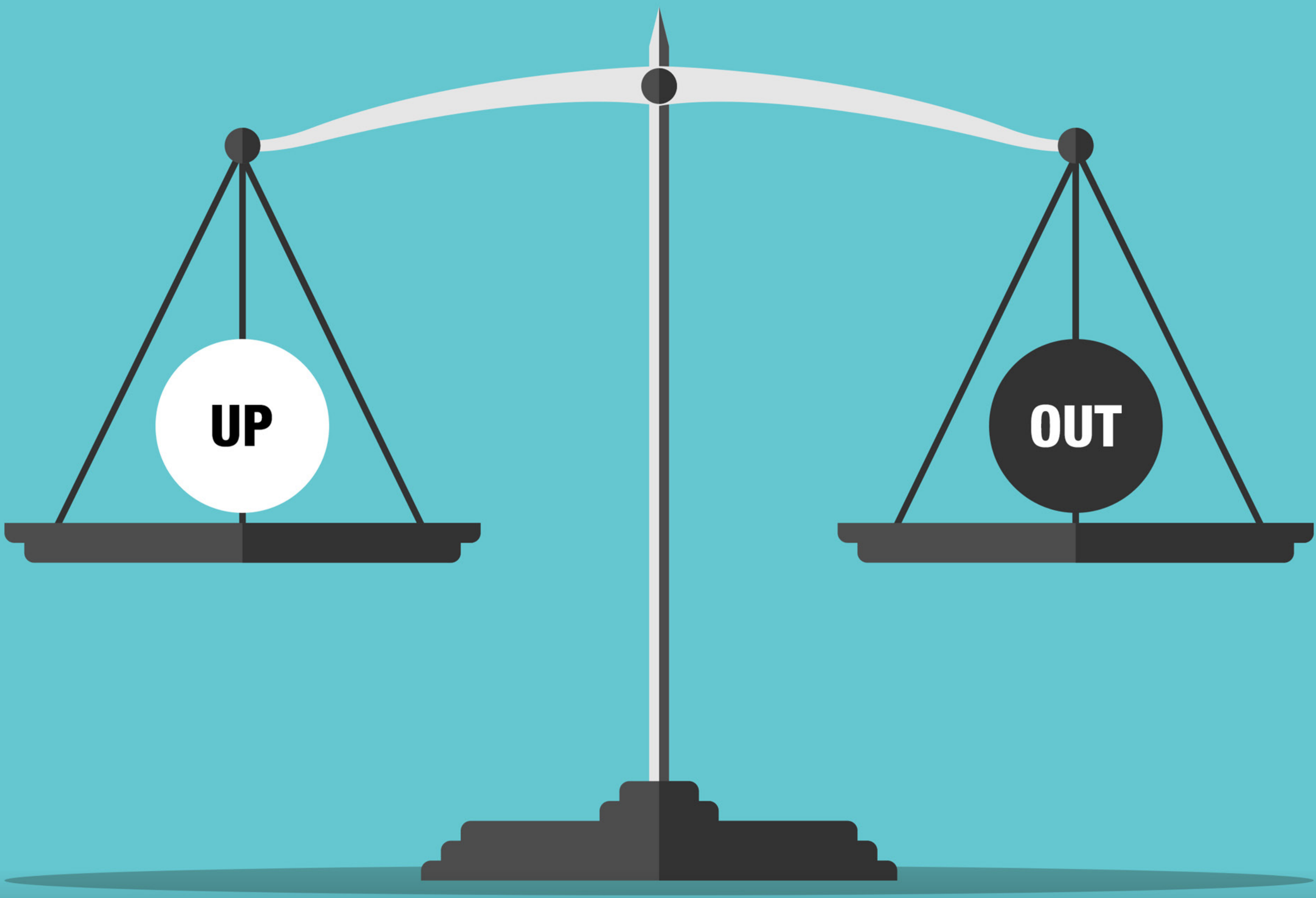
ENABLING TECHNOLOGY, SOCIAL RETURNS TO INNOVATION, AND ANTITRUST: THE TRAGEDY OF DEPRESSED ROYALTIES



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I. INTRODUCTION

Advancements in science and technology fuel today's innovation economy. Science is usually funded by the public, because scientists possess few methods to capture monetary value from their efforts. Technological development likewise has elements of the same value capture problem. Many inventions and technologies cannot be naturally protected and easily brought to market by the inventor. In recognition of this issue, intellectual property rights ("IPRs"), and in particular the patent system were devised to encourage inventions. No advanced society has succeeded without an intellectual property system.

However, patent rights sometimes appear to stand in the way of commercial players who, like many others in society, would like something for nothing (or very little). Patented technology is a most tempting theft opportunity, since the technology is already in the public domain, its use is often difficult to monitor, and infringement seems to the myopic to be harmless since it doesn't obviously appear to diminish what is left for others.

