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Mitigating damages to global science from "the anti-commons"

New moves in 'legal jujitsu' to combat adverse unintended consequences of commercial exploitation of the IPR on publicly funded research results

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Introduction and Overview

Most of the discussion and debate among legal scholars and economists concerning the so-called 'anti-commons' has been restricted to questions about the existence and seriousness of the obstacles to discovery, invention and innovation that Heller and Eisenberg (1998) suggested could result from "over-patenting" in the biomedical research area. But the anti-commons, as a conceptualization of the perverse resource allocation effects of the distribution of private ownership rights, has a considerably wider potential range of empirical relevance, and warrants commensurately more careful study. This chapter underscores that analytical point,first by considering a stylized model of the impediments imposed upon the conduct of research by the burdensome licensing charges that arise from the dispersed distribution of ownership rights in a multiplicity of research tools that are complementary. To make more transparent the generic character of the argument, this heuristic analysis focuses on multiple database resources as the "research tools" of interest, individual access rights to each of which are held by differeent IP rigths owners. Adopting that approach both recognizes the emergence and growing role of digital databases as critical facilities of the research infrastructure in many scientific and technical domains, and serves to demonstrate the generality of the phenomenon of "multiple marginalization" that emerges from the uncoordinated exercise of market power by individual rent-seeking rights-holders in setting licensing charges on their IP. Having briefly examined the relationship between that "core" phenomenon and other parts of the "anatomy of the anti-commons," I turn next to consider whether market processes themselves could not correct the pathology. This part of the discussion briefly exposes several serious limitations of what may be viewed as the likely "spontaneous," profit-driven institutional responses that could emerge to mitigate the anti-commons – in imitation of the private copyright clearance agencies and music performance rights collection societies. As it is unreasonable to expect that effective remedial developments of that kind will be forthcoming, there is a stronger case for pursuing new policies that would promote the "contractual construction" of scientific research commons, by common-use licensing agreements among the owners of IP arising from publicly funded scientific projects. This 'bottom-up' approach offers a path toward more far-reaching institutional changes that would mitigate some of the unintended consequences of the spread of efforts to claim and exploit intellectual property rights based upon publicly funded university research results.

Understanding the "anti-commons" – a brief anatomical tour

There are three analytically distinct layers of the troublesome object that has been labeled " the anti-commons." Each is associated with a different kind of problem that may arise from the distribution of perfect exclusion rights over resources, rights of the sort that are conveyed by legal property ownership – and by intellectual property monopolies in particular. Searching to locate the owners of relevant rights, negotiation with those rights owners from whom access rights are needed, and paying the pecuniary charges for the licenses that are granted, are the layered activities; each may impose costly burdens on enterprises that require access to the use of such assets when they are both numerous and in the hands of many other parties. Distinguishing among these potential sources of cost for scientific and technological research enterprises in which they represent required"inputs" is important. Their economic implications are differently affected by the structure of productive relationships among the resources that enter into the research process, and particularly by the degree of technical complementary among various "research assets" that fall under the control of diverse owners of exclusion rights (such as are conveyed by IP ownership). Further, dealing separately with these parts of the anatomy of the anti-commons acknowledges that such inefficiencies in the allocation of research resource as they would occasion may differ in seriousness, be amenable in different degrees to market solutions, or, failing that, require distinctive institutional remedies.

Search costs are entailed in order to determine whether particular "tools" described in the scientific research literature – such asdatabases, or fast algorithms for mass spectrographic analysis, or specific biotechnology techniques (enzyme restriction methods, polymerase chain reaction, monoclonal antibodies, and others that are less well known) – are in the public domain or under patents, and if so who owns the rights to use them. The necessary searches that projects might conduct can be time consuming, and mount in costs when many such tools are needed and the rights to use each of them can be in the hands of different owners. Similarly, finding all the specialized annotated databases containing the chromosomal locations of genetic mutations, or extended series of satellite images showing the locations and durations of plankton blooms and other oceanographic phenomena, and identifying whether each map or image is available in the public domain, or under copyright protections owned by various parties, would be quite burdensome when they are not collected and made available by a single licensing intermediary.

