# Access to Genetic Patents and Clearinghouse Model

# - Economic Perspective

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### 1. Introduction

Several institutions have been identified as mechanisms that can be used to facilitate access to genetic patents: research exemptions, compulsory licensing, open source collectives[1] and various clearinghouses[2], and patent pools[3]. I follow van Zimmeren's classification of mechanisms ``for access" and ``for access and use" but divide the second group into two subgroups: collective rights organizations (CRO) and incomplete contract structures (ICS). Incomplete contract structures is expansion of open source and includes contractually structured liability. Each category has a different purpose: ``for access" CH are characterized by network and transaction cost reduction, CROs set prices to intellectual property so that they will be used optimally for production, and ICSs address incontractable, uncertain and dynamic nature of innovation. While there are working examples of aforementioned systems, we will also discuss the contractually constructed liability regime[4] which is a new concept.

[1] Hope, J. CUP
[2] Van Overwalle, G., van Zimmeren, E., Verbeure, B. and Matthijs, G., 2005. 'Models for facilitating access to patents on genetic inventions,' *Nature Review Genetics*, doi:10.1038/nrg1765, www.nature.com/reviews/genetics
[3] Verbeure, B., CUP
[4] Rai, A.K., J.H.Reichmann, P.F.Uhlir, and C. Crossman, CUP

We categorize the clearing mechanisms[5] by functions[6]. The first two mechanisms, "information clearinghouses" (information CH) and "technology exchange clearinghouses" (technology exchange CH) are "for access" are purely for *exchange*. The purpose of an information exchange is for IP or technology owners to disseminate and the potential users to find the information about the technology. Technology exchange clearinghouses go one step further in that technology is sold or licensed in addition. The property owners and users interact directly and property owners retain ownership.

There are institutions that promote both "access and use" such copyright collection societies (CCS) and patent pools[7]. We will refer to this subgroup as Collective Rights Organizations (CRO)[8], In addition, we expand open source models to include another "access and use" institution, contractually constructed liability (CCL). Both open source and CCL take into account the uncertain and dynamic nature of innovation. I will refer to this subgroup as incomplete contract structures (ICS) because they define relationships and contingent transfers (fees) when there are non-contractable elements such as risk.

**2. Exchanges**

[5] van Zimmeren, E, CUP

[6] Aoki,R.and A.Schiff, 'Promoting Access to Intellectual Property: Patent Pools, Copyright Collectives and Clearinghouses', 38 *R&D Management*, 2008, 118-204 at 186 also uses *ownership* to classify clearinghouses.

[7] May also include patent royaly collection clearinghouse (van Zimmeren, CUP).

[8] Merges, R.,'Contracting into liability rules: intellectual property rights and collective rights organizations', 84, *California Law .Review*, 1996, 1293-1393. The aforementioned "copyright collection societies" are equivalent to what Merges refers to as "royalty collection organizations".

Benefit of information CH and technology exchange CH comes from reduction of transaction costs, primarily search costs. Typical examples of this catergory are PIPRA[9] and GBIF[10]. There is additional reduction of contracting costs if the exchange offers some sort of standard licensing agreements that provider and user can adhere to. Standard licenses promote exchange and are provided as a service. The design of license itself is not the objective as in "acess and use" mechanisms. We therefore include standard licensing CH[11] in this group. We believe the Creative Commons[12] is anr example. Creative Commons not only reduces search cost by providing information about available materials, but it also reduces contracting cost by providing licensing formats. That is, Creative Commons undertakes a "task of devising and encouraging the use, not of standard licences, but of standard clauses for licences, standard mechanisms for resolving common licensing problems" proposed by Spence and David[13].

Exchanges are based on the "network effect" that arises from the exchanges' ability to reduce search costs. The particulars of the network effect must be taken into account for a successful formation of an exchange.

### 2.1. Network Effects

[9] Bennett, A.B., and Boettiger, S., CUP
[10] Edwards, J.L., CUP
[11] van Zimmeren, E., CUP.
[12] Nguyen, T. CUP
[13] Spence, M. CUP

An institution has a network effect when benefit to the members depends on the number of members. The following is a very simple model that captures this effect. There are continuum of agents, represented by interval $[0,1]$. Agents are indexed by $x \in [0,1]$.

