Strandburg, *supra* note 9.
[32] *See, e.g.,* Walsh & Cohen, *Real Impediments*, *supra* note 2.
[33] See references *supra* note 2. *See also* Strandburg, *supra* note 9.

do-it-yourself research tool in this context is thus likely driven by other factors, such as whether the tool has non-research commercial applications (e.g. as a diagnostic test).

II.E. Sharing Norms for Research Materials, Data, and Methods That Are Costly to Disseminate

So far I have assumed in this discussion that research tools or methods can be disseminated effectively and cheaply by publication. There are at least two situations in which this may not be the case. First, use of a research tool or method may require access to a particular reagent, cell line, or other material that is not easily reproduced from its description, either because it is difficult or costly to produce from scratch or because standardization is important for the research. Similar issues arise when a research method relies on using a voluminous data set that cannot be or customarily is not appended to the publication. Such a dataset functions as a research tool. Second, the use of a particular tool or method may require significant tacit knowledge[34] not easily or customarily codified in a publication, perhaps in part because of article page length restrictions which are common in the sciences.

When materials, data, or tacit knowledge are involved, sharing a research tool or method imposes additional costs upon the scientist who developed it either in the form of "face time" in transferring tacit knowledge or of the costs of disseminating materials or data to researchers who request them. Most critically, unlike the single cost of publication, these costs rise in proportion to the number of members in the group to which they must be disseminated. If the cost of each dissemination is denoted C, the total cost of dissemination is now (N-1)C. The strategic situation for Scientist A is modified as follows

Other Members

[34] *See, e.g.,* Robin Cowan, Paul A. David & Dominique Foray, *The Explicit Economics of Knowledge Codification and Tacitness*, 9 INDUS. & CORP. CHANGE 211 (2000); Markus Perkmann & Kathryn Walsh, *Engaging the Scholar: Three Types of Academic Consulting and Their Impact on Universities and Industry* (Loughborough Univ., Wolfson Sch. of Mech. & Mfg. Eng'g, Working Paper, March 2008), *available at* http://ssrn.com/abstract=1133581.

		Share	Don't Share
Scientist A	Share	NU+M+R-(N-1)C	U +M+R-(N-1)C
	Don't Share	NU+E	U+E

In other words, the cost of dissemination is now (N-1)C, rather than simply C. The three regimes discussed earlier now look like:

Regime I: M+R-(N-1)C > E; region of uncoordinated sharing;

Regime II: M+R+(N-1)U – (N-1)C > E > M+R-(N-1)C; region where coordinated sharing is preferred by scientists and a social norm is likely to be viable;

Regime III: M+R+(N-1)U-(N-1)C < E; region where exclusive use of one’s own tool is preferred even to access to all of the community’s tools.

If the cost of disseminating a tool to each other scientist is at all substantial, the total cost of sharing will be much larger in these case than for do-it-yourself tools. The value of exclusivity to a scientist, E, on the other hand, may be larger for materials than for do-it-yourself tools since it may be significantly less likely either that other researchers will develop substitutes or that the tool can "diffuse" to other scientists as a result of the general openness of the scientific community. Moreover, the rewards specifically attributable to sharing, R, may also be decreased. Because publishing is no longer necessarily tied to sharing the rewards of publication may be available whether or not a scientist shares.

For all these reasons, Regimes I and II are likely to be significantly smaller than they were in the do-it-yourself tool case. It is clearly more difficult to establish and maintain a norm of sharing materials and tacit knowledge than a norm of sharing easily appropriable “do-it-yourself” tools and methods by publication. This analysis is consistent with the empirical studies described in Part I, which find significant problems with materials sharing among researchers in the life sciences and which attribute those difficulties to scientific competition (relatively large values of E-M in our model) and the costs of disseminating research materials.[35]

III. POLICY INITIATIVES TO PROMOTE SHARING

If the simple model presented here captures the essence, even if not the subtleties, of the difference between sharing do-it-yourself research tools and sharing research materials, data, and tacit knowledge, then it suggests particular policy directions for shoring up the traditional sharing norms. Shoring up sharing norms is likely to be worthwhile from a social perspective even when scientists themselves prefer exclusivity (i.e., Regime III). This is because of positive social spillovers associated with more rapid scientific advance. In terms of the model, this means that the social value of U is greater than the private value to individual scientists. Moreover, the social value of exclusivity, E, is likely to be negative – society benefits most when research tools are available to all. Finally, some of the policy prescriptions – particularly those related to reducing sharing costs and increasing rewards – make both scientists and society at large better off.