The *transactions costs* are distinct from search costs, and arise only after one has identified the owner(s) of the IPR and begun to seek a license, or an agreement to transfer materials. Under the heading of transaction costs belong the time spent by lawyers or other negotiating agents – including the interesteed researchers who may need to personally contact members of other research groups at a firm or university that holds the IPR;they may have to work out a research collaboration as a way of arranging for cross-licensing, to gain access data or techniques or transfers of materials between laboratories. If a number of research tools and inputs are required, the sunk costs for each agreement negotiated may yield little of value to the project if they are strict complements of another "tool" for which no access agreement can be concluded. "Hold-ups" occur when owners refuse to deal, or wait until all the other properties have been assemble and seek to extract all the available "rent" in exchange for completing the

tool-package. When the components of the package are in many hands, the risks of this rise, since it is more difficult to determine the likelihood that one of the IPR owners –for one is all it takes—will behave in this strategic matter. In some sense, the latter amounts to a second order search cost problem. Search and transactions costs, as they have been defined here, are incurred before any deals can be concluded, and it should be acknowledged that specialized intermediaries could undertake to carry out the search and transaction negotiations. Economies of scale and scope, and free entry into that business therefore would work to contain these costs even as the number of parties increased.

But that does not apply to the third layer of burdensome costs the prospective research product. These stem from the effect on the price of access to the bundle of tools arising from a form of "royalty-stacking" that is referred to as "*multiple-marginalization"*. The distribution of exclusion rights to multiple items means that they may be priced in a way that disregards the negative pecuniary externalities of raising the price on any single item. When tools are gross complements, rather than substitutes, the resulting inefficiency is the dual of that produced by ignoring congestions externalities.

This duality has been shown by Buchanan and Joon (2000), who responded to the challenge in Heller's (1998) original paper on "The Tragedy of the Anti-Common." Heller had remarked that there was no formal analysis that proved his intuition that dispersed property rights might imped the workings of markets. Buchanan and Joon set up a simple model in which the pricing of strictly complementary components by their owners' ignores the negative income effects (pecuniary externalities) that their supply price would have upon the demand for the project as a whole. The combined effect of all the vendors' independent decisions is found to be to so raise the price of each item in the bundle of commodities that the quantity demanded of the entire bundle will be driven not only below the efficient use level that would obtain if every item was priced at its marginal cost, but lower than what would result if a single monopolist held all the items and priced them to maximized her profits on the whole lot. This is the economic core of the anti-commons problem.

The generalized "research data anti-commons" – a heuristic model

For convenience in showing the symmetry between the exhaustion of the value of a finite resource that is over-used, because there are no exclusion rights in the hands of any of the potential users of a tangible resource, and loss of the value of a bundled of resource whose differentiated but complementary parts are owned by so many monopolists that a resulting high-priced bundle as a whole remains un-utilized, Buchanan and Joon (2000) construct an artificial case: a physical space that can be used as an urban parking lot. Under one regime access to the spaces are unrestricted (and un-priced), and the lot is completely congested, so that its value to those needing to park is destroyed. In the other case, to occupy any space requires purchasing many types of (differently colored) tickets, one from each of many different exclusive owners of tickets of a distinct color. The price of the effective permission to park would rise until nobody would use the spaces, and the value of the resource thereby is destroyed.

The connection between the effects on scientific research of the distribution of IPR, and this formal analysis of the anti-commons is perhaps a little too strained to effectively convey the

generality and the implications of "multiple marginalization" for the allocation of resources among research projects of different kinds. Multiple-marginalization should be seen not only as potentially impeding the use of patented or copyrighted research tools, and thereby blocking some research projects, but, more generally, as degrading the exploration of large data-fields – or "discovery spaces" formed by the federation of databases – which have become particularly important in many exploratory research domains.

To fix ideas here, one can take as a concrete example, the haplotype map, or "HapMap" as an emblematic a database tool that has been created to allow biomedical researchers to find genes and genetic variations that affect health and disease. The DNA sequence of any two people is 99.9 percent identical, but the variations may greatly affect an individual's disease risk. Sites in the DNA sequence where individuals differ at a single DNA base are called single nucleotide polymorphisms (SNPs – referred to colloquially as "snips"). Sets of nearby SNPs -- on the same chromosome -- are inherited in blocks; the pattern of SNPs on a block is called a haplotype. Blocks may contain a large number of SNPs, yet a few SNPs are enough to uniquely identify the haplotypes in a block. The HapMap is a map of these haplotype blocks and the specific SNPs that identify the haplotypes are called "tag SNPs". By reducing number of SNPs required to examine the entire genome for association with a phenotype -- from the 10 million SNPs that exist down to roughly 500,000 tag SNPs – the HapMap provides a means of greatly reducing the costs and effectiveness of research in the field of genetic medicine. By dispensing with the need for typing more SNPs than the necessary tag SNPS, it raises the efficiency and comprehensiveness of genome scan approaches to finding regions with genes that affect diseases.