An agent $x$ gets benefit of $1-x$ per interaction with another agent. In case of an exchange, benefit comes from learning about the others' technology. All agents benefit but the magnitude of the benefit depends on the agent and we index the agents by their magnitude of benefit. That is, if $x > y$, then agent $y$ gets higher benefit per interaction than agent $x$. Suppose $n$ is the number (in this case proportion of agents to be precise) that are members in the exchange. We can formulate the surplus of an agent $x \in [0,1]$ as,

$$U(x) = \begin{cases} n(1-x) - p & \text{if } x \text{ is a member} \\ 0 & \text{otherwise} \end{cases},$$

where $p$ is the price of joining the exchange. Greater the number of members and lower the price, greater the surplus. The marginal agent, $\hat{x}$, is indifferent between joining and not joining exchange,

$$U(\hat{x}) = n(1-\hat{x}) - p = 0.$$

This also means all the agents in interval $[0, \hat{x}]$ are in the exchange since all agents $y < \hat{x}$ have higher surplus. Noting that $n = \hat{x}$ [14], we have,

$$\hat{x}(1-\hat{x}) = p.$$

This is the relationship between price and those that decide to be members, i.e., demand function of membership. However the relationship between demand (to be member) and

[14] Since all consumers with index $x \in [0, \hat{x}]$ join the exchange $\hat{x}$ is the also the proportion of consumers that join the exchange. If there are total of $N$ consumers, then number of consumers that join the exchange is $n = N\hat{x}$. Rather than using this number in which case $N$ cancels out, we use $\hat{x}$,

price is not monotonic (Figure 1). Higher price can increase demand for some region. Furthermore, at any price, $p$, there are two levels of membership that are equilibriums, one with low membership, $x_L(p)$ and the other high, $x_H(p)$.

It is possible for an exchange to be in equilibrium with very few members. However this is not a stable equilibrium. Any deviation of membership above $x_L(p)$ will move the market to the other equilibrium, $x_H(p)$. Since non-members have no surplus, it is better to be in equilibrium with larger membership.

**2.2. Model of an Exchange**

The interesting question with exchanges is how they can be successfully formed. To answer this question we differentiate between providers of information or technology and the users. Only the number of providers matter for a user while only the number of users matter for a provider. Except for the indirect effect of making the exchange attractive to the users, there is no gain to provider from having more providers. It would just increase competition.

Suppose both providers and users are separately distributed over interval $[0,1]$. The surplus of a provider ( $x_P$ ) and a user ( $x_S$ ) are given below. The variables $n_P$ and $n_U$ are the number of exchange members and cost (price) of participating are denoted by $c_P$ and $c_U$.

$$U(x_P) = \begin{cases} n_U(1-x_P) - c_P & \text{if member of exchange} \\ 0 & \text{otherwise} \end{cases}$$
$$U(x_U) = \begin{cases} n_P(1-x_U) - c_U & \text{if member of exchange} \\ 0 & \text{otherwise} \end{cases}$$

Again, as in the case of simple network example, if the marginal agent is $x_P$, then $n_P = x_P$. From the indifference conditions we obtain the following two demands for memberships, one for users and the other for providers,

$$x_U(1-x_P) = c_P, \qquad x_P(1-x_U) = c_U.$$

We can rewrite the first equation as,

$$x_P = 1 - \frac{c_P}{x_U}.$$

This is a provider's demand function for membership: how many providers join the exchange given cost is $c_P$, and there are $x_U$ users in the exchange. There will be more providers joining when cost is low and there are more users.

Equilibrium memberships, $x_P(c_P, c_U)$ and $x_U(c_P, c_U)$, satisfy the two demand functions at once. Curves $D_P$ and $D_U$ in Figure 2 are the graphs of the two functions. There are two intersections, meaning there are two levels of equilibrium membership: one when membership from both sides is high and one when membership is low. Because of the network effect, exchange can be in equilibrium at a very small scale.

If the costs are too high, there may be no intersection between the two curves, such as $D_P$ and $D'_U$, i.e., no one will join the exchange. In a case like this, one can subsidize the users to make them join. This will also induce providers to join.