Infringers use legalistic fig leafs to clothe such theft. In real commercial circumstances, the antitrust laws can sometimes be invoked against purported monopoly pricing, despite a patentee's right to exclusive use, for a period of time, of the patented invention. Society should stand alert. As Nobel Laureate economist Douglass North has reminded us:

> Throughout man's past he has continually developed new techniques, but the pace has been slow and intermittent. The primary reason has been that the incentives for developing new techniques have occurred only sporadically. Typically, innovations could be copied at no cost by others and without any reward to the inventor or innovator. The failure to develop systematic property rights in innovation up until fairly modern times was a major source of the slow pace of technological change.[2]

Recent efforts to enlist antitrust as a lever against patents have threatened to undermine incentives for R&D in several important areas. Subtle theory-based antitrust arguments around patent hold up are a handy disguise for implementers and antitrust agencies to use to under-reward and thereby under-incentivize legitimate innovators.[3]

II. GENERAL PURPOSE / ENABLING TECHNOLOGY

The concept of "general purpose technologies" ("GPTs") entered the economics of technical change literature about three decades ago, motivated by observations from economic historians that (1) certain key technologies were central to economic growth, and (2) complementary assets were important to the creation, diffusion and adoption of new technologies.

Oversized gains to the economy and consumers can be traced to GPTs. Bresnahan & Trajtenberg,[4] who had respectively studied the computing and computed tomography ("CT") scanner industries, defined three characteristics of a GPT; it is (1) pervasive; (2) suited to ongoing technical improvement; and (3) given to complementary innovations. In other words, GPTs affect entire industries, get even better over time, and spawn other innovations as invention in one area triggers discoveries and creates opportunities elsewhere.

Bresnahan & Trajtenberg recognize that the GPT notion is not entirely novel, resembling as it does Mokyr's[5] *macro invention*, Dosi's[6] *technological paradigm*, Usher's[7] *strategic invention*, and other authors' *enabling technology*. A GPT/enabling technology exerts its effect over a

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2 North, *Structure and Change in Economic History*, 1981, New York: W.W. Norton & Company, p. 164

3 There is a need to understand how antitrust and other anti-patent policy interventions can, in the context of enabling technologies, have particularly deleterious consequences. There is also a need to understand how the domestic orientation of the debate/discussion in the U.S. and EU has negatively impacted inventors and innovation not domiciled in the U.S. or EU. Antitrust should become cognizant of global ramifications.

4 Bresnahan, "General Purpose Technologies." *Economics of Innovation*, vol. 2, North-Holland, 2010, Ch. 18, pp. 763 -791. Also: Bresnahan & Trajtenberg, "General Purpose Technologies: Engines of Growth?" *Journal of Econometrics* 65:1 (January 1995), pp. 83-108.

5 Mokyr, *The Gifts of Athena: Historical Origins of the Knowledge Economy*. Princeton University Press, 2002.

6 Dosi, "Technological Paradigms and Technological Trajectories." *Research Policy*, vol. 11, 1982, pp. 147–162.

7 Usher, *A History of Mechanical Inventions*. Harvard University Press, 1954.

protracted period — years and decades. Further invention is often the result of collaboration among individuals with disparate skills. For example, Rosenberg's[8] study of the machine tool industry identifies such mechanisms over seven decades of engagement.

Enabling inventions may not be immediately identifiable. For example, when the laser was invented around 1960, it was of scientific interest but had no obvious application. Today, lasers are ubiquitous, implemented in applications ranging from CD players and supermarket checkout stands to weapons systems, with other uses in surveying, medicine, telecommunications, manufacturing, entertainment, and more.

The threshold for a GPT is very high, but an enabling technology (present but not well defined in the literature), is simply a junior GPT, meeting criteria (2) and (3), above, but not necessarily having measurable economy-wide impacts. The traditional list of GPTs is relatively short and include blockbusters such as the printing press, the steam engine, electricity, radio, and the Internet. Enabling technologies might not be thought of individually as "growth engines" by economic historians, but each is nevertheless important to particular firms and industries. In their countless ubiquity they can often disrupt the *status quo* and generate very considerable spillover benefits.

Both GPTs and enabling technologies exhibit large positive spillover effects of two kinds: static and dynamic.[9] *Static* spillovers are externalities that do not change behavior by other economic agents, either at the time or in the future. *Dynamic* spillovers from an innovation alter the current and future value of existing technologies and open further technological opportunities for other agents. Profiting from such innovation is complex and difficult.

Few investments can match the social benefit to society of GPTs/enabling technologies. Protecting and amplifying society's reward structure for the creators of such beneficial technology should have high priority.

It is especially difficult to design workable business models to capture the fruits of R&D when an invention has a plethora of applications. The inventor must be willing and able to make downstream investments in multiple verticals, or rely on licensing. Accordingly, a proper functioning market for technology (often characterized by vibrant licensing activity) keeps investment flowing into the R&D activities that generate enabling technologies and GPTs. However, there are inherent limits to the licensing model.

III. THE COMMON STREAM (AND MULTIPLE APPLICATIONS) OF ENABLING TECHNOLOGY

Certain economic activities have especially large positive spillovers because of the problems of appropriability, as recognized in the standard economic treatment:

> …the primary output of resources devoted to invention is the knowledge of how to make new goods and services, and this knowledge is nonrival: use by one firm does not preclude its use by another. To the extent that knowledge cannot be kept secret, the returns to the investment in knowledge cannot be appropriated by the firm undertaking the investment, and therefore such firms will be reluctant to invest, leading to the underprovision of R&D investment in the economy.[10]

Numerous studies have measured spillovers to investment on R&D. A consensus finding is that social returns are three to six times the magnitude of private returns. Table 1 summarizes a few of the relevant studies.