One may then imagine the situation of distributed exclusion rights that could arise from the independent patenting of tagged sequences by separate research groups, working in different universities and firms. But, even supposing that the SNPs individually were left in the public domain, multiple owners of rights to exclude researchers from searching for particular "tag SNPs" could arise where legal protections were afforded to database owners who had made an investment in assembling the contents. Deep-linking and database federation can be impeded by the legal protection of database rights afforded by national legislation conforming to the EU's 1996 Directive on the Legal Protection of Data Base Rights, as these apply to both copyrighted materials or materials that are not copyrightable. Access costs charged by each collection of "tag SNPs" would then tend to impede the research use of extensive "discovery spaces" for exploratory research in genomics, proteinomics and related epidemiological data, even where owners were prepared to license extracting content from them. (See e.g., Cameron, 2003, on the infeasibility of contrasting something resembling the European Bioinformatics Institute's federated database structure under present presently prevailing conditions.)

To examine this a little more formally, consider a simple model of a research production project: the output is results, R, produced under cost-minimizing conditions on a budget of G

$$G = \Sigma[p\ \{i\}]\ [b\{i\}] + X,$$

according to the production function

$$R = F(S , X),$$

where X is a vector of inputs of experimental time and equipment and S is the output of a search activity, according to search function:

$$S = S(b\{1\}, b\{2\}, \ldots b\{B\}), \text{ in which}$$

b{i} is the information extracted from database i.

We may suppose that the search function, S, takes a special form described by a constant elasticity of substitution (CES) production function, in which the inputs b{i} enter symmetrically. The latter -- which says they are equal in the intensity of their use in the search -- is assumed for convenience, as is the condition of first-degreee homogeneity: neither increasing nor decreasing returns to scale in the search. In other words, the informational output of the search S will be doubled by doubling the amount of information extracted from each of the B databases that are examined.

Further, the specification of the search production function S allows for substitutions among material from different databases, indicating the ease of substitution by the elasticity of substitution parameter σ: $\sigma = 0$ then corresponds to the condition of strict complementarity in which no substitutions are possible and the materials would be extracted from the different databases would be in fixed proportions to one another, regardless of their relative prices; $\sigma = 1$ corresponds to the (Cobb-Douglas) case in which a project's cost-minimizing search will allocate invariant shares of its total search budget to each of the B databases, and, given the assumption of symmetry among them in the search production function, it implies that the relative amounts of data from any pair of databases would vary inversely with the relative unit prices of the data to be extracted from each.

For expositional purposes we restrict this discussion of the model's implication to the case in which all research projects have identical search strategies, constrained by the same search technology, and the same form of derived demands for database contents. From the (common) CES production function for "search" one obtains these derived demands for access to database contents for each project, as a function of unit extraction charges, the project's real budget level and the elasticity of substitution among the B databases. Assuming database owners have legal monopolies and set profit-maximizing royal rates for data extraction independently (as discriminating monopolists), one may solve for the resulting relative prices that will emerge as the Nash solution from the interactions of the effects of their price-setting the project derived demand schedules for one another's data. The resulting prices then determine each project's consequent cost-minimizing search, and, given its budget constraint, the informational output that will entes its research production, and hence affect its research output.

The basic qualitative features of the results that have been discussed in the context of the simpler Buchanan-Joon (2000) turn out to hold in this setting. Even if the b{i} are not strict complements, and there is symmetric non-zero elasticity of substitution between them, when database rights are separately owned and priced independently to maximize the owners' separate revenues, the larger is the number of required databases (B), the more severely degraded will be

S. Hence R (research output) for given funding levels will be reduced – so long as S and X are not infinitely substitutable. Of course, the lower is the elasticity of substitution among the different database inputs in the search activity, the more marked would be the adverse income effects on the overall research project's output of the mark-ups charged by database monopolists—given its fixed budget constraint. If the elasticity of substitution between the search activity and other inputs is unitary, then the effects of the independent pricing strategies of the data-base owners translate into degraded search output, against with there can be offsetting increases in the intensity of other inputs. The outcome from an economic welfare efficiency viewpoint can be shown in this case, as in the standard multiple-marginalization analysis, to be inferior to that which would obtained under joint monopoly ownership of rights to the required (database) inputs.