It is not necessary to lower the cost (price) for both sides. In the graph $D'_U$ is user demand when $c_U = 0.3$. One only needs to lower $c_U$ from 0.3 to 0.1 (curve $D_U$) in order to have an equilibrium. It is also possible to reduce providers' cost and shift $D_P$ instead. A typical example of this is how community newspapers are financed. Some allow free classified advertisement so people will buy the newspaper while some charge for advertisement and distribute the paper for free.

**2.3. Formation and Stability**

Because of the network effect, some form of coordination is necessary to form an exchange. It is necessary to get a critical mass, at least as large as $x_L(p)$. If price is lowered slightly to $p' < p$, the exchange will converge to a higher equilibrium, $x_H(p')$. This demonstrates the importance of coordinated subsidy to guarantee an equilibrium. The role of financial resource at early stage of formation may be essential for a successful launch of an exchange. It is not surprising that SNPs had financial backing from Welcome Trust and GBIF had NSF support.

This equilibrium is stable, meaning the economy will not move away even if there is a small perturbation of prices. In this sense, once attained, institutions with network effects are very stable.

We observed with the simple model that in order to accumulate critical mass, one does not have to lower price (or cost) to everyone. It is sufficient to make it attractive to one side, providers or users. Call to join can concentrate on one side of the exchange. If institutions such as governments and international organizations are to subsidize formation, it may be more cost effective to concentrate on one side. Of course, information about the exchange's existence must be disseminated to both sides.

**3. Collective Rights Organizations**

Collective rights organizations (CROs) provide a bundle of goods, usually IP rights and prices are set as a bundle. We focus on copyright collection societies (CCS) and patent pools. We may also include open source CH as special case of CRO. Open source is "priced" so that the price is not a payment to the organization prior to use but is the forgone future earnings. This can also be interpreted as an extreme example of "low payment"[15] required for blanket licenses to be pro-competitive.

CCS and patent pools differ in the access patterns of the users. Each PRCCH licensee (IP user) accesses a different combination of goods from the bundle. Open source is similar to CCS in this regard. For instance, in case of American Society of Composers, Authors,

[15] van Zimmeren, CUP

and Publishers (ASCAP), each radio station has a different play list made up of ASCAP music catalogue. On the other hand, every patent pool licensee uses the same combination of patents. For example, if a patent pool is for implementing a standard, a particular combination of patents must be used to implement the standard. That is, all MPEG LA licensees basically use same bundle of patents.[16]

When a bundle of goods such as set of IPs must be used together, i.e., goods are complements, there is economic benefit other than reduction of transaction costs through elimination of double-marginalization, originally pointed out by Cournot[17]. For this reason patent pools offer a completely different advantage from CCS. Even if there is no benefit from elimination of double-marginalization, the fact that licensees choose subset of IPs means the marginal constraint does not bind[18] and a pool is welfare enhancing. On the other hand, there is no similar economic efficiency justification for CCS pricing the whole bundle of IPs as a "blanket license".

### 3.1 Patent Pools

Notable patent pools were already established in the 19th century, such as the sewing machine pool formed in 1856. Today, the most prominent patent pools are formed to

[16] Horn, L. A., CUP
[17] Also discussed by Verberure, CUP.
[18] Lerner, J. and J. Tirole, ``Efficiency of Patent Pools", 94(3), *American Economic Review*,2004, 691-711.

implement technological standards. The Motion Pictures Experts Group Licensing Administration (MPEG LA)[19] and Digital Versatile Disc (DVD) are such examples[20].

### 3.1.1. Example

There are three firms, A,B and C, that each have a patent to implement a standard. The total number of licenses demanded when total royalty is $r$ is,

$$Q = 1 - r. \qquad (1)$$

If there is only one licensor that charges $r_0$, then $r = r_0$. If there are two licensors charging $r_1$ and $r_2$ respectively, then $r = r_1 + r_2$.

There are three possible licensor configurations:

- Patent pool - all 3 firms form a single pool, there is only one licensor
- Independent Licensing - all 3 firms license independently, 3 licensors
- Firm C is an outsider - firms A and B form a pool but firm C is independent, 2 licensors.