8 Rosenberg, "Technological Change in the Machine Tool Industry, 1840-1910," *The Journal of Economic History* 23:4 (December 1963), pp. 414-443.

9 Carlaw & Lipsey, "Externalities, Technological Complementarities and Sustained Economic Growth." *Research Policy*, vol. 31, no. 8-9, Dec. 2002, pp. 1305–1315.

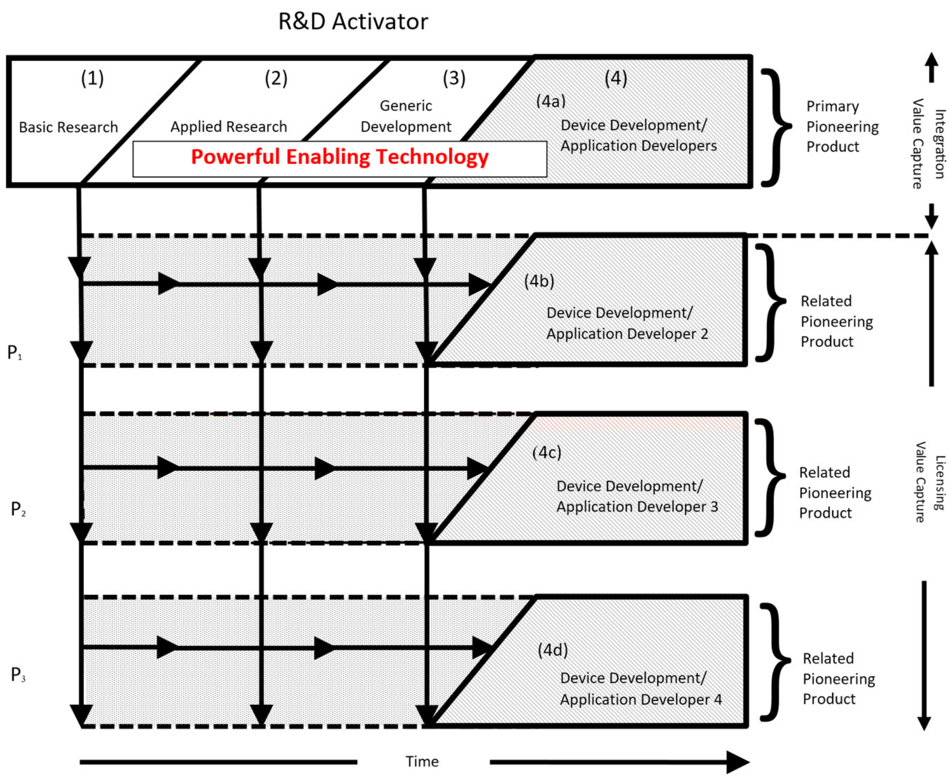
10 Hall & Lerner, "The Financing of R&D Innovation." *Economics of Innovation*, vol. 1, North-Holland, 2010, Ch. 14, p. 611.

TABLE 1: COMPARISON OF FIRM-LEVEL RETURN WITH SOCIAL RATES OF RETURN

Study	Private Return	Social Return	Notes
Mansfield et al. (1977)[11]	25%	56%	Median values across 17 product and process innovations
Tewksbury et al. (1980)[12]	27%	99%	Median returns across 20 product and process innovations
Teece et al. (2000)[13]	21%	29% to 62%	Estimated returns to Pilkington plc's intellectual property portfolio for the float glass process
Bloom et al. (2013)[14]	21% to 40%	55% to 74%	Estimated returns to R&D for 700 firms with at least one patent

In the typical spectrum of scientific and technological activities, the appropriability problem is greatest for basic research and less severe (possibly nonexistent) as development activity approaches the final customer/user. This is illustrated below in Figure 1 for a "generic" or enabling technology where the enabling R&D supports not only one pioneering product but multiple related pioneering products, such as devices or applications.

FIGURE 1: ENABLING TECHNOLOGIES SUPPORTING A PIONEER PRODUCT AND MULTIPLE RELATED PRODUCTS P1, P2, P3



Note: Dotted areas are avoided costs due to the generic multiproduct nature of enabling technology. R&D for the primary pioneering product supports multiple (technology-related) products.

11 Mansfield, Rapoport, Romeo, Wagner & Beardsley, (1977), "Social and private rates of return from industrial innovations," Quarterly Journal of Economics, 91(2), 221-240.

12 Tewksbury, Crandall & Crane, (1980), "Measuring the societal benefits of innovation," Science, 209(4457), 658-662.

13 Teece, Grindley & Sherry, (2002), "The Glass Industry and the Pilkington Float Process," in Teece, ed., Managing Intellectual Capital: Organizational, Strategic, and Policy Dimensions, New York: Oxford University Press, 225-276.

14 Bloom, Schankerman & Van Reenen, (2013), "Identifying technology spillovers and product market rivalry," Econometrica, 81(4), 1347-1393.

