Organizing Information Sharing – Some Insights from Economics

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February 4, 2017

Abstract

This paper focuses on sharing of information during the innovation process. Many of the questions raised by the organization of firms and markets for innovation have been analyzed in economics, and a first goal of the paper is to show how previous work in industrial organization about patent pools, Standard Setting Organizations (SSOs) and public-private partnerships (PPPs) may provide guidance on the costs and benefits of different ways to organize information sharing among firms subject to regulatory approval. A second goal is to highlight how the recent developments in the market for innovative medicine leads to novel questions for economists, both for the industrial organization structure of the market and the organization of firms and markets.

1 Introduction

Innovating is inherently a risky endeavor. The literatures in economic, management and innovation have focused on the uncertainty inventors face on whether their research ideas will succeed, whether they will find investors willing to finance the development of the innovation, and whether the future returns from the final product will cover the costs of research and development. However for many industries, there are also significant societal risks. Products may fail, and in some instances failure may impose a high cost on a large number of individuals. Disruptive technologies like self-driving cars, a new design for long-haul airplane carriers, a new drug have in common the need for society to insure that they are safe before they are put on the market; waiting for the market to sort out the good from the bad is often too risky because these technologies are difficult to reverse and because faulty design and product failures may lead to disasters.

In such settings, regulation serves the role of a market gatekeeper by filtering out the safe from the unsafe products while trying at the same time not to discourage innovation. Because regulation increases the risk

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of innovation for the inventors and developers there is a chance not to get regulatory approval the organization of the market for innovation must also balance the regulatory risk and the need for innovation.

An increase in individual risks often induces firms to cooperate to share risk. Sharing of risk can take many forms: firms may join forces by creating joint ventures or licensing their innovation but they may also decide to share information during the innovation or development processes. The sharing of information among inventors, developers, and regulators can provide more certainty about the likelihood that a given innovation will go through the regulatory gate. It also allows firms to faster identify promising research avenues or those that are likely to fail. The aggregation of multiple signals may help avoid type I (accepting bad products) and type II errors (rejecting good products) which are typical in any certification process. But it may also lead firms to act strategically, e.g., by releasing information to influence the regulators approval or other firms research paths.

Sharing of information is at times imposed by the regulator but it is also a choice made by the innovators, or developers, even if they are competitors on the market. One example is the Federal Aviation Administration where data is shared anonymously by airline companies; that information is then used to help predict or avert safety challenges. The US Transportation Secretary Anthony Foxx recently suggested that a similar model could be used by the auto industry for the development of driverless cars[1] In the pharmaceutical industry, regulations in the US and in Europe have required firms to disclose information about toxicology results. But this does not induce information sharing since enforcement of such rules proves difficult, or disclosure of that information to other parties may be overturned in court. For instance, in the case T–729/15 MSD Animal Health Innovation and Intervet international v European Medicines Agency (20 July 2016) the General Court granted an injunction to prevent the European Medicines Agency to release information on some toxicology reports.[2] Nevertheless, since the development of new drugs is subject to many hurdles, since clinical trials are prone to statistical identification mistakes, and since there is a significant regulatory risk, pharmaceutical firms have also voluntarily developed in the last years private initiatives to share information.

The challenges in designing a market for sharing of information are multiple and are related to the types of risks involved. Some of these risks are exogenous (the idea for the compound may not be viable, clinical trials fail to produce satisfactory results, regulation of prices is not flexible) but many of them are endogenous to the way firms and the markets for innovation and the final drug are organized (effort to collect information, decision to stop clinical trials, decision on which type of drug to develop, marketing intensity once the drug is approved.) For these reasons, when evaluating the organization of the R&D process, in particular the way firms collaborate or share information, it is crucial to understand that reorganizations modify the behavior of the market participants, change the endogenous risk faced by innovators, and the performance of the whole

[1] See the transcript of the interview at NPR http://www.npr.org/templates/transcript/transcript.php?storyId=494765472).

[2] While public access to information collected by the EMA is governed by Regulation 1049/2001 (so-called Transparency Regulation), exceptions exist when this may create a danger to the public interest or the commercial interests of legal persons. See the Rules for implementation of Regulation 1049/2001 in EMEA/MB/203359/2006 of 19 December 2016.

system.

2 Information Sharing in Pharma

2.1 Recent examples

Consortia for information sharing have recently emerged in the pharmaceutical industry (see also Stevens et al., 2016 for a more detailed description as well as other examples.)