A quick look at the model suggests three potential prongs of attack: decreasing the costs of sharing; increasing the rewards for sharing (or, equivalently, the penalties for not sharing); and reducing the exclusivity premium. In this part, I consider existing and potential means to accomplish each of these goals in the contexts of materials, data, and tacit knowledge.

III.A. Decreasing the Costs of Sharing

[35] *See, e.g.,* Walsh *et al.*, Patents, MATERIAL TRANSFERS AND ACCESS TO RESEARCH INPUTS, *supra* note 2 at 38.

The most promising avenue for encouraging sharing of materials, data, and tacit knowledge is to try to decrease the private cost. One approach is to lower the cost of each instance of sharing. Independently, or in addition, the burden on an individual research tool developer may be reduced by spreading the cost of sharing throughout the community either through a centralized distributor or by spreading distribution duties across the community.

III.A.1 Decreasing the Costs of Sharing Materials and Data

Distribution from a centralized repository, which may be funded directly by government or other non-profit enterprises or supported out of research grants, is a very attractive option for reducing the cost burden on scientists who have developed research materials or extensive datasets. A number of research communities have set up such repositories to handle distribution of biological materials or sharing of data.[36] The NIH Grants Policy encourages such deposits[37] and some have suggested making participation in uniform licensing or materials depositories mandatory for recipients of certain types of federal funding.[38]

A centralized repository reduces sharing costs in two ways. First, such a repository may decrease the absolute costs of distribution--in part because the costs of having individual scientists distribute materials include opportunity costs of time taken

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[36] SCOTT STERN, BIOLOGICAL RESOURCE CENTERS: KNOWLEDGE HUBS FOR THE LIFE SCIENCES (Brookings Institution Press 2004) at 17; Fiona Murray, *The Oncomouse That Roared: Resistance and Accommodation to Patenting in Academic Science* (2005), *available at* http://web.mit.edu/fmurray/www/papers/THE%20ONCOMOUSE%20THAT%20ROARED_FINAL.pdf).

[37] NIH GRANTS POLICY STATEMENT (December 2003), *available at* http://grants2.nih.gov/grants/policy/nihgps_2003/NIHGPS_Part7.htm#_Availability_of_Research. *See also* PRINCIPLES AND GUIDELINES FOR RECIPIENTS OF NIH RESEARCH GRANTS AND CONTRACTS ON OBTAINING AND DISSEMINATING BIOMEDICAL RESEARCH RESOURCES: FINAL NOTICE, 64 FED. REG. 72,090, 72,093 (Dec. 23, 1999), available at http://www.ott.nih.gov/policy/rt_guide_final.html.

from research, which may be extremely high compared to the actual distribution costs, and in part because a repository develops expertise in distribution and in codifying and conveying any tacit knowledge needed to make use of the materials or data. For data, in particular, which can be shared electronically, the costs involved in setting up a centralized repository may be relatively small, marginal costs per distribution virtually nil, and access to the data can be restricted using simple measures such as password protection. A centralized repository will likely also develop standardized terms for depositing and accessing the materials and data it holds, saving the transaction costs otherwise expended in negotiating individual transfers. Second, such a repository shifts the costs from individual scientists, who may not find it privately worthwhile to incur the costs, to the community as a whole (or, in many cases, the government), which may well find the benefits of distribution to be worth the costs. Governement funding of centralized repositories may be particularly attractive because sharing is likely more valuable to society as a whole than it is to the scientific community.

Though it is not generally thought of as a mechanism for enhancing sharing, commercial supply of research materials is an alternative mechanism of centralized distribution which alleviates the cost to a research tool developer of sharing the tool. Laboratory equipment and reagents are routinely supplied by commercial distributors, of course. There are many advantages to commercial distribution. Commercial suppliers have expertise in manufacturing and production that certainly cannot be replicated by individual scientists and is likely to reduce the costs of distribution substantially. If commercial distribution were competitive and materials sold at marginal cost, there

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[38] Walsh *et al.*, PATENTS, MATERIAL TRANSFERS AND ACCESS TO RESEARCH INPUTS IN BIOMEDICAL

would be little real difference in cost to the public between commercial distribution and distribution managed more directly by the research community, since both commercial purchases and depository costs of distribution would be paid for by research grant money.

The rub, of course, is that often the same factors that preclude "do-it-yourself" tool use by scientists also make competition between commercial suppliers less likely. This may be the case regardless of whether a material is patented, since scientific factors (such as the need for standardization or for access to a specific cell line) may favor a single supplier. Where a material is patented, exclusive licensing may also preclude competitive commercial supply. In these cases an exclusive commercial supplier can collect monopoly rents and commercial supply would be more costly to the research community than a community-supported repository.