The foregoing results may be interpreted to support the intuitive notion that the anti-commons problem's incidence will be particularly heavy in the case of exploratory science, such as that in bioinformatics, but also in design fields such as advanced computer software, where many libraries may be searched for modular algorithms that have been found to interoperate in unproblematic ways with an existing code base. By contrast, narrowly focused searches, say, for particular targets in a SNPs database might be less impacted. Moreover, commercially oriented R&D projects in which the "research" portion of the budget is small in relation to the development costs, would be far less likely to be adversely affected because even if it is not possible to substitute D for R, the impact of the elevated search costs on R will scarcely be noticeable in the overall costs of the innovation.

Perhaps the most interesting implications of this generalized model of "multiple-marginalization" in the market for legally protected scientific research data are those concerning the differential incidence of the search-degradation on exploratory research, by comparison with focused commercial applications-oriented R&D. This points to the need for a more nuanced approach in empirical efforts to assess the ways in which this and other cost-imposing dimensions of the anti-commons problem would manifest themselves. Reconsidered from that angle, the conclusions drawn from the questions posed to academic researchers by the pioneering survey- and interview-based studies of the impact of patented research tools in the biomedical area seem to be overly sanguine, in supposing that the existence of a "serious anti-commons" effect would take the form of the blocking or abandonment of research projects. That such events are reported to be "as rare as the White Tiger," will be seen not to be surprising, and consistent with more subtle but cumulatively distorting long term effects on the advance of fundamental science upon which the ability to sustain innovative will be based (see Walsh, Arora and Cohen (2003), and David (2005) for a critical discussion). Of course, the apparent readiness on the part of the academic biomedical researchers who were surveyed to simply ignore the question of whether they might be infringing patented tools also could account for the rarity with which they reported that their research projects were actually blocked by "patent thickets".

The limits of spontaneous order: anti-commons ills that markets can and cannot cure

Before moving to the conclusion that protection of exploratory scientific research requires special measures to counteract the potential harms from anti-commons effects, especially where database protections compound the effects of patent laws, it is proper to us to inquire whether the problems

created by the distribution of IP ownership cannot be solved by the same means. That question can be treated in two specific connections, considering first the idea that the existence of transferable rights would allow the problems of search and negotiation costs to be mitigated by the development of institutionalized solutions modeled on copyright collection societies, and second, that these might also be a palliative for the "royalty stacking" created by uncoordinated pricing of bundles of patents that constitute "thickets."

The second connection is simply a more general formulation of the latter claim -- viz. that owners of complementary intellectual property rights may well have private profit-incentives to exploit those rights in a collectively managed "pool," and therefore could act spontaneously to mitigate the worst inefficiencies of multiple-marginalization. But,the proposed copyright collecting society-like mechanisms on closer inspection turn out to be inadequate to deal with the core source of the inefficiency arising from distributed exclusion rights to complementary research assets that are protected by patents, or by technical means such as encryption in digital rights managements system, (This is pointed out Spence (2006). on which the following draws.)

Why can't private "intermediating" organizations emerge and profit by providing a market solution for scientists' anticommons problems? The answer is that the proposal to encourage the organization of profit-oriented collections societies is based upon an inadequate analogy with the problems in music copyrights and performance rights that induced the formation of such institutions. This "solution" aims to reduce costs of search and transacting, and lower the costs of rights enforcement, by using economies of scale and scope in search, and re-utilizing the information in repeated licensing transactions. By making the use of IPR less costly, collecting societies could actually encourage greater research production – by inducing widespread patenting of research tools. In addition, the collections society has an incentive to write contractual provisions (e.g., grant backs), in order to induce non-cooperating owners to share use of their exploitation right in exchange for royalties. While accomplishing all that does sound like a good thing, it may be too good to be realistic. There are quite a number of reasons why private "intermediating" institutions are not the best, or even the second-best solution for scientists' anti-commons problems.

First, there are likely to be feasibility and cost problems with the generic "collections society solution" that don't cause comparable difficulties with the copyright collecting organizations because they deal with a form of IP that is very different from the contents of patents, and database rights:

Copyright authors typically want their products distributed widely, but this is not so generally the case with patents.