Activities (1) through (3) on the left of the top bar in figure 1 are, or turn out to be, "general purpose," investments in that they effectuate multiple lateral or downstream (application) innovations/implementations. Product developments 4(a), 4(b), 4(c), and 4(d) all feed from common stream activities (1), (2), and (3), which may be performed by government labs, private R&D labs, universities, or some combination among them.

If individuals and companies are unwilling to risk the necessary investment at the socially desirable levels, two other possibilities present themselves: (1) Government can directly fund the activity; (2) Stakeholders can form consortia to fund upstream enabling technology … but such "collusive" activity may be limited by the antitrust laws, as well as by the ever-present lack of predictability of application areas.[15]

Licensing is a fallback business model for capturing value far beyond the core pioneering product. However, as discussed below, the licensing model requires judicial and public policy support. In their absence, it will likely fail, and investment in breakthough generic R&D will likely suffer too.

These common stream enabling investments are precious. The social rates of return associated with them are likely very high, much higher than the tripling of private returns generally associated with a broad array of technologies. Put differently, enabling technologies will surely generate the highest social return, even allowing for diligent appropriability efforts by inventors for their investors.

As a practical matter, governments tend to financially support basic, applied, and generic research where positive spillovers are so significant that value capture is difficult no matter what business model is employed. In the U.S., national security imperatives propel such investment too, delivered through organizations such as by DARPA and ARPA.

However even with government subsidy, these types of generic research can remain undersupported despite the high payoff to consumers and to society. Hence, *policy* support (including from the judiciary) for research on enabling technologies which does in fact attract private funding is essential. Put differently, if government financial support isn't available or is insufficient, private investment in enabling technology should attract positive judicial and policy support.

IV. THE BUSINESS MODEL CHALLENGE FOR ENABLING TECHNOLOGIES

Commercialization strategies available to the developers of GPTs/enabling technologies are typically devoted to licensing of patents and trade secrets. As a practical matter, pioneers of upstream enabling technologies are not necessarily proficient in the relevant downstream applications ("verticals").

This "capability mismatch" generates a need to license technology.[16] One remarkable feature of modern market economies is that markets for innovation and technology do in fact exist.[17] Their fragile existence is a tribute to the sophisticated nature of property rights and contract law and their proper enforcement in a modern private enterprise economy.

Some firms (e.g. AT&T in the 1940's with the transistor) have invested heavily in enabling technologies. Their appropriability problem was, in this and other cases in the mid-20th-century telecom industry, "solved" in the U.S. because AT&T enjoyed a special fee that regulators imposed on telephone subscribers to help offset the cost of research at Bell Labs, the heart of AT&T's system of innovation.

In other cases, the pioneer lost out. EMI in the U.K. invented the CAT scanner and lost in the marketplace to General Electric, Siemens and others. Pilkington invested in the float glass process (arguably an enabling technology) on its own, reaping benefits until antitrust intervened. Qualcomm in the U.S. invented the key technology behind CDMA, the 3G wireless standard, which it has successfully licensed.

15 Nelson, "The Simple Economics of Basic Scientific Research." Journal of Political Economy, vol. 67, no. 3, June 1959. In the paper, Nelson explains why basic research is hard for specialized (i.e. undiversified) firms to support. He raises a general problem, applicable to enabling technologies too. Quite simply, value capture from early stage generic research and development is difficult.

16 See Teece, "Profiting from Innovation in the Digital Economy," Research Policy (forthcoming, 2018); Teece, "Reflections on 'Profiting from Innovation," Research Policy 35:8 (December 2006), 1131–1146; Teece, "Profiting from Technological Innovation," Research Policy 15:6 (December 1986), 285–305.

17 Teece, "The Market for Know-how and the Efficient International Transfer of Technology," The Annals of the Academy of Political and Social Science 458:1 (November 1981), 81–96. Also see Arora, "Markets for Technology: The Economics of Innovation and Corporate Strategy," MIT Press, 2004.

Despite occasional success stories, licensing is not an especially effective tool with which an inventor can capture value. Patents licenses are not self-enforcing — the power of the court is needed. All licenses are negotiated in the shadow of the court. Without proper enforcement, and the readiness of a court to enforce patents, licensing agreements yield little value. This helps explain Nobel Laureate Ken Arrow's puzzle:

> Patent royalties are generally so low that the profits from exploiting one's own invention are not appreciably greater than those derived from the use of others' knowledge. It really calls for some explanation, why the firm that has developed the knowledge cannot demand a greater share of the resulting profits (Arrow, 1962, p. 355).[18]

He was still puzzled 50 years later:

> Why is it that royalties are not an equivalent source of revenues? In simple theory, the two should be equivalent. Indeed, if there is heterogeneity in productive efficiency, ... then it should generally be more profitable to the innovator to grant a license to a more efficient producer... I have the impression that licensing is a minor source of revenues (Arrow, 2012, p. 47).[19]

The puzzle can be resolved once one takes into account the reluctance of the court to enjoin. In the U.S., the Supreme Court's *eBay Inc. v. MercExchange LLC* decision in 2006 amplified this problem.[20]

Because of these inherent business models and enforcement difficulties, antitrust must tread carefully in the licensing space. As noted, the wonder of technology markets disguises a fragility that antitrust authorities should recognize. Failure to do so is likely to be even more harmful to the economy and consumers than it is to private interests — because it chills technology markets, and discourages investment in R&D, particularly that which supports challenging blue-sky initiatives. It is not just that royalties get chiseled down; the bigger problem is that market transactions evaporate and are steered into the courthouse, at great cost to society, the parties, and the smooth functioning of markets for know how/technology.