Commercial supply may be unavoidable, however, when a material has a lucrative non-research market alongside its use in research. While a commercial market might in principle co-exist with a non-profit repository for supplying a material to scientists, distributing the same materials commercially and through a repository would mean duplication of effort, possibly undermine the goal of standardization, and probably lead to conflicts about the terms of distribution. The more likely scenario is that both the non-research market and the scientific community will obtain their materials from a commercial supplier.

While there are, as mentioned above, benefits to purchasing from a commercial supplier, which provides uniform quality, simplified transactions, and reduced costs of production, a commercially attractive material is more likely to be patented and may

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RESEARCH, *supra* note 2 at 39.

simply command a higher price due to its non-research applications. Moreover, turning the material from a research tool into a commercial product may require large additional investments which a supplier will need to recoup. For example, expensive clinical testing might be necessary to satisfy regulatory requirements, but be unnecessary to use an invention in some kinds of research. In such situations, the goal should be to encourage commercial suppliers to provide substantial discounts for research use.

Non-profit researchers often do get substantial discounts on research materials.[39] Suppliers may be motivated to offer discounts as a form of monopoly price discrimination, but it also may be that reputational penalties can be imposed on suppliers who refuse to provide research discounts. Commercial suppliers who engage in research overlapping that engaged in by non-profit scientists or for whom such scientists are important customers can be susceptible to boycotts.[40] In some fields, non-profit research may be seen as such an important contributor to public health or some other social concern that the public at large might protest a failure to make accommodations for academic research. In certain cases, however, particularly those involving physicians who wear both researcher and clinician hats, academic discounts are certain to pose difficult line-drawing problems and raise the specter of arbitrage. Indeed, such situations are centers of controversy.[41]

Where a commercial supplier does not engage in overlapping research and does not count on scientists as important customers, the research community may have little

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[39] Indeed, materials are often supplied without charge. Walsh *et al.*, PATENTS, MATERIAL TRANSFERS AND ACCESS TO RESEARCH INPUTS IN BIOMEDICAL RESEARCH, *supra* note 2 at 25. (Though sometimes not without a fight, *see* Murray, *supra* note 36.)
[40] *See, e.g.,* Murray, *supra* note 36.
[41] *See, e.g.,* David C. Mowery & Arvids A. Ziedonis, *Academic Patents and Materials Transfer Agreements: Substitutes or Complements?*, 32 J. TECH. TRANSFER 157 (2007).

leverage. In such cases any norm of discounted pricing must be implemented through the licensing practices of the non-profit scientist who developed a tool. The costs to a scientist of negotiating a license to favor non-profit research include the transaction costs of negotiating non-profit discounts along with whatever reduction in compensation for the license the scientist must "pay" to the commercial supplier in exchange for the discount. Reducing the transaction costs of research-friendly licensing is the aim of another approach to sharing cost reduction, to which I now turn.

While distribution by a centralized depository would often provide the lowest cost means for sharing research materials and data, there are situations in which it is not feasible for or acceptable to researchers and their institutions. Sometimes researchers prefer to control the distribution of materials and data not so much to use them exclusively as to use them as a means of entry into collaborative and co-authorship arrangements. The legitimacy and value of such practices may be disputed – indeed, commenters on the NIH's Principles and Guidelines specifically complained of this practice[42] -- and probably depend on technical field. In any event, scientists may in some cases not be willing to give up this particular type of tit-for-tat exchange. As mentioned above, scientists and university technology transfer offices also may at times be unwilling to relinquish control of materials or data with both research and commercial applications.

If, for whatever reason, the option of centralized distribution is unworkable, a next-best means to reduce sharing costs is to reduce the transaction costs of individualized transfers. Of course the lowest transaction cost (and likely still most common) mechanism for individualized transfers is the traditional method of simply shipping samples off to a colleague. Where this is not acceptable to the parties involved, perhaps because the material also has commercial applications, one way to reduce the cost of sharing is for scientists and their institutions to specify uniform terms of transfer

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[42] NIH PRINCIPLES AND GUIDELINES, *supra* note 37

in advance. The moderately successful "Uniform Biological Materials Transfer Agreement" (UBMTA), a uniform contract for sharing biological materials, is an example of such an effort.[43] Developed by the NIH in 1995, the UBMTA provides for materials transfer for non-commercial research with no reach-through rights, royalties, fees (except for minimal fees to cover costs), or publication restrictions. While numerous institutions have signed the agreement, its use is not mandatory and many universities have modified the terms of the agreement, undermining to some extent the attempt to reduce transaction costs.[44] Nonetheless, most transfers from one academic institution to another involving materials transfer agreements now seem to occur without substantial delay.[45]

Another possible role for standardized transfer terms is in transfers from non-profit research institutions to commercial institutions. Though attempts to promulgate an industry-university version of the UBMTA have been unsuccessful,[46] attempts to encourage non-profit institutions to include research exemptions in exclusive materials transfer agreements to industry may be more successful because they can be enforced by research community norms. A standardized practice of this sort would have the beneficial side effect of reducing the costs to individual researchers of negotiating such licensing restrictions.