Copyrights in songs, in texts and even images are more likely to be substitutes than is the case with patents, and scientific data.

Copyright collection societies target specific use-markets, but uses of research tools are much wider and more difficult to predict, so pricing decisions are more difficult.

Secondly, while there most likely would be cost-savings in patent searches and the location of specialized scientific databases, and in identifying the rights-holders who will grant non-exclusive licenses, it is possible that the consequences of these could be perverse. Spence (2006) points out that by making the use of IPR easier for universities and other public research

organizations, a collection society approach could also encourage strategic uses of licensing terms that would disadvantage rival research projects, or encumber researchers in rival institutions. The view that universities would not behave that way seems overly sanguine in ignoring the competitive pressures under which many of these institutions are operating today. Some U.S. universities holding biomedical patents have not been hesitant to write letters pointing out infringements, and requesting that the letter-recipients apply for licenses. In the UK several universities have been drawn into conflicts with one another over competing claims to the same database that, in various stages of its development, was hosted on their websites by a researcher who career exhibited the mobility one might expect of a talented contributor to the biogenetics literature (see the case of the "Signs" database, in David and Spence (2003)).

Next, one has to ask whether there will be an improvement on the existing situation in the public sector – where, according to Walsh, Arora and Cohen (2003), academic biomedical researchers say they just ignore patents. Compared to the state of non-compliance and non-enforcement, collections societies could make things much worse from the viewpoint of public research productivity – while improving compliance with the law. There is a trade-off here, but some might argue that the most effective way to remove a bad law is to enforce it vigorously.

Fourthly, and by no means least in significance, the historical record of the music copyright collecting societies reveals a potential for abuse of market position (Einhorn 2006). Bundling of wanted and unwanted licenses is an attractive strategy for the society, so competition authority supervision would be needed on that score, as well as on grounds that the interests of members of those societies shift in the course of their development toward attempting to exclude variant content that could be substituted for that of the existing rights holders. It may well be the case, however, that the existence of more than one cluster of completementary research tools is a reflection of the useful adaptation of tool-sets to variant problems that are specific to different research domains, or to special research environments. Forcing users to pay for redundant alternatives is an abuse, but so is denying them access to alternatives that are not always redundant in order to raise the rent that can be extracted from those that are provided. True, the collecting societies in the field of music performance rights are restrained from excessive pricing by the adverse effects on revenue, but that is in large part because other copyright material are available as substitutes. This condition is less usual in the case of patents, and, especially when some patents in the bundle that were complements, there may be unjustifiably big markups.

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The burden of this analysis. therefore is that substantial doubt surrounds the wisdom of an implicit policy position that prefers letting "anti-commons problems" be remedied by the workings of new institutions engendered by forces in the markets for valuable intellectual property. Thus, some positive policy action would appear to be called for, particularly in view of the distribution of IP rights to exploit research results arising from publicly funded R&D projects that is being produced by the workings of the Bayh-Dole Act of 1980 in the U.S., and kindred legislative and administrative measures introduced in the EU and elsewhere. The following section's proposals offer a preliminary response to that challenge.

Common-use contracting in IPRs -- clearing pathways through some "mental thickets"

A discussion of suitable policy measures would aim to (a) clarify the meaning and practical significance of the idea of legally creating an "information common" for scientific and technical research communities by means of common-use contracting, (b) inquire into the conditions under which these are likely to emerge spontaneously as "clubs" or "pools" among holders of IPR in research tools and databases, rather than having to be pro-actively encourage by public agencies, and (c) consider specific policy measures that would be appropriate and effective in promoting participation of universities and other public research organizations in IPR licensing arrangements of that kind. It is possible on this occasion only to touch upon some of the salient points under each of those headings.