V. MOBILE (WIRELESS) TECHNOLOGY AS ENABLING TECHNOLOGY

In recent decades, one of the most outstanding displays of powerful enabling technology at work has been mobile wireless. In the main, this has been privately funded. Technical developments in wireless have involved a great deal of discovery, testing and validation by business enterprises mainly in the U.S. and Europe. Each new generation of mobile wireless communication technology requires billions of R&D dollars invested over the course of a decade to develop and formalize standards. The standards process for wireless is orchestrated by the European Telecommunications Standards Institute ("ETSI").

The mobile wireless sector affords numerous examples that illuminate the issues of value capture. The key advances leading the digital communications revolution began with many proprietary technologies. These were then codified in a series of wireless standards, each of which provided a step change improvement in communication performance running from 2G in the early 1990s through the current 4G. Major revision to standards has been more than incremental. Each generation has dramatically improved performance in transmission capacity, service quality, congestion management, cell handover, and signal quality.

5G, the next generation, is on a path to be rolled out beginning in 2020 with further enhancements to latency and speed. This cluster of inventions will facilitate new, wireless-based business models in industries dealing with massive quantities of data or mission-critical processing. Each generational advance makes new types of data services possible.

The required technological advances have been enabled by armies of engineers at numerous companies, including AT&T, IBM, TI, Motorola, Siemens, and Ericsson with research labs distributed around the world. The other current major wireless technology developers are Qualcomm (which also sells chips using its technology and licenses its patented technology), Nokia, (which is now almost exclusively a telecom equipment supplier), and InterDigital, (a pure licensing company).

18 Arrow, "Comment on The Origins of the Basic Inventions Underlying Du Pont's Major Product and Process Innovations, 1920 to 1950," in The Rate and the Direction of Inventive Activity: Economic and Social Factors, 355 (Nelson ed., 1962).

19 Arrow, "The Economics of Inventive Activity Over Fifty Years, in the Rate and the Direction of Inventive Activity Revisited 43," 47 (Lerner & Stern eds., 2012).

20 *eBay Inc. v. MercExchange LLC*, 547 U.S. 388 (2006)

Complex and interdependent wireless technologies embodied in the mobile data revolution have laid the foundation for multiple, connected business ecosystems for a range of new services such as streaming media, cloud computing, the Internet of Things, and mobile payment systems.

In the case of smartphones, 4G standard technology stimulated sales of smartphones, particularly those that could use the new technology most beneficially and compellingly. Some of the technology has been embodied in a baseband (modem) chip, but most of the value extends beyond the chip to the smartphone and even to the network.

Improvements in standardized communication technology, rolled out in carrier networks, and employed on consumer and business devices, in time enables new and better apps like Facebook and Netflix. Better apps feed back to the demand for devices, particularly those with technologies and features that are highly complementary to the standardized technology. Hence implementers that attract and use the most complements benefit the most.

When private parties negotiate for legal access to patented wireless technology, the value generated by the technology ought to be taken into account. Certainly, the bargaining range ought to be impacted by such considerations, thereby allowing the patent owner to claim a portion of the spillover or broader (social) value to be taken into account but typically only that piece that the licensee would directly benefit from.

Dynamic efficiency for ongoing innovation justifies a portion of this downstream value to flow upstream to the wireless interface technology developers. Such royalties ought not be thought of as a "tax" in any meaningful sense — royalties simply are the transfer of financial resources needed to keep the research enterprise advancing.

VI. THE FRAND ROYALTY APPROACH

A. FRAND and the Innovation System

The need for a forward-looking approach to technology development on mobile wireless was recognized from the outset by ETSI. The original architects of ETSI IPR policies sought a "balancing of the interests" of technology contributors (patent owners) and implementers. ETSI 3GPP started as a European governmental initiative, to assemble a broad set of actors committed to fairness and benefits to the broader telecommunications sector (ecosystem) and consumers. This broad constituency is still apparent today and includes chipset designers and fabricators, handset and base station makers, cellular service providers, app developers and, of course, consumers.

The standards development system was not designed to favor one constituency over the others. Indeed, initial versions of the ETSI IPR policy which didn't attract technology developers were all rejected in favor of versions that yielded balance. Where standards technology contributors enable so much of the subsequent downstream innovation, it is critical that technology developers not be short changed. This conclusion is not only consistent with ETSI IPR policy; it is economically desirable and therefore entirely reasonable from a public policy perspective.

Standard development organizations ("SDOs") require their members who own patented technologies, before technologies are accepted into a standard, to agree to make licenses to their patents available on FRAND terms. What is "fair and reasonable" ("FR") and what is "non-discriminatory" ("ND") often raise questions. In this paper I will only address the FR aspect of FRAND, in the context of ETSI.