- The Coalition Against Major Diseases (CAMD), a consortium of pharmaceutical companies, research foundations, patient-advocacy groups, health organizations, and regulatory agencies, which will share information on clinical trials for treatments for neurodegenerative diseases.[3]CAMD is led and managed by C-Path, which is funded by a cooperative agreement with FDA and a matching grant from the Science Foundation Arizona, a publicprivate nonprofit organization focused on facilitating science-based initiatives. (Hence, this is an example of both a SSO and a PPP.)
- The cancer data sharing consortium created in 2016 by AstraZeneca and the software company Repositive,[4] utilizes the existing platform of Repositive to share patient molecular data. The consortium was created at the impetus of the non-profit organization Pistola Alliance.
- Etox project[5] develops a business model with insiders who contribute information about past clinical trials and outsiders who do not contribute but may benefit from results obtained from models developed with the total information contributed by the insiders. Insiders may keep some information private from other insiders, but contribute it because it may improve the quality of the model.

While this note will focus on the strategic and organizational aspects of information sharing, there are also technical as well as legal aspects that may have to be overcome. For instance, databases, the coding of information may be different among firms, and standardization of metadata and the way information is encoded will facilitate information sharing. Patients may be reluctant to having their information shared with other firms than the firm that did the clinical study. Specific consortia, SSOs, have formed to alleviate these technical and legal concerns. For standardization of metadata, and the technology of sharing information, see the Clinical Data Interchange Consortium.[6] For privacy (make anonymous patients data prior to information sharing, relationships with legal institutions like the Department of Justice, FCC), some pharmaceutical and

[3]See http://www.pharmtech.com/pharma-companies-form-clinical-information-sharing-consortium

[4]See http://www.fiercebiotech.com/it/astrazeneca-repositive-call-big-pharma-to-join-cancer-data-sharing-consortium).

[5]http://www.etoxproject.eu.

[6]http://www.cdisc.org. CDISC is a standard-setting organization that establishes standards relating to the acquisition, exchange, submission, and archive of clinical-research data and metadata. Its standards have been used, for instance, by CAMD. Participation is subject to a fee that is a function of the number of employees in the firm and services that the firm wants to obtain, e.g., training of its employees..

biotech companies have formed the International Pharmaceutical Privacy Consortium[7]

2.2 Trade-offs in Information Sharing

Better information about the future state of demand allows a firm to tailor its investments or business strategies and to reduce the variance of future returns. Information about the health of a firm, its projects for capital expansion or mergers, allow an investor to buy stocks at a premium.

Information about the successes of failures of past experiments shapes future directions R&D, allows the firm to avoid directions that have proven in the past to be unfruitful. Consortia organized for information sharing differ in this respect from SSOs. In SSOs, firms contribute technologies that have proven to work, and many of these technologies are covered by patent protection. Exchanging data about failed clinical trials may prove quite valuable and save significant research costs; see for instance the *Accelerating Medicines Partnership* created by the US National Institutes of Health to identify compound liabilities early in the research process. Sometimes projects that increase the risk of failure may be attractive, because of the learning benefit; Canidio & Legros (2016) shows that entrepreneurs may choose to engage in projects with lower short term return, or a higher risk of failure, in order to learn and increase the return of future projects and Chiou et al. (2016) establishes that failed projects can be cited more often than patents lacking clinical or preclinical information.

Hence, information is beneficial to all firms; it has the flavour of a public good, waiting to be shared. By aggregating their private information about the state of demand or about past experiences, each firm will have more precision on the future state of demand or the likely returns from different R&D programs. Unfortunately such social benefits of sharing cannot be achieved without providing incentives for firms to share information.

There is indeed a natural tension between the incentives for firms to share information and to keep their information private.[8] Even if the information that is disclosed can be verified, firms may have an incentive to modify the way they collect information Henry (2009); Dewatripont & Legros (2013). Keeping ones information private is a source of extra profits: by not sharing information about ones costs or future demand, a firm with market power may get a competitive advantage in the market; by disclosing its information publicly, an investor will eliminate all possibilities of buying a stock at a premium; by not disclosing the results of past experiments, the firms competitors have a higher probability of engaging into infertile research projects. Solving this tension often requires putting in place organizations and contracts for information sharing; the complication being that the way the exchange of information is organized also modifies the incentives for sharing or create new incentives for gaming the system.