Each licensor sets its royalty $r_i$ to maximize own revenue, $Qr_i = (1 - r) \times r_i$. If there is only one licensor, $r = r_i$, otherwise $r > r_i$. Revenue maximizing royalty and revenue according to number of licensors is shown in Table1.

[19] Horn, CUP.
[20] Aoki, R. and S.Nagaoka, 'Coalition Formation for a Consortium Standard through a Standard Body and a Patent Pool: Theory and Evidence from MPEG2, DVD and 3G'. Institute of Innovation Research Working Paper 2005, WP\#05-01,, Institute of Innovation Research, Hitotsubashi University.

Note that total royalty increases with number of licensors. This is due to double marginalization. When choosing royalty rates separately, each licensor does not take into account the decline in profit of other firms from reduction in license demand when it raises its own royalty. When they choose a royalty rate together as a pool, loss of profit for all members from raising royalty is taken into account. This phenomenon occurs because the patents must be used together (complements). This observation is the principle behind competition authorities' positive views of standard implementation patent pools. A patent pool of all firms reduces number of licensors to one, achieving lowest possible total royalty, which is 30 in the example. Total royalty is 45 if the 3 firms license independently.

| Regime | Patent Pool | Firm C Outsider | Independent Licensing |
|---|---|---|---|
| No. of licensors | 1 | 2 | 3 |
| Each licensor royalty | 30 | 20 | 15 |
| Total royalty | 30 | 40 | 45 |
| Total licenses demanded | 60 | 20 | 15 |
| Each licensor revenue | 900 | 400 | 225 |

*Table 1*. Royalties and revenues with different number of licensors

Another important observation is that because of low total royalty, firms are better off organizing into a single pool. Pool revenue is 900 which is greater than the total of all three licensees were they to license independently which will be 675 in the example.

### 3.1.2. Formation and Stability

Standard implementation patent pools consist of complementary patents, that is, patents that must be used together. In the example, this is reflected in (1): for a given level of total royalty, $r$, demand for all patents are the same. There is no trade-off between patents when royalty rates differ (which would be case if patents were substitutes). For such a bundle of patents, price of a bundle will be cheaper than the total price if patents were priced independently, as seen in the example. This is something that patent owners are keen to take advantage of which makes forming a pool of complementary patents attractive. In addition when the patents are for implementing a new standard, reduction of total royalty rate will help promote adoption of the new standard.

However many pools suffer from instability, that is, some members leave. This occurs because reduction of licensors (by bundling) means an independent licensor can charge more. Unless appropriate compensation is given to the patentee by the pool to make it attractive enough to stay in the pool, a member may leave and license independently.

In the example, focus on firm C's profit in the 3 different regimes. If all 3 firms are independent, firm C's profit is 225. If firms A and B form a pool so that there are only 2 licensors, then firm C's profit is 400. This is more than one third of 900, what it would get if it joined the pool and revenue was divided equally. This explains why some firms leave the pool or refuse to join when others have formed into one licensing organization. Firm C refusing to join is very unfortunate for the other 2 firms which only get 200 each.

In this case, firms A and B should guarantee a bit more than 400, say 410, to induce firm C to join the pool. Even after giving firm C's 410, firm A and B can split 900 - 410 = 490, which is more than 200! The incentive to leave and free rider on the patent pool which leads to ex-post instability[21] also contributes to ex-ante instability and impede formation of a pool.

Instability of patent pools is well documented. The DVD standard established by the DVD Consortium made up of 10 patent owner firms in 1995. They agreed that a patent pool should be formed to maintain the cost of licensing low in order to promote the new standard. In 1996, Thompson left the consortium and started to license independently. The nine firms continued efforts to license but Phillips, SONY and Pioneer expressed dissatisfaction with how the revenue of the pool would be distributed. In 1997 the 3 firms left to license their patents together but separate from the Consortium. The two groups started licensing separately the following year. As result, it is necessary to have three separate licenses in order to implement the DVD technology. However in many cases, by adjusting the payment it is possible to induce firms to join.[22] Distribution of patent pool revenue (licensing fees) must be designed to prevent members from leaving and licensing independently. This means distribution according to number of patent ownership may be inappropriate.