III.A.2 Reducing the Costs of Sharing Tacit Knowledge

Reducing the costs of sharing tacit knowledge requires somewhat different strategies since tacit knowledge cannot simply be donated to a centralized repository. Two primary options are available: diffusion, which does not necessarily reduce the total cost of transferring the knowledge but spreads it throughout the community; and

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[43] See Rai, *supra* note 1313at 113; Eliot Marshall, *Need a Reagent? Just Sign Here*, 278 SCIENCE 212, 213 (1997).
[44] See Mowery et al, *supra* note 41 at 161-62.
[45] Walsh *et al.*, PATENTS, MATERIAL TRANSFERS AND ACCESS TO RESEARCH INPUTS IN BIOMEDICAL RESEARCH, *supra* note 2 at 3.
[46] See Arti K. Rai & Rebecca S. Eisenberg, *Bayh-Dole Reform and the Progress of Biomedicine*, 66 L. & Contemp. Probs. 289, 305-06 (2003).

codification, which can both reduce the total cost of sharing knowledge and allow for centralized distribution.

Many of the current practices of the scientific community facilitate the diffusion of tacit knowledge of research methodology and there may not be much more to do in this regard other than to recognize the role these practices play in facilitating sharing. Thus, visiting scientists, postdoctoral researchers, and graduate students learn from their experiences and interactions and take tacit knowledge with them as they move from one laboratory to another. They pass that knowledge along to others with whom they later interact. This means of sharing tacit knowledge greases the wheels of inter-institutional collaboration, no doubt to the overall benefit of the scientific enterprise.

There are some downsides to relying on diffusion as a means of sharing tacit knowledge, however. Diffusion is a slow process and is heavily reliant on the structure of particular social networks. Knowledge about tools and methods that might be useful in addressing a variety of technical problems may become "stuck" in a particular sub-discipline. In such cases, codification is a desirable alternative. There is nothing particularly new about this observation, of course; it is as old as writing itself. But it does draw our attention to the way in which facilitating codification of tacit knowledge might enhance the viability of sharing norms.

To the extent that codification of tacit knowledge about research practices can be achieved inexpensively through written exposition, current practices of publication, grant application, and dissertation writing, encourage it. More interesting for present purposes is the potential for technological codification of research practices by implanting them in standardized equipment or in protocols which employ standardized materials and tools or by automating them.[47] Some of this sort of codification will be a natural outgrowth of the diffusion of the use of the tool throughout the community. But codification efforts may

[47] *See, e.g.,* Cowan *et al.*, *supra* note 34; VON HIPPEL, *supra* note 4 at 70-72 (discussing the role of manufacturers in developing innovations related to reliability and standardization).

be costly for researchers because they take time away from research. Just as there are advantages to centralized distribution of research materials and data, there may be advantages to centralized codification.

One approach to centralized codification is to transfer the tacit knowledge to a commercial tool supplier to produce a more "user-friendly" standardized version of the tool, which can be adopted by later users with minimal transfer of tacit knowledge. Tool suppliers can then also take on some of the task of tacit knowledge transfer by providing training in how to use the tool or method (essentially providing centralized distribution of tacit knowledge).

The idea that manufacturers, rather than users, would be responsible for innovations involving standardization is in fact a general one, as studies of the genesis of scientific instrumentation and of other user innovations have demonstrated.[48] To induce a commercial entity to invest in standardization, the exclusivity provided by a patent on the original tool or method may or not be necessary (depending in part on whether the improvements involved in standardization are themselves patentable). Indeed, the need for codification is perhaps the best normative justification for patenting research tools that do not have dual commercial and research uses. The more standard argument that university inventions are so "embryonic" that they require the special incentive of patents to induce commercial entities to bring them to market is generally weak for research tools, which are already being used in the lab.[49]

Codification of tacit knowledge into a commercial research tool may require the involvement of both the scientist who developed it and a manufacturer.[50] A number of

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[48] VON HIPPEL, *supra* note 4.

[49] *See, e.g.,* A. Jensen, Jerry G. Thursby & Marie C. Thursby, *Disclosure and Licensing of University Inventions: 'The Best We Can Do with the S**t We Get to Work With'*, 21 INT'L J. INDUS. ORG. 1271 (2003); F. Scott Kieff, *Property Rights and Property Rules for Commercializing Inventions*, 85 MINN. L. REV. 697 (2001). *See also* Strandburg, *Users as Innovators*, *supra* note 4 at 512 (discussing this issue).