There is little theoretical and empirical analysis of how to organize information sharing in markets subject to regulatory approval.[9] There

[7] http://pharmaprivacy.org; as of 23 January 2017, 17 firms had joined the consortium.

[8] See for instance Vives (2008*a*) for a review of the economic literature on information sharing in oligopolies.

[9] There is work however about the way a *single* firm will behave when subject to regulatory approval. For instance, Di Tillio et al. (2015) and Henry & Ottaviani (2014) show that a

is nevertheless sufficient overlap with some questions related to patent pools, SSOs and public-private partnerships to warrant a review of some of the literature on these organizational forms, with the hope that this may provide a first bootstrap for a future analysis of the organization of pre-competitive of information sharing.

3 Some economics of collaboration among competitors

3.1 A Taxonomy

Information sharing or other forms of collaboration among competitors can take many forms, and we review first the most common forms that have been studied in economics: joint ventures for the development of new products, patent pools that provide a one-stop shopping for developers and Standard Setting Organizations (SSOs) for the development of new standards. Many industries have also professional organizations that provide a place where firms can, among other things, share information about market conditions. This review will give us the opportunity to illustrate how they modify the behavior of participants and how regulation has stepped in to correct for potential distortions created by these collaborations.

Type	Access	Who	Motivation	Pluses	Minuses	Examples
Patent pools	close	IPR owners	Sell a bundle of patents	One stop shopping	reduction of competition	Telecommunication Electronics Medicines patent pool
SSOs	open	IPR owners producers regulators consumers	development of a standard	innovation	locking effects essential patents (EPs) market power ex-post	3G, 4G DVD light bulbs data format
PPPs	close	public private	improve incentives budgetary pressure	task specialization accountability	conflicts in objectives public vs. private	infrastructures prisons hospitals medicine
Mergers	close	producers horizontal vertical	cost synergies market power financial consolidation	cost synergies coordination	market power conflicts of objectives	all industries
Joint ventures	close	producers innovators	new products	innovation synergies cost reductiosn	market power	telecommunications oil automobiles media pharma

Table 1: Types of cooperation among competitors

3.2 Patent Pools

Patent pools are agreements among different patent holders to license all their patents at a unique price.[10] By doing so, they create a one-stop-shopping for developers of new technologies. They have been present in most industries but had a modest presence in life sciences; for instance, for the biotechnological industry, a 2000 white paper of the US patent office Clark et al. (2000) suggests that patent pools may be a win-win strategy for the industry (see also Resnik, 2003), but they are still a

firm subject to regulatory approval, like a pharmaceutical firm subject to FDA approval, will manipulate the way information is collected or sampled (assigning patients to treatments), or selectively report the information that will be transmitted to the regulator.

[10]For an historical perspective see Gilbert (2004).

rarity.[11] There are many benefits of patent pools: easier access to patented technologies; reduction of transaction costs; if the pool licenses important technologies at a zero price, this may encourage innovation and reduce the risk faced by developers of future patent litigation. In general, pools among patents of technologies that are *complement* a firm needs both technologies to produce a final product will reduce the royalty paid by end users with respect to a situation of independent licensing.[12] But there are also potential costs for consumers. In particular, if the pool includes technologies that are substitute; because these technologies are now available within the same pool, their IPR holders do not compete (Gilbert, 2004). Recently Lerner & Tirole (2004) show that this negative effect can be prevented by forcing the pool members to also license the individual patents, a policy which may have to be accompanied also by a requirement on a cap on these independent licenses.[13]

3.3 SSOs

While patent pools are restricted to patent holders, standard setting organisations (SSOs) include not only patent holders but a variety of other stakeholders, consumer representatives, regulators and manufacturing firms. This collaboration among different stakeholders is necessary to insure that the often complex technological standard (e.g., 4G technology) that will be developed meets the demand of these different stakeholders, hence has a chance to be adopted and used in the market place. The social value of standards is potentially high because they economize on coordination costs and facilitate economies of scale in production.