[21] Verbeure, CUP.
[22] Aoki,R. and S.Nagaoka, 'The Consortium Standard and Patent Pools,' 55(4), *The Economic Review*, 2004., 345-356

It is also known that heterogeneity contributes to instability.[23] That is, a non-manufacturing firm such as Rambus has a very different incentive from that of Toshiba whose profit is primarily from manufacturing. Distribution of pool revenue should also take this heterogeneity into account.

### 3.2 Copyright Collection Societies

There are many successful examples of CCS, including ASCAP (US), and BELGRAMEX (Belgium), GVL (Germany), Associatione Nazionale dei Fonografica Italiani (Italy) and Phonographic Performance Limited (UK). There are also many copyright collectives that collect royalties from photocopy of books and articles, such as Copyright Clearance Center (US) and Copyright Licensing Agency (UK), and many others in Europe[24].

A CCS issues "blanket licenses" to licensees that charges a fixed fee, independent of which music is played or which photograph is used or intensity of use. The fixed fee is usually a proportion of licensee's revenue which is set to reflect licensee's value of music or photographs. For instance, music would be more valuable to a radio station than a restaurant whose main business is serving food. Thus the rates for radio stations are higher than for restaurants. This pricing policy is rational because it is very difficult for CCS to know which particular music or photograph is most valuable to the licensee. Under such circumstance, it is better not to price the individual IPs separately for it may distort the choice. Blanket license is designed so that each licensee will choose whatever

[23] Aoki and Nagaoka, "The Consortium Standard".
[24] Corbet, J., CUP.

combination of IPs will maximize its profit. CCS will take a fixed proportion of that maximized profit. CCS charges the same price (actually zero) for each IP so it will not distort licensee's profit maximizing choice.

CCS distributes license revenue to members according to how much the member's music or photograph was used. Intensity of use is obtained by combination of reporting by major licensees such as major television and monitoring of other licensees.[25]

### 3.2.1. Simple Model

The following model is due to Bensen, Kirby and Salop[26]. When the size of intellectual property (IP) rights is $N$, the value to society of the catalogue is $V(N)$. We assume $V(N)$ is increasing concave function of $N$. Each licensee would be paying their individual value of the catalogue and the sum of all the fees should be equal to $V(N)$. Thus this is CCS's licensing revenue. The CCS's administration cost is $C(N) = F + cN$, where $F$ is the fixed cost of administration and $c$ is the cost per IP. Typically $c$ would be the monitoring cost. The surplus is $\pi(N) = V(N) - cN - F$.

For simplicity we assume one member has one IP right and CCS surplus is divided equally among its $N$ members. Then in order to maximize per member profit, membership size should be chosen to maximize

[25] Corbet, CUP.
[26] Bensen, Stanley M., Sheila N.Kirby and Steven C. Salop, 'An Economic Analysis of Copyright Collectives', 78,, *Virginia Law Review*, 1992. 383-411.

$$\frac{\pi(N)}{N} = \frac{V(N) - cN - F}{N}.$$

The per member maximizing size, $N^m$ satisfies,

$$\frac{d}{dN}\frac{\pi(N^m)}{N^m} = 0 \quad \Leftrightarrow \quad V'(N^m) - c = \frac{V(N^m) - cN^m - F}{N^m}. \qquad (2)$$

The membership size $N^m$ to maximize per member surplus is set so that marginal surplus equals surplus per member.

The socially optimal membership size is to maximize total surplus, $\pi(N)$ and the optimal membership $N^*$,

$$\pi'(N) = 0 \quad \Leftrightarrow \quad V'(N^*) = c.$$

The socially optimal membership size, $N^*$ is set to equate marginal surplus to marginal cost. Comparing equations (1) and (2), we observe that membership is kept too small if CCS tries to maximize surplus per member, $N^m < N^*$.