[50] *See, e.g.,* Jeannette Colyvas, Michael Crow, Annetine Gelijns, Roberto Mazzoleni, Richard Nelson, Nathan Rosenberg, and Bhaven Sampat, *How do University Inventions Get into Practice?* 48 MGMT. SCI. 61 (2002); Jensen et al, *supra* note 49; Richard Jensen & Marie Thursby, *Proofs and Prototypes for Sale:*

studies have documented the importance of scientist involvement in commercializing university inventions (though it is not clear how many of these inventions are research tools).[51] While the costs to a scientist of assisting with the codification of tacit knowledge may be less than the costs of imparting that tacit knowledge to the entire researcher community one by one (in other words, they do not scale with the size of the community), they may still be significant. Because involvement in such codification projects takes a scientist away from her research, incentives to assist, such as patent royalties, consulting fees, or research funding, may be required. These incentives may be as or more important than the more often emphasized use of patents to incentivize participation by a commercial supplier.[52] Patent exclusivity may not be necessary to induce manufacturers to compensate scientists for these codification efforts depending on how easily the standardized tool can be copied by cometing manufacturers.

It is also possible to consider the potential for the analog to the non-profit centralized repository – a non-profit centralized codifier. Non-profit institutions seem already to play this kind of role for research software in some cases, often on an open source basis. It may be worth exploring whether the model of non-profit centralized codifier could be employed more frequently so as to avoid the higher prices that undoubtedly accompany commercial codification efforts. Such an institution would have to develop mechanisms, perhaps through reputation or research funding awards, to induce scientists to participate in the codification process, which is likely to be more time-consuming than a simple transfer of data or materials.

The Tale of University Licensing, 91 AM. ECON. REV. 240, 243 (2001) (discussing the importance of inventor involvement in commercializing university inventions); Robert A. Lowe, *The Role and Experience of Inventors and Start-Ups in Commercializing University Research: Case Studies at the University of California* (U. Cal. Berkeley, Ctr. for Stud. in Higher Educ., Research & Occasional Paper Series CSHE.6.02, 2002); Markus Perkmann & Kathryn Walsh, *Engaging the Scholar: Three Types of Academic Consulting and Their Impact on Universities and Industry* (Loughborough Univ., Wolfson Sch. of Mech. & Mfg. Eng'g, Working Paper, March 2008), *available at* http://ssrn.com/abstract=1133581.

[51] See references *supra* note 50.

[52] *Compare* Kieff, *supra* note 49 *with* references *supra* note 50.

Optimally, intellectual property policies of non-profit institutions would distinguish between situations in which scientists can pick up the tacit knowledge needed to use a research tool relatively easily through knowledge diffusion and situations in which significant investment in codification is worthwhile. Because scientists are sophisticated users of research tools, one might expect situations in which significant commercial investment in codification is needed to be relatively rare. Only in such situations, or in situations involving a non-research market, is patenting, or any form of exclusive licensing, of research tools like to be socially beneficial. The NIH has recognized a similar point in its Principles and Guidelines for grant recipients, noting that for research tools for which "further research, development and private investment are [not] needed to realize" their primary usefulness, the goals of technology transfer "can be met through publication, deposit in an appropriate databank or repository, widespread non-exclusive licensing or any other number of dissemination techniques. Restrictive licensing of such an invention, such as to a for-profit sponsor for exclusive internal use, is antithetical to [these goals]."[53]

III.B. Means to Increase Rewards for Sharing and Penalties for Failing to Share

Another way to enhance the viability of a sharing norm is to increase the rewards for sharing (or equivalently the penalties for failing to share). "Norm entrepreneurs" often play a role in attempting to increase reputational penalties for failing to share.[54] Recently, for example, a group of research universities issued a list of nine points to consider in licensing university technology which urges universities to negotiate all licenses, even those involving industry, so as to reserve rights for all non-profit organizations "to transfer tangible research materials . . . to others in the non-profit and government sectors."[55] This proposal goes beyond the UBMTA, particularly in its

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[53] NIH PRINCIPLES AND GUIDELINES, supra note 37 at 72,093.
[54] *See, e.g.* HETCHER, *supra* note 3 at 268-72.
[55] Ass'n of Am. Med. Colleges *et al.*, *In the Public Interest: Nine Points to Consider in Licensing University Technology* (White Paper, March 6, 2007), *available at* http://news-

emphasis on retaining rights for academic research when transferring tools and materials to commercial entities. Such public pronouncements of intentions to share also serve as pre-commitment devices, since the reputational penalties of backing out of a promised course of action are presumably heightened. In a similar attempt to delineate a research commons, the non-profit research community is also directing greater attention to potential conflicts of interest in technology transfer, another means of drawing attention to deviations from sharing norms.[56]