A trivial example of coordination benefit is a standard defining the size, the shape of sockets for light bulbs, or a standard defining the wattage increments of light bulbs, or a standard defining the shape of USB connectors. Even for such simple settings, producers may be reluctant to participate in the definition of a standard: on one side, standardization allows them to reach a bigger market (all consumers will be equipped with the same sockets) but on the other side, all firms will be able to provide light bulbs for these consumers. Hence a firm may face more competition, and obtain lower profits, when a standard is adopted than when it has a proprietary technology.[14]

Beyond situations where the standard is simply to coordinate the design of products, SSOs are also creators of new technologies, by pushing the technological frontier (like when going from 3G to 4G) and leveraging existing technologies which may or may not be protected by patents. Once the SSO has created a standard, the patent holders of technologies that were deemed *essential* obtain significant market power which can

[11] Exceptions exist, like Medicines Patent Pool (http://www.medicinespatentpool.org/about/) which has been created at the initiative of the United Nations to facilitate access to HIV and other treatments for low and middle-income countries.

[12] This is an illustration of the Cournot effect: if A and B are licensed individually, each patent holder has effectively a monopoly on his patent which cannot be competed away by the other patent since the end use *needs* both patents. Hence with independent licensing there are *two* monopoly rents that are extracted. Within a pool only one monopoly rent is achieved, and this benefits both end users and the firms.

[13] Otherwise, the pool members could still stabilize a monopoly licensing price for the pool by setting arbitrarily larger licensing fees for the individual patents (Boutin, 2014).

[14] This is one standard may emerge only through market competition rather than through cooperation; the cost to consumers of market based standards is that it tends to be proprietary and will happen with a delay when firms play a war of attrition (Farrell & Saloner, 1988).

be leveraged into high royalties. Indeed, the network externalities[15] offered by a standard create large switching costs for users, and each holder of essential patents has a strong bargaining power ex-post to claim high royalties.

These problems of leveraging market power are moot when the standard facilitates coordination and compatibility among products, as in our light bulb example or in the adoption of a unique codification of metada, but loom large for really innovative standards like 4G. In both situations, there is often a tension between the social and private benefits of standardisation, which can lead some firms to fight for their own technologies to be included to the standard, even if they are inferior to others, to engage in a war of attrition with other technology holders resulting in delays in adoption. Finally, the costs of participating in SSOs, especially for firms willing to contribute technologies, can be significant (Farrell & Simcoe, 2012) and may deter some small firms from doing so, resulting in an imbalance. Finally, patent holders may prefer to stay outside the SSO in order to escape regulatory constraints like FRAND, which clearly limits the benefit of the standard for the end users and he SSO participants, and also to save on the costs of participation.

For these reasons, there is scope for public intervention. Public authorities could initiate the standard, serve as a financier for the organizational costs, impose restrictions on participants (FRAND and royalty setting) or even mandate participation of patent holders whose technologies are known to be essential for the future standard.[16]

Similar tradeoffs and issues arise when firms have to share information: their databases should be codified in a similar way, use the same language, and moving to a unified standard may require significant costs. If sharing of information is mandated by the regulator, non adoption of a common standard for data processing may reduce the amount or the quality of information sharing, which may be a way to circumvent the regulatory obligation. In medicine, an example of such a SSO is the Clinical Data Interchange Consortium (CDIC); the standard codifies the acquisition, exchange, submission and archive of clinical data and metadata. Such a standard becomes an important instrument for information sharing in other collaborations.[17]

FRAND

To reduce the possibilities of opportunistic behavior by owners of essential patents, SSOs have adopted a Reasonable And Non-Discriminatory (or FRAND, where the F stands for Fair in Europe) rule that mandates

[15]There is a network externality when the value of a product or service to an individual is increasing in the number of individuals adopting the product or there are more add-on products that the consumer could use with this product; an example of the former is telecommunication, an example of the later is a computer and its operating system and compatible softwares (like Word, Excel) that can be used with the computer.

[16] Bruhm & McKenzie (2017) analyze the effects of the In-Tech program in Poland which provides grants to members of consortia in scientific and industrial areas on the basis of their (externally, peer, evaluated) quality. They show that funding increases the probability of a collaborative project being completed from 20% to almost 80%. While the magnitude of the effect is large, it is not fully clear whether the effect is due to the *level* of funding itself generates this effect or the *screening* of quality (funding is contingent on members passing a quality threshold): in other words knowing that one collaborates with high quality partners may, by itself, increase the incentives to collaborate, put effort in the project, by all partners.