To make space for the "Commons solution" one needs to clear away economists and lawyers' misconceptions about "the Commons," and stop textbook repetitions of the travesty of the 'Tragedy', like this one:

> "The *anticommons* is a play on words and refers to the 'tragedy of the commons' which is taught in freshman economics. In the tragedy of the commons peasants in early modern Britain overgrazed shared pastures ('the commons') because the absence of private property eliminated incentives to conserve." -- Scotchmer (2004:88)

The historical reality is totally different. Contrary to the historical fantasy of a "common pool problem" promulgated in the influential essay by Garrett Hardin (1968), this "tragedy" never was: from the 13th century onwards, the records of Europe's agrarian communes detail regulations adopted "by common consent" of the villeins (tenants) to control the exercise of rights of common grazing on the fallow fields, the meadows, and the stubble-fields (the post-harvest grain-fields) of the village's arable land. Internal management accompanied exclusion of strangers. Ostrom's (1990), and subsequent works on "common property resources," has shown the relevance of this to real resource problems in developing economies. Studies of the historical experience of successfully managed Common Property Resources document this abundantly. For example, by the 'early modern era' in Britain, and equally in the more densely settle arable farming regions of northern Europe, the management of common grazing rights prescribed *stinting*: tenants in the village were allocated "stints" that specified the numbers of specific animals that commoners could put on the fallow or common pasture lands, apportioning these rights in relation to the size of their holdings in the arable field, and sometimes in the meadowland.

The Commons in tangible exhaustible resources is not a defunct institution, for collective ownership of exhaustible resources did not, and does not translate automatically into a chaotic struggle for possession among neighbors, nor does it result in the egalitarian distribution of use-rights. Even in western Europe today, such arrangements based upon *de jure* common use rights (*res communas*) dating from the Middle Ages have survived in the Swiss Alps and Northern Italy—e.g., the Magnifica Comunità di Fiemme, in the valley of Aviso (Trento) -- where they still govern the use of tens of thousands of hectares of alpine forests, pasture and meadow land. Moreover, a growing number of contemporary empirical studies in the

developing world -- following Ostrom (1990) – also are showing how common pool resources can be managed successfully under a variety of common property regimes. .

Selective implementation of common-use contracting: efficient IPR pooling agreements

• The case for efficient patent pools rests on overcoming the obstacles to research and innovation posed by the growth of "thickets" and designed complementarities in claims that create blocking patents.

• Defense against anti-trust objections to pooling would be easier where there an empirical procedure for establishing the likelihood that an inefficient patent cluster, i.e., a "thicket" had formed.

• Clarkson (2005) proposes and demonstrates an application of network analysis to discover patent thickets.

• But, dual pricing policies by foundations running PRC-i's, are potentially subject to abuse, and competition among the foundations will be limited if complementaries are to be internalized. So anti-trust supervision will be necessary.

What is to be done? Creating a "research commons" by licensing of intellectual property is not an unprecedented idea, indeed, it has been gaining adherents in practical applications:

• Free and Open Source Software approach to ensuring access to software tools, using copyright licensing terms: GNU GPL ('copyleft' principle) requires distributors of code to do so on the same open source, royalty free, attribution basis on which they received the code.

• Open access scientific and engineering pre-print repositories established by PROs, which requirements that researchers at the institution deposit electronic copies of their publications for use by other members of the teaching and research staff.

• Science Commons: common use licensing of data contributed to repositories, cross-licensing of patented research tools, pre-commitment to materials transfer licensing on RAND terms.

GISCI – the Global Information Commons for Science Initiative, launched at the Tunis WSIS in the fall of 2006 is intended to provide support facilities for 'bottom-up' commons building initiatives, and programs for reinforcing "top down" public agency support actions. This new undertaking may help keep track of the myriad experiments that now are being launch, and perhaps lead to greater coordination on effective practices, as well as reduced set-up costs.

A summary of the argument, and where it leads us

This presentation has advanced the case for a particular approach to restoring a healthier balance. National funding agencies should agree individually and jointly to exercise their authority to impose compulsory common-use licensing of IPR in complementary research "tool sets"; they should set management rules for the irrevocable assignment of IPR to regulated "public research commons in information" (PRC-i) when such rights arise directly from projects that draw significant public funding.

The argument for this course of action has been mounted in seven steps:

• Prop. 1: Scientific and technical research in the modern world entails the production of data and information (which are international public goods) by means of the same class of international public goods.

• Prop. 2: There are three pure types of institutional solution for the allocation problems in the production and distribution of information that result from the latter's public goods properties: Property, Patronage and (Public) Provision.

• Prop. 3: Each of the "3 P's" offers an imperfect solution, and most of the successful modern economies employ all of them in some degree, but the mixture has shifted towards Property.