Particularly in cases where centralized distribution or codification do not replace "face-to-face" dissemination – and hence costs scale with the number of researchers to whom knowledge or materials are transferred – sharing may be facilitated by rewards that scale with the number of transfers. Interestingly, co-authorship and collaboration practices often seem to serve this end. Interviews suggest that links between co-authorship or collaborative opportunities and transfers of materials, data, or tacit knowledge are sometimes quite explicit and are scaled back as the community perceives that a practice has become sufficiently codified or sufficiently widespread, suggesting that the cost of transferring the tool or method has also declined.[57] As noted above, the practice of awarding co-authorship for providing materials is controversial, probably because it might dilute the signal of scientific competence which co-authorship is intended to send. The extent to which this is a serious concern no doubt varies by discipline, since it easy to imagine that in some fields scientists gain well-deserved reputations as good tool developers in this way.

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service.stanford.edu/news/2007/march7/gifs/whitepaper.pdf. *See also Guidelines offered for responsible technology licensing*, STANFORD REPORT (March 7, 2007), *available at* http://news-service.stanford.edu/news/2007/march7/tech-030707.html. *See also*, Murray, *supra* note 36.

[56] *See, e.g.,* Patrick L. Jones & Katherine J. Strandburg, Technology Transfer and An Information View of Universities: A Conceptual Framework For Academic Freedom, Intellectual Property, Technology Transfer and the University Mission (2006) (unpublished paper), *available at* http://works.bepress.com/katherine_strandburg/10; David Korn, *Conflicts of Interest in Biomedical Research*, 284 J. AM. MEDICAL ASS'N 2234 (2000); OF AM. UNIVS, REPORT ON INDIVIDUAL AND INSTITUTIONAL FINANCIAL CONFLICT OF INTEREST (2001).

[57] Murray, *supra* note 36at 22-23.

III.C. Decreasing the Exclusivity Premium

Finally, it may be possible in some cases to use policy mechanisms to decrease the potential benefits of exclusivity. To some extent, the exclusivity premium for materials, data, and tacit knowledge is inherent in their nature. If a scientist does not take affirmative steps to share materials and data, they remain in her hands, barring theft. Tacit knowledge cannot even be stolen. The social structure of academic science mitigates this situation, however. Post-doctoral researchers and graduate students may take materials and data (and unavoidably take tacit knowledge) with them when they move on to other laboratories. While universities may have policies requiring formal material transfer agreements when graduate students and postdocs move on to other institutions, it seems likely that such policies are evaded informally with some regularity.[58] Similarly, while confidentiality agreements would be possible in principle, they are unlikely to be employed in this setting, since the whole point of graduation education is to impart the skills and knowledge necessary for independent research. Graduate advisors are rewarded when their students become successful independent researchers, reputationally and often through ongoing collaborations.

Nonetheless, and in contrast to the situation with do-it-yourself research tools, a fair degree of potential payoff from refusing to share materials and extensive datasets remains as long as it is possible to publish research results (and obtain the corresponding rewards) without sharing related materials or data. The potential advantages of refusing to share materials and data can be reduced by linking scientific rewards – journal publication and awards of research funding – directly to sharing. To that end, scientific journals are implementing policies requiring that materials and data necessary for

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[58] Walsh *et al.* PATENTS, MATERIAL TRANSFERS AND ACCESS TO RESEARCH Inputs , *supra* note 2 at 25 (only 35% of materials transfer requests between academics requested a Materials Transfer Agreement) is at least suggestive in this regard.

replicating published results be made available to the research community.[59] A report of the National Academies of Sciences in 2003 entitled "Sharing Publication-Related Data and Materials[60]" was the impetus for a number of journals to "insist[] that data and materials described in an article be made widely available."[61] Such policies have the effect of coupling publication to sharing, just as requiring sufficient explanation for replicability does in the do-it-yourself research tool context. Scientists can (and no doubt do) maintain exclusivity for a time by delaying publication, but there is a limit to the extent that this is possible because of competition for scientific priority and of the need to publish regularly in order to retain funding and attention from and participation in the research community.