[17]For instance, as already noted, the *Coalition Against Major Diseases* uses the CDIC standard to exchange information in their consortium.

firms to disclose all patents that could be essential for the standard but also to agree ex-post to set royalties that will not distort the adoption decisions of firms, and prevent the holders of essential patents to engage in hold-up (increase the royalty once the consumer is captive).[18] This restriction has been put in place as part of the FRAND requirements in order to avoid situations where the holder of a patent that is essential to the standard does not disclose it and claims, once the standard is put in place and adopted by manufacturers, that the standard is in violation of that patent.[19] While forced contributions help avoid hold-up, they may induce firms to contribute patents that are not essential to the standard, for fear to be found in violation of FRAND or for strategic reasons. For instance, Dewatripont & Legros (2013) show that the anticipation of participation into SSOs when forced disclosure is in effect will influence the way research is conducted, and eventually the quality of the standard. Forced contributions may also affect the willingness of firms to participate in the SSO, and this had led the regulator to entertain the idea that IPR holders may have to be forced to contribute to the SSO.[20]

Royalty Setting

Royalty setting takes many forms in SSOs, even under the umbrella of FRAND: a patent holder may decide to license individually, within a patent pool or engage in cross licensing with other patent holders. Because *essentiality* of a patent is a weak concept, both on the technological and legal fronts,[21] patent pools are not necessarily among complement technologies and we have here the same potential distortions as in general patent pools. In particular, because if two patents are in a pool and one is weak while the other is not, an end user may be reluctant to refuse to pay the royalty of the pool and dispute the weak patent since he knows that he will have to pay some type of royalty for the good patent anyway.

Another possibility is for patent holders who are also producers of the end product to agree to *cross-license*; If A and B have essential patents, they could agree to offer a license free use of their technology to each other. The license price is equal to zero for A and B, but such an agreement is beneficial if *in the absence of cross licensing* they would have each settled on similar royalties. Note that cross-licensing gives a competitive advantage to firms that are vertically integrated, that is which have patents and also produce the final output, with respect to firms that only produce downstream: the vertical firms have lower marginal costs than the later firms which have to pay royalties.

[18] This guideline is obviously vague and in the case of disputes the judge decides on a per-case basis whether the royalty asked by the holder of an essential patent satisfies the FRAND requirement. To avoid some of the problems of excessive royalties, essential patent holders often form patent pools within the SSO.

[19] Such a behavior is dubbed patent ambush; see for instance Galetovic et al. (2015).

[20] This is reminiscent of regulatory interventions that force firms to license their technology to competitors.

[21] For instance Goodman & Myers (2005) show that up to 80% of patents that were deemed essential to the 3GPP standard were not from a purely technological point of view. Farrell & Shapiro (2008) argue that most patents are *weak* from a legal perspective because the patent office and the courts (where disputes are settled) are imperfect filters; patents could be granted on technologies with prior art.

Dynamic Effects of SSOs

While there is now a better understanding of the strategic behavior of firms in SSOs with respect to pricing and participation, there is less of an understanding on the dynamic effects that SSOs generate. An exception is Dewatripont & Legros (2013) who show that if a firm that contributes more technologies to the standard obtains higher royalties, as is implicitly the case in FRAND agreements, private information about the quality of patents leads firms to pad by contributing patents that are 'inessential for the given standard, a phenomenon that seems to be widespread and is, in their paper, correlated with the quality of the standard. Another dynamic aspect that has received little attention is the repeated nature of the interaction among SSO members. Repetition enlarges the strategic possibilities of participants, and this can be used to discipline members, and be pro-competitive, but can also be used to sustain collusive practices, in particular with respect to royalties, and be anti-competitive.

Because the participation in patent pools or in SSOs is voluntary, there is no reason to assume that participation will be socially optimal. In fact, being an outsider rather than an insider may be a good strategy for firms that have key technologies: the value of these technologies will increase once a standard is created and the outsider is not bound by FRAND agreements. This is why *force participation* of holders of key patents has been proposed in the literature, e.g., **?**. In general, when participation is a crucial element of quality, public authorities may have to step in and provide incentives for participation.

3.4 Other Forms of Cooperation

Public-Private Partnerships

Public-private partnerships exist in many industries, and this form of contracting emerges for a variety of reasons. One motive is to strengthen incentives; it may be easier to provide incentives to private parties than to public servants, and efficiency may improve. In infrastructure projects (roads, prisons, schools), private firms may be delegated not only the task of building the infrastructure but also to manage it. However, as Hart et al. (1997) have argued, the difference of objectives between the private firm and the public authorities leads the private firm to put too much weight on the cost, which is contractible, and too little on quality, which is more difficult to contract upon.