• Prop. 4: The "Property solution"(IPR) creates legal monopoly rights to exploit the new information, and may improve the market allocation of resources in information production through the incentive effects; but commercial exploitation of the rights itself inhibits information use – and the "deadweight burden" that is incurred in scientific and technological research itself is likely to be particularly heavy for society.

• Prop.5: Information disclosed and left in the public domain enables the efficient growth of knowledge through the conduct of "open science" research, so long as (a) patronage is available and (b) "enclosures" of the public domain does not impede access to the research tools.

• Prop.6: There are conditions under which IPR in research tools is particularly damaging to scientific progress, these have come to be referred to loosely as "the anti-commons" – which needs to be precisely defined; in those conditions, "common-use" pooling of information resources is likely to be both socially more efficient, and a dominant strategy for researchers.

• Prop.7: IPR owners can contractually construct "information commons" that emulate public domain conditions that will be sustainable against opportunistic "enclosure"; and in the case of a non-exhaustible resources (information), there is good reason not to exclude any contributor of IPR to the research commons -- so long as the additions also are complements of the rights from which the existing PRC-i has been formed.

It is necessary to close with some remarks on the political economy of the proposed program of meliorative action. The policy thrust of the argument that have been advance here is tantamount to a an indirect route to reforming the workings of the Bayh-Dole and Stevenson-Wydler Acts in the U.S., and parallel legislative measures that were subsequently introduced in a number of OECD countries. It calls for the development of specific institutional arrangements for the administration of "scientific research commons" (SRCs) formed by IP right-holders that would need to address five key issues. These include:

(i) conditions of eligibility to participate

(ii) limitations upon the scope of legally protected content that can be placed within the commons

(iii) principles for the management and pricing of licenses granted to non-commoner for use of intellectual property rights contributed to, and arising from the utilization of pooled research assets

(iv) relationships among independent SRCs and between SRCs formed by universities and other public sector research organizations that presently maintain technology licensing/transfer offices

(v) the implications of competition policy safe-guards against the creation of inefficient pools, and the abuse of patent cartel power.

The foregoing is in a sense concerned to describe the characteristics of the destination at which I advocate arriving. What it does not indicate is whether this is a feasible route for making such a journey from where we now find ourselves. One wishes to design a process with favorable transition dynamics: each commons would provide positive externalities to those who join, and those who are already participating, to the extent that the new use-rights are complements of those already in the pool. But in general these benefits will be more attractive to universities will small and less coherently structured IP portfolios, and offer less to the comparatively few institutions that have many patents and effective, well funded TLO operations. On the other hand, the question is whether the immediate portfolio return consideration of those research universities and their TLO staffs will prevail over the interests of their researchers in pursuing fundamental scientific research un-encumbered by the need to overcome, or avoid obstacles created by the dispersed distribution of patent holding on research tools. In general it may be supposed that the interests of leading researchers that have a demonstrated capacity to gain public funding will weigh heavily with all but the most myopic and reckless university administrators. This is a hopeful notion, because it implies that even when influential academic scientists are prepared to simply ignore other institutions patents, public funding agencies could set conditions for grant recipients to pool patents on relevant tools that their institution owns with those held by other public grant recipients. This could be done a condition for eligibility to submit grant proposals, which would create a strong incentive for university compliance if they sought to retain the scientists that had promising trajectories of research in that field.

The problem with this approach, however, is that it is not clear that such researchers will be ubiquitously distributed among the research universities, so where they were not currently present, patent-holdings at those institutions could remain "un-pooled" blocking patents. Across-the-board pooling requirements would address that defect, but at the expense of mobilizing all those with less to gain from securing their star researcher's eligibility to compete for public research funding.

Another potential problem with bottom up coalition formation on behalf of the commons-building goal concerns the interests of the university technology licensing professional that have become a potentially important lobbying force in the U.S., and may be emulated elsewhere. There will be winners and losers if the business now conducted in many small TLO's is consolidated in the hands of a smaller number of regional- and domain-specific independent foundations. The public research funding agencies and major private charities have crucial roles to play in bringing the handful of large but important research institutions that have been gainers under the existing regime into the new scientific research commons. But that probably is not the best place to begin. In short, this journey of institutional reform, like many journeys worth undertaking for 'the arrival' rather than the intrinsic pleasures of travel, will have some travails; in order to succeed it will demand sophisticated reconnoitering of the terrain to be traversed, careful attention to questions of sequencing, and very considerable patience and persistence. But it should not be deferred.

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