Similarly, if funding agencies were to require that materials and data associated with publications resulting from grants be made available to other non-profit researchers, the potential for exclusivity would be reduced drastically. The NIH has implemented a number of policies aimed at promoting the sharing of data and research tools and materials resulting from NIH-funded research. Thus, with regard to research data, the NIH Grants Policy, adopted in 2003, states the following:

> NIH . . . expects and supports the timely release and sharing of final research data from NIH-supported studies for use by other researchers. . . . [I]nvestigators submitting an NIH application [above a certain funding level] are expected to include a plan for data sharing or state why data sharing is not possible.[62]

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[59] *See, e.g.,* Murray, *supra* note 36at 40. *See also*, regarding the importance of sharing scientific information via publication, THE ROLE OF SCIENTIFIC AND TECHNICAL DATA AND INFORMATION IN THE PUBLIC DOMAIN: PROCEEDINGS OF A SYMPOSIUM (Julie M. Esanu & Paul F. Uhlir eds., Nat'l Acads. Press 2003); Paul David*, The Economic Logic of "Open Science" and the Balance between Private Property Rights and the Public Domain in Scientific Data and Information: A Primer, in* THE ROLE OF SCIENTIFIC AND TECHNICAL DATA AND INFORMATION IN THE PUBLIC DOMAIN: PROCEEDINGS OF A SYMPOSIUM 19 (Julie M. Esanu & Paul F. Uhlir eds., Nat'l Acads. Press 2003); Eric G. Campbell, Brian R. Clarridge, Manjusha Gokhale, Lauren Birenbaum, Stephen Hilgartner, Neil A. Holtzman & David Blumenthal, *Data Withholding in Academic Genetics: Evidence from a National Survey*, 287 J. AM. MEDICAL ASS'N 473 (2002).

[60] NATIONAL ACADEMIES OF SCIENCES, SHARING PUBLICATION-RELATED DATA AND MATERIALS (2003) .

[61] Murray, *supra* note 36at 40.

[62] *Supra* note 37.

With regard to research materials, the Policy provides:

> NIH considers the sharing of such unique research resources (also called research tools) an important means to enhance the value of NIH-sponsored research. . . . Therefore, [after publication] it is important that they be made readily available for research purposes to qualified individuals within the scientific community. . . .

Peter Lee has recently discussed the way in which California employs similar (and more stringent) requirements to tie funding from its stem cell research initiative to sharing of research tools and materials with other researchers in California.[63] While the restriction of the sharing requirement to California researchers may not be globally optimal, the program illustrates how sharing may be tied to funding.

To the extent that policies of this type are actually enforced, they can play a very important role in reducing the available exclusivity premium. Even if unevenly enforced, publicly adopted policies such as these can play a role in norm development and hence in increasing reputational penalties for refusing to share.

Where materials and data useful in research have commercial markets outside of the research context, commercial exclusivity has benefits over and above the payoff for scientific exclusivity we have focused on here. Trouble for sharing norms arises when these two forms of exclusivity are coupled: if a researcher fears that sharing with other scientists will undermine her potential to recoup profits from commercialization, she will be less motivated to share. Terms imposed by industrial partners can also provide academic researchers "cover" against reputational penalties for failing to share. In the case of the oncomouse, for example, a colleague noted the benefits of the exclusivity that

[63] Peter Lee, *Contracting to Preserve Open Science: The Privatization of Public Policy in Patent Law*, available at http://ssrn.com/abstract=1263125

the inventor's deal with DuPont gave him and said that he had "a perfect alibi in refusing to send [mice] to others -- he was no longer a strategic opportunist but rather a scientist beleaguered by legal constraints."[64]

Policy initiatives should aim to distinguish between sharing for the purpose of research and sharing for commercial purposes, thus, in terms of our model, decoupling the scientific exclusivity payoff, E, from the payoff from commercial exclusivity. The NIH Principles and Guidelines, for example, distinguish between sharing with for-profit and not-for-profit entities.[65] For do-it-yourself research tools, patents may facilitate this distinction, since patent rights can be ignored in the context of research, but enforced against sellers to a commercial market.

Where a research material that is not easily copied is at issue, decoupling may be attainable without patents --- a scientist can simply share the material with other scientists and sell it to the commercial market. Of course, if a material is sufficiently valuable on the commercial market, the scientist who developed it (or his or her technology transfer office) may want to restrict dissemination even to other academic researchers for fear of arbitrage. When journal and funding agency policies require sharing with other researchers the choice not to share with other scientists becomes more costly, however. Here, again, patents may have a role to play in policing the boundary between research use and commercial exploitation, since infringement by other scientists can be tolerated (or licensed on non-restrictive terms) while pursuing commercial infringers.[66] At the

[64] Murray, *supra* note 36at 35.
[65] *Supra* note 37.
[66] *Strandburg, supra* note 9. *See also* Murray, *supra* note 36 for a discussion of the role patents play in maintaining a boundary between academic and commercial research.

margin, some developers of particularly lucrative tools and materials will choose to defect from the research community and concentrate on commercialization.