Another motive is financing. In infrastructure projects, the private sector provides financing, which makes PPPs attractive to public authorities since they can shift the budgetary burden to private firms and obtain political returns from infrastructure building without the perceived cost of doing it. For PPPs related to the creation of consortia or SSOs in the medicine however, the initial financing has been traditionally public in order to solve for a collective choice problem (no firm wants to be the first to finance the organization), with the private sector matching the contribution either in monetary terms or, as in consortia for medical research, in full time equivalent personnel or use of existing laboratories.

Finally, public intervention may be crucial to initiate collaborative efforts, by providing the initial financing or reducing the risks to the members. An illustration of this is the IMI initiative (see Goldman, 2013) of the European Union and of the European Federation of Pharmaceutical Industries and Associations (EFPIA).

Mergers and Joint Ventures

An extreme form of collaboration is a merger, for instance between a pharmaceutical company and a biotechnological firm. Integration may bring costs and benefits for society. Antitrust authorities which are mandated to provide approval for mergers often articulate costs and benefits in terms of increased concentration in the industry versus potential cost synergies. When the product lines are the same before and after the merger, increased concentration tends to lead to higher prices because the merged firm has more market power and can extract higher profits at the detriment of consumers. At the same time, integration may bring coordination benefits, economies of scope that will reduce costs and these savings could be passed via a lowering of prices to consumers.

This simple dichotomy between costs and benefits of increased concentration is not directly applicable to innovative firms, when the product lines are not the same before and after the merger. Indeed, for such firms, market power may be sometimes conducive to more innovation (Schumpeter) while too much competition may be hindering innovation. Market power protects firms from competitors and this may make them lazy innovators but at the same time market power allows a firm to reap most of the return from innovation. Competition gives low returns to innovation, but at the same time the risk of bankruptcy may be an engine for innovation, a survival strategy. There is a large theoretical and empirical literature suggesting that such ambiguous effects are at play (Aghion et al., 2005; Vives, 2008*b*).

This tradeoff between concentration and efficiency is also inoperative when the market is competitive, for then increased concentration should not generate costs to consumers. The modern theory of the firm Aghion et al. (2015) nevertheless provides a framework for identifying costs and benefits of integration in such competitive settings. Since mergers often combine assets of different nature, the objectives of these assets holders may differ significantly, and the allocation of decision rights will matter for their welfare. What is good decision for one party may be a bad decision for another, and since a merger reallocates decision rights to another party, there is often a loss in welfare, due to the loss of control, and the merger will go through only if all the parties are compensated (in general monetarily) for their loss. Hence mergers will tend to arise when the value of the product that the merged entity will produce is high, for then the ability and willingness of one party to compensate the other for the loss of control is also high (Legros & Newman, 2013). This suggests that merger waves are pro-cyclical while divestiture waves are counter-cyclical.

Joint ventures are agreements between direct competitors (like between two pharmaceutical companies) or between firms at different levels of a vertical chain of production (like a producer of media and a TV operator, or a biotech firm and a pharmaceutical firm) are often subject to scrutiny and require authorization from antitrust authorities because they may have market effects similar to a full merger.[22] Because cooperation is often socially beneficial at early stages of research, authorities typically look favorably on joint ventures if the firms commit to compete and stop communicating once they sell the products or if the firms are not likely to compete head to head, e.g., because they are located in different regional

[22]Ventures differ from mergers because the firms retain ownership of their initial assets and contractually agree to share the returns from the product that will emerge out of the venture.

or product markets.

4 Conclusion

Sharing of information in early stages of research brings important benefits to firms and society. Firms can redirect their research, leapfrog the time to discovery; society may avoid replication of failed experiments, witness the emergence of new research ideas. However, sharing of information also has to confront many of the challenges faced by other types of cooperative efforts among competitors, and letting the market organize the exchange of information is prone to inefficiencies, delays in information sharing, or opportunistic behavior by some firms. This makes public intervention important, but as we have illustrated, the details of this intervention are key to prevent new distortions in the market. There is much to do for understanding how to organize information sharing at early stages of R&D processes, but the hope is some of lessons learned from the academic research on patent pools and SSOs will prove useful.

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