There is little doubt, and Dr. Bertram Huber an ETSI founder confirms this view,[21] that ETSI was concerned with establishing a vigorous standards process to support the development of a robust telecommunication industry in Europe and around the world. ETSI requires FRAND commitments from its technology contributors, with the expectation that implementers would take a license under FRAND terms.

The mobile phone industry was very much in its infancy at the time ETSI was founded. The focus then and now is on what, in modern language, we think of as creating a robust innovation ecosystem.

> …the ETSI IPR POLICY seeks a balance between the needs of standardization for public use in the field of telecommunications and the rights of the owners of IPRs. … IPR holders whether members of ETSI and their AFFILIATES or third parties, should be

21 Author conversations with Dr. Bertram Huber, 2017.

adequately and fairly rewarded for the use of their IPRs in the implementation of STANDARDS and TECHNICAL SPECIFICATIONS.[22]

In what follows, I give consideration to the issues, with specific reference to ETSI policy. I also consider the cost of error and elaborate the point that under-rewarding the patent holder of an enabling technology has very high societal costs, and should be avoided.

B. Social Value Criteria

There should not be a rule that would prevent the parties from casting their eyes in all directions to see the total value which they create, and endeavor to realize a portion of that in some fashion. Certainly a "social planner" (a hypothetical omniscient "architect" endeavoring to design a robust ecosystem) would do so. Even in the absence of horizontal spillovers, economic principles, support the notion that the rewards for early stage innovators should include some of the anticipated surplus that subsequent stakeholders (i.e. implementation/application stakeholders) garner through use of standards technology. Downstream value is revealed only over time.[23] Nor should there be a cap in the price of the royalty base as more expensive smart phones are likely to make more intensive use of more advanced standardized technology. One way to take account of uncertainty is to use a royalty base consistent with a likely value meter, such as the smart phone rather than the cellular chipset.

In short, the relevant lens for assessing full value ought to be the ecosystem, not a particular segment which might use the patented technology. This happens, for good reasons, to be consistent with industry practice.

The reason for looking at full or total value as a starting point for FRAND negotiations is because doing so is consistent with economic reasoning and ETSI's goals and policies. It's also what willing licensors and willing licensees, guided by an ecosystem "architect" or "regulator," would naturally focus on in guiding negotiations. Such negotiations would increase the likelihood of rewarding upstream technology contributors commensurate with what's needed to draw forth the investment in upstream innovation at levels likely to keep the ecosystem robust. If licensing negotiation between parties must somehow be blind to the downstream value that is created, the inherent underinvestment problems owing to inadequate rewards will only be amplified.

VII. FROM HOLD UP TO HOLD OUT: TIME TO CLOSE THE DEBATE?

A. Intellectual History

A vigorous telecommunication industry requires a robust innovation ecosystem. Various parties and occasionally antitrust regulators have clumsily tried to undo ETSI's good design around FRAND issues.[24]

As mentioned earlier, there is a penchant for absconding with the fruits of innovation — particularly once those inventions are disclosed to implementers. Patent infringement is facilitated if "fig leafs" are available to disguise the infringer's motive. For the last decade or so, the antitrust theory of patent hold up has been just such a fig leaf.

The intellectual history on patent "hold up" and "hold out" theory is checkered. It is also a red herring. The first (mis)application of the hold up concept to the realm of patents was Shapiro in 2001.[25] While IP scholars subsequently became aware of these patent hold up theories, scholars and practitioners close to the world of licensing understood this work to be theoretical musing and little else.

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22 ETSI Rules of Procedure, November 30, 2011, Annex 6: ETSI Intellectual Property Rights Policy, p.34.

23 E.g. microprocessors were first used and made for the Japanese Busicon calculator, but rapidly found other applications. (See Hoff, "The Birth of the Microprocessor and Beyond." *Stanford University*, Stanford Engineering, available at: https://engineering.stanford.edu/news/ted-hoff-birth-microprocessor-and-beyond.) In advance it's impossible to know all of the potential applications, but they can be anticipated to some degree.

24 ETSI of course leaves the rate to negotiations between the parties under the shadow of the FRAND commitment.

25 Shapiro, "Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting," in Innovation Policy and the Economy 1, edited by Jaffe, Lerner & Stern, 2001, Cambridge: National Bureau of Economic Research and The MIT Press, pp. 119-150.

Opportunism that lies at the heart of the idea is frequently observed. But guile is also needed.[26] If a patent owner promised to charge one rate, and specific investment was made on the basis of that promise, and patent owners subsequently, without good reason, changed their minds, then the Williamsonian criterion for hold up might be met. But such situations are likely to be rare. More commonly, the patent owner merely promises to make licenses available on FRAND terms, but *without* specifying in great detail until later on what rates it would seek to charge.

Numerous implementers making standards-compliant products have latched onto the patent holdup argument, claiming that hold up in the context of standard essential patents ("SEPs"), is the norm. Only in recent years has policy concern over hold *out* (i.e. implementers not taking licenses but nevertheless using the technology) arisen even though it has been a perennial problem in the marketplace. Indeed, the current head of the DOJ Antitrust Division, correctly in my view, states that "collective hold out" behaviors in standard settings are more pernicious than unilateral hold up by SEP holders.[27] The belated recognition of hold out is what may have led Contreras to argue that:

> To the extent that hold-up impedes the efficient operation of standard-setting processes, SDOs can, and have, adopted internal procedures, including disclosure and licensing requirements, to curtail that behaviour … it may thus be time to close the debate over the systemic prevalence of this form of behaviour. (p24)[28]

Hold up theories have begun to wane for a lack of evidence. Furthermore, it is widely accepted that contractual mechanisms (by which SDOs seek enforceable FRAND commitments from SEP holders) are already in place to deal with patent hold up.