Reducing the exclusivity premium for tacit knowledge is more difficult than reducing the exclusivity premium for materials and data. In principle, journals might go some way by requiring more explicit descriptions of research tools and methods. Something like this is accomplished by the enablement standard of patent law[67] and by the generally accepted requirement that published research be reproducible. Essentially, these requirements ensure that a certain amount of tacit knowledge is codified by the scientist in writing. However, there are limits both to the extent to which tacit knowledge can be effectively codified in written form and the extent to which journals are likely to require more explicit description in light of page length restrictions.[68]

Moreover, like some materials, some tacit knowledge has both scientific and commercial value. For example, empirical studies have noted that participation by the scientist who developed a technology is often critical to the success of university technology transfer.[69] Much more than with materials and data, it is very difficult to preclude other researchers to whom one transfers tacit knowledge from later using that knowledge for commercial purposes. If there is a very large commercial value to particular tacit knowledge, it thus may be difficult to decouple the scientific and commercial exclusivity payoffs so as to reduce the parameter E in our model. It thus seems unlikely that the exclusivity premium from tacit knowledge can be significantly

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[67] 35 U.S.C. § 112.
[68] *Compare* CHISUM ON PATENTS § 7.03[4] (Discussing a similar issue with respect to the "undue experimentation" limitation on the enablement requirement of patent law).
[69] *See, e.g.,* Jensen & Thursby, *supra* note 49.

reduced as a practical matter. Other approaches to encouraging sharing are likely to be more effective.

IV. CONCLUSIONS AND SOME IMPLICATIONS FOR USER INNOVATION

Our understanding of empirically observed differences between norms of sharing "do-it-yourself" research tools (even if patented) and norms of sharing research materials is enhanced by considering a simple rational choice model of social norms. The model suggests that the primary difference between the two cases is the fact that costs of sharing materials frequently rise in proportion to the size of the research community because materials cannot be disseminated by the standard publication mechanism. Similar issues would then be expected to arise with regard to sharing large data sets and tacit knowledge. Focusing on the sharing cost and other parameters of the model allows us to interpret a number of observed behaviors and suggests policy directions for bolstering sharing norms. In particular, the model suggests that attention continue to be paid to centralizing distribution of materials and data for non-profit research and that more attention be paid to the possibility of centralized non-profit codification, such as may be going on with some types of research software.

This case study also raises issues which should be of concern to those with more general interest in user innovator communities or "collective invention." Case studies often show user innovators freely revealing their inventions to one another.[70] Historical studies of collective invention have noted the important role that publication has played in facilitating collaborative progress.[71] Like the scientific community, user innovator

[70] *See, e.g.,* VON HIPPEL, *supra* note 4 at 77-92.
[71] *See, e.g.,* Allen, *supra* note 5; Peter B. Meyer, *Episodes of Collective Invention* at 3, 5, 13, 21 (U.S. Dep't of Lab. Bureau of Lab. Stat., Working Paper No. 368, 2003), *available at* http://ssrn.com/abstract=466880.

communities, particularly when composed of lead users, are often well suited to "do-it-yourself" dissemination of inventions because users tend to have high absorptive capacity for inventions made by other users. Like research tools and methods, user innovations often go through a cycle of "do-it-yourself" use followed by commercial standardization and supply.[72] The experience of the scientific research community, at least according to the preceding analysis, suggests that it may be fruitful to contemplate whether sharing in other user communities may be undermined to some extent by sharing costs incurred by individual user innovators and, if so, what might be done to centralize and reduce such costs. Investigation of the means by which user innovations become commercial products (often by entrepreneurship on the part of user innovators) is one entrance point into this issue, but no doubt there are others, particularly in contexts where, as in scientific research, most user innovators are not interested in becoming commercial distributors of their inventions.

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[72] *See, e.g.*, Sonali K. Shah and Mary Tripsas, *The Accidental Entrepreneur: The Emergent and Collective Process of User Entrepreneurship*, 1 STRAT. ENTREPRENEURSHIP J. 123 (2007); Sonali K. Shah, *From Innovation to Firm Formation: Contributions by Sports Enthusiasts to the Windsurfing, Snowboarding & Skateboarding Industries*, PROC. SIXTH ANN. MTG. OF THE INT'L SPORTS ENG'G ASSN. (2006); VON HIPPEL, *supra* note 4; Thierry Burger-Helmchen, *A Case Study on Video Game Industry* (Working Paper, June 2008), *available at* http://ssrn.com/abstract=1146531; Sheryl Winston Smith, *Strategic Venturing in the Global Medical Device Industry: Corporate Venture Capital and Entrepreneurship*(Working Paper, May 2008), *available at* http://ssrn.com/abstract=1105461.