### 3.2.2. Formation and Stability

One advantage of CCSs is the reduction of transaction cost for enforcing property rights. CCS saves monitoring cost by monitoring all music or photograph use on behalf of the members, making individual monitoring by each IP owner unnecessary. However, the economies of scale effect of monitoring cost is not the only reason why CCSs do not suffer from instability. First of all, there is no externality that non-members can free ride on as in the case of patent pools. Instead the “blanket license” practiced by CCS

contributes to stability. Because licensees pay a fixed fee, there is no marginal cost of using more from the CCS IP catalogue. On the other hand, licensee must pay a separate royalty to use a non-member's IP, making it costly not to be a CCS member. Thus not only is there incentive to stay, there is an incentive to join CCS. It is not surprising that CCSs have been stable over time and memberships have grown.

## 4. Incomplete Contract Structures

Arrow in his seminal work[27] argued that risk was NOT the essence of innovation since this can be contracted away in a perfect capital market. The reality is that the capital market is not perfect. Both open source and CCL address the issue of uncertainty in innovation.

An outcome of innovation is uncertain and not always successful. Which idea, which may be in form of an IP[28],) or molecule is most likely to succeed is often unknown a priori. Which researcher will be most effective may also be unknown. In addition to these uncertainties, there are informational problems. That is, IP owner may be more informed than a researcher about quality and likely success of IP or a molecule. Similarly, a researcher may be better informed about his or her ability than the IP owner. Furthermore, IP owner may only not be able to observe how much talent a researcher has (hidden information) but also may not be able to observe how hard she is working (hidden action).

[27] Arrow, K. `Economic Welfare and the Allocation of Resources for Inventions' in Nelson, R.(ed), *The Rate and Directions of Inventive Activity*, Princeton, Princeton University Press, 1962, 635 p..

[28] An diea is the subject of an IP right. Access and use of an idea differs according to the fact whether there is IP on the idea. Author is greatful to the editor for pointing to this very important distinction.

While some uncertainties are possible to contract away, it is difficult to write contracts when there are informational asymmetries (hidden information).[29] It is also not easy to induce optimal effort with contracts when effort is not observable (hidden action) and it is usually not possible to have an efficient outcome. That is, IP owner will have difficulty having others conduct or invest in innovation to improve or develop its IP.

Open source and CCL are functioning as form of incomplete contracts when there are these uncertainty and informational problems. The problem is made worse by the dynamic nature of innovation. In case of software improvements, improvements are cumulative. This means rents from innovation need to be distributed between generations and these distribution rules in turn affect incentive to innovate. As Hope[30] argues, it is possible to obtain private returns from open source material through complementary goods, return from market positioning etc., meaning there are rents appropriated by each generation of cumulative innovation with open source.

An important function of ICS is to provide am environment to innovate and to realize value of IP. In this sense, The Alliance Centers of the Consultative Group on International Agricultural Research, the "CGIAR"[31] has aspect that should be included in this group. It maintains germplasm from around the world that can be distributed to crop breeders upon request, a function similar to the Molecular Libraries Initiative - CCL regime. It provides opportunity to realize value.

[29] Bolton, P. and M. Dewatripont, *Contract Theory*, Boston, MIT Press, 2005. 724 p.
[30] Hope, J., CUP.
[31] Henson-Apollonio, V. CUP.

## 5. Concluding Remarks

We have categorized various clearinghouses and contractually constructed liability according to economic  fucntions. **Exchanges** reduce transaction costs (search and contracting costs). Any resulting contracts are bilateral and IP owners retain ownership. **Collective rights organizations** include well established clearinghouse mechanisms: copyright collection societies and patent pools. Their main function is to provide access to a large catalogue of IPs and collect royalties. IPs are complements in case of patent pools while existing copyright collection societies offer blanket license because relationship among IPs are not clear a priori.

The last group of clearinghouses, the **incomplete contract structures** exist to facilitate access to IP and innovation using them. By definition structures are for IP used for further research, either because they are very basic as in molecules (contractually constructed liability) or because knowledge is part of ongoing cumulative innovation process (open source). Open source is already in existence although not very well understood. Contractually constructed liability is a new concept yet to be put into practice. Both systems are promising and surely will attract future research interest.

Last but not least, all clearinghouses are based on the network effect. There is danger of an equilibrium with very few participants. Coordination, by public or private or by national or international entities, is essential for successful formation. The network effect

by itself is very stable meaning it becomes self enforcing once an organization has been established.

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