There is an emerging consensus that it is time to shut down this antitrust ruse, at least until evidence of hold up emerges. However, even if the debate is drawing to a close in the U.S., we are nevertheless left with (a) foreign competition agencies and bureaus now using the hold up argument to favor national champions and (b) a sense that perhaps the debate has come to a stalemate with arguments and evidence on both sides. The assessment in (b) is inappropriate because the antitrust frameworks that look at both hold up and hold out are both static and too narrow. The social returns to innovation issues discussed earlier have been ignored. Had they been recognized, the academy might not have lead the judiciary and policymakers astray.[29] The occurrence of "hold out" has greater cost than "hold up." This is especially true for emerging technologies, into which category many wireless technologies fall. When emerging technologies are at issue, and dynamic consideration are taken into account, the merits favor erring on the side of worrying about hold out, and depressed royalties.

B. The Asymmetric Cost of Error Associated with Antitrust Interventions

The empirical economics literature shows no evidence of patent hold up; moreover, litigation has yet to establish that patent hold has taken place. Yet there are numerous instances of hold out as evidenced by protracted litigation in multiple jurisdictions around large SEP portfolios as to which there is no ambiguity of patent validity and infringement.

Consistent with ETSI goals, analyzing the situation from an economic perspective leads to several observations:

1. Implementers are third-party beneficiaries of a FRAND contract between the SDO and owners of standard essential patents, so:

    a. FRAND requires making licenses available. The patent owner has, for most practical purposes, foregone the option of avoiding dealing with an opportunistic implementer.

    b. Forward vertical integration by the patent owner often doesn't work to protect the inventor against harm from hold out. The patent holder's capabilities may not favor pursuing such a business model.

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26 See Williamson, "Markets and Hierarchies: Analysis and Antitrust Implications, A Study in the Economics of Internal Organization," Free Press (1975); "The Economic Institutions of Capitalism: Firms, Markets, Relational Contracting," Free Press (1985).

27 Delrahim, "Take It to the Limit: Respecting Innovation Incentives in the Application of Antitrust Law," Remarks delivered at USC Gould School of Law, Los Angeles CA, November 10, 2017, at 5, available at: https://www.justice.gov/opa/speech/assistant-attorney-general-makan-delrahim-delivers-remarks-usc-gould-school-laws-center.

28 Contreras, "Much Ado About Holdup," (February 13, 2018). University of Illinois Law Review, Forthcoming. Available at: https://ssrn.com/abstract=3123245 or http://dx.doi.org/10.2139/ssrn.3123245.

29 Barnett, "Has the Academy Led Patent Law Astray?" Berkeley Technology Law Journal, Issue 4, vol. 32, (2018), pp. 1313–1380.

c. Implementers can refuse to pay, whereas the patent holder cannot physically withhold the technology once patents are published. In short, *de facto* infringement is an option for implementers. Denial of access to the patented technology isn't possible without the association of costs. It is therefore not surprising to see infringement for many years by putative licensees.

2. The shadow of litigation covers royalty negotiations. If a court determining infringement awards too low a royalty, the innovator remains undercompensated. "Too high" an awarded royalty has very little negative social impact because it would be a relatively rare blip against the dominate forces under-rewarding enabling technology. Awards that are "too low" have outsized negative impacts once externalities are taken into account. Awards "too high" (by private rate of return criteria) may nevertheless remain too low by *social* reward criteria.

In short, the cost of error is not symmetric, especially when enabling technologies are implicated. The antitrust standards literature to date has been remiss in not balancing the interests of patent holders and implementers, and in not adopting the proper dynamic perspective.

VIII. A NOTE ON "*EX-ANTE*" FRAND ROYALTIES

Some antitrust economists nonetheless cling to the hold up fiction. They suggest that the way to handle it is to set royalties at some level they call "*ex-ante.*" There are, as explained elsewhere,[30] multiple meanings of *ex-ante*. Advocates of an *ex-ante* approach have left its meaning indeterminate. *Ex-ante* means "before." But before what? The usual interpretation is *after* the technology exists, and thus after the innovator has sunk its investment in developing the technology, at least to the point where it can be considered for incorporation into the standard, but *before* the SDO chooses which technology to incorporate into the standard, and *before* implementers have made any investments in making standards-compliant products. As such, what is often termed *ex-ante* is more properly thought of as *"interim"*: after one party (the innovator) has made its investment, but before the other party (the implementer) has made its investment.

Even some theoretical notion of *ex-ante* value (e.g. setting royalties consistent with bargaining power anchored to an inventor's irreversible investment but before an implementer's irreversible investment) such a rate may remain incalculable without indicating dynamic consideration.

One consequence of the oft-times advocated *ex-ante* approach is to bestow all the gains from standardization to the implementers. Even without spillovers, neither economic theory (nor equity) justifies this approach, especially if the very success of the standard owes partially to the patented technology that was selected. Excluding the developers from claiming some share of the gains from standardization is also inconsistent with ETSI's desired balancing of interests.

Moreover, even if a SEP does not rise to the level of an enabling technology, inventors may remain under-rewarded, because of the inadequacy of value capture business models; additional compensation would encourage the higher level of investment that social dynamic requires.

The *ex-ante* approach follows from an implicit claim that hold up is ubiquitous. Indeed, the claim is sometimes made that an opening offer for anything other than the "*ex-ante*" value (whatever that is) is tantamount to evidence of hold up. This of course makes no commercial common sense and implicitly defines as a violation of antitrust law any sharing/balancing (which is in fact necessary to comply with ETSI's IPR policy!).

It is also important to note that if a technology were so superior that it would be used whether adopted as a standard or not, or so superior as to have no commercially viable alternatives, then its incorporation into the standard does not confer any additional market power beyond that already present in the patent, and the standard makes little difference to the royalties the technology would command in a well-functioning market.

Advocates of the *ex-ante* approach like to argue that setting a low royalty rate is warranted because it is compensated for by the greater value the standard confers, and in particular the fact that patent holders whose technology is chosen for incorporation into a standard will get a "volume effect" of being able to seek royalties on all standards-compliant products which they would not have in the absence of standardization. However, causation could run the other way: a standard may only succeed because of the powerful (patented) technologies embedded in it. The volume effect may be as much a result of patent technologies' success as it is the cause. Endogeneity likely exists.

30 Teece and Sherry. "Licensing and Standards Setting: The Multiple Meanings of 'Ex Ante' Negotiations and Implications for Public Policy." *Tusher Center for the Management of Intellectual Capital*, 21 May 2015, businessinnovation.berkeley.edu/wp-content/uploads/businessinnovation-archive/documents/Tusher-Center-Working-Paper-10.pdf.

IX. THE PROBLEM OF DEPRESSED ROYALTIES

The forces at work in a market economy even with reasonably well developed intellectual property rights tend to result in royalty rates that are too low. These forces can be summarized as follows:

1. Spillover from enabling technologies are likely very considerable. Technology is accordingly underpriced because of inherent appropriability problems.

2. Patents are not self-enforcing because patented technology is disclosed when a patent is granted; once in a standard, it is disclosed yet again, (as standards are published).

3. Implementers are in no hurry to take a license. They can run out the clock on the term of the patentee's grant. When there is no effective threat of injunction[31] infringers might merely pay damages (plus prejudgment interest, often at low rates).[32]

4. When a patent owner encounters a recalcitrant licensee, of which there are likely many if implementers aren't themselves SEP owners who might cross-license, then the patent owner sometimes discounts royalty rates still further in order to prime a bandwagon effect. This factor may depress observed royalty rates below the first-best.

5. Antitrust allegations against a patentee, such as "hold up," are sometimes used to blunt allegations of willful infringement by a would-be licensee. Antitrust at a minimum causes uncertainty which can retard the advance of a licensing program. This tactic muddies the water to an infringer's advantage. *Unilateral* "hold *out*" typically is not treated symmetrically under the antitrust laws, which seeks to deter *coordinated* effort to boycott or otherwise use monopsony power against the patent owner.

6. Given the absence of any criteria put forward today by hold up champions — no workable structure was put forward by Shapiro in his original article — the hold up theory is tailor-made for politically motivated competition authorities to simply announce that proposed royalty rates are "too high," on antitrust grounds. An antitrust theory not properly grounded in markets *as they operate* invites mischief by national governments seeking to advantage domestic industry at the expense of domestic consumers, foreign competitors and technology creators.

X. SUMMARY

Empirical studies show that almost all classes of R&D activity are under-supported. Two in particular are grossly undercompensated: (a) basic research and even applied research (b) enabling (or general purpose) technologies. Accordingly, when courts or regulators are reviewing or setting royalty rates then consideration needs to be given to amplifying, not diminishing, incentives for upstream investment in R&D. Such investment is perhaps among the most precious that society makes.

FRAND issues are contract issues, not antitrust issues. Should courts be tempted to frame patent hold up issues as antitrust issues, then that frame should be rigorous and robust. Broader dynamic considerations must be brought into play. Enabling technologies warrant special care in the intellectual property commons. The mistake of undercompensating technology creators would lead to the tragedy of diminished innovation, and, as a longer term consequence, less competition. A properly functioning technology market can do better.

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31 The difficulties of securing injunctions in many jurisdictions means that licensees have little to fear from being shut out of the market. Hence, drawing out negotiations is relatively costless to the implementer (other than the prospect of having to pay prejudgment interest on a damages award). Meanwhile patent owners are denied cash, making the funding of ongoing research difficult especially in for a public company for which quarterly earnings forecasts can be missed if license income flows slower than expectations.

32 Epstein & Noroozi, "Why Incentives for 'Patent Holdout' Threaten to Dismantle FRAND, and Why It Matters," Berkeley Technology Law Journal, Issue 4, vol. 32, (2018), pp. 1381 – 1430.