IS THERE AN ANTICOMMONS TRAGEDY IN THE WORLD SMARTPHONE INDUSTRY?

Alexander Galetovic,[†] *Stephen Haber*[††] *& Lew Zaretzki*[†††]

ABSTRACT

An influential literature claims that standard setting for high–technology interoperable products potentially creates monopoly power for the owners of standard–essential patents. Moreover, because there are many owners of standard–essential patents, and each may independently exercise monopoly power (a phenomenon called royalty stacking), an anticommons tragedy may ensue. With actual data from the canonical case of the smartphone industry, this Article shows that royalty stacking theory predicts a cumulative royalty yield of nearly eighty percent. That is, it predicts that four–fifths of the price of a smartphone will accrue to patent holders. Even if all patent holders would combine to eliminate the tragedy of the anticommons and behave as a single monopolist, theory predicts a cumulative royalty yield of nearly sixty–seven percent. That is, it predicts that two–thirds of the price of a smartphone will accrue to patent holders.

This Article then uses actual data from licensors in the smartphone value chain to estimate the actual cumulative royalty yield. It finds that in 2016, the cumulative royalty yield in the world smartphone value chain was only 3.4 percent of the average selling price of a smartphone. This suggests that patent holders do not exercise any meaningful monopoly power to increase prices in the world smartphone market, much less that there is an anticommons tragedy in the smartphone industry.

DOI: https://doi.org/10.15779/Z38F76670Q

† Alexander Galetovic is Professor of Economics, Universidad de los Andes, Santiago, Chile; alexander@galetovic.cl.

†† Stephen Haber is the A.A. and Jeanne Welch Milligan Professor in the School of Humanities and Sciences, Professor of Political Science, Professor of History, Professor (by courtesy) of Economics, Senior Fellow of the Stanford Institute for Economic Policy Research, and Peter and Helen Bing Senior Fellow at the Hoover Institution, at Stanford University; haber@stanford.edu. Haber directs the Hoover Institution Working Group on Intellectual Property, Innovation, and Prosperity (Hoover IP2). Hoover IP2 succeeded the Hoover Project on Commercializing Innovation (PCI). To ensure academic freedom and independence, both PCI and IP2, along with all work associated with them, have only been supported by unrestricted gifts. Some major donors have included Microsoft, Pfizer, Interdigital and Qualcomm.

††† Lew Zaretzki is Managing Director, Hamilton IPV a Silicon Valley IP strategy consulting firm serving many of the world's finest technology companies and leading technology investors in matters of corporate strategy, IP strategy, M&A, and IP transactions; lew@hamiltonipv.com.

TABLE OF CONTENTS

> It is generally accepted that the main source of profits to the innovator are those derived from temporary monopoly. Why is it that royalties are not an equivalent source of revenues? In simple theory, the two should be equivalent. Indeed, . . . it should generally be more profitable to the innovator to grant a license to a more efficient producer . . . but I have the impression that licensing is a minor source of revenues.
>
> – Kenneth J. Arrow (2012)[1]

I. INTRODUCTION

An influential literature claims that standard setting in high technology, compatible and interoperable products, creates an opportunity for the exercise of monopoly power by the owners of standard–essential patents. The core of this claim is that there are "too many" owners of the intellectual property rights necessary to make interoperable and compatible products, each of whom is able earn "excessive royalties" from the monopoly power conferred upon them through the process of standards development. These claims can be found not only in the academic literature, but also in court cases, published reports by competition authorities, and in the declarations of the officials that head those authorities, both in the United States and Western Europe.[2]

1. Kenneth J. Arrow, *The Economics of Inventive Activity Over Fifty Years*, *in* THE RATE AND DIRECTION OF INVENTIVE ACTIVITY REVISITED 43, 47 (Josh Lerner & Scott Stern eds., 2012).

2. *See, e.g.*, FED. TRADE COMM'N, TO PROMOTE INNOVATION: THE PROPER BALANCE OF COMPETITION AND PATENT LAW AND POLICY ch. 2 at 3 (2003), www.ftc.gov/sites/default/files/documents/reports/promote–innovation–proper–balance–competition–and–patent–law–and–policy/innovationrpt.pdf; ("[R]esearchers who require access not just to a single patent but to *multiple* patents may find their work impeded by high transaction costs, royalty stacking, hold up in patent thickets, and oligopolists seeking to bar new entry. . . . [T]hese are not merely hypothetical concerns."); FED. TRADE COMM'N, THE EVOLVING IP MARKETPLACE: ALIGNING PATENT NOTICE AND REMEDIES WITH COMPETITION 147 (2011) [hereinafter FTC, EVOLVING IP MARKETPLACE], www.ftc.gov/sites/default/files/documents/reports/evolving–ip–marketplace–aligning–patent–notice–and–remedies–competition–report–federal–trade/110307patentreport.pdf ("Large numbers of patents can create 'patent thickets' and increase transaction costs for manufacturers that seek to clear the rights needed to produce a product."); FED. TRADE COMM'N & U.S. DEP'T OF JUSTICE, ANTITRUST ENFORCEMENT AND INTELLECTUAL PROPERTY RIGHTS: PROMOTING INNOVATION AND COMPETITION (2007), www.justice.gov/sites/default/files/atr/legacy/2007/07/11/222655.pdf ("Royalty stacking occurs when access to multiple patents is required to produce an end product, forcing the manufacturer's products 'to bear multiple patent burdens' . . . ."); Bill Baer, Assistant Att'y Gen., U.S. Dep't of Justice, Reflections on the Role of Competition Agencies When Patents

The reasoning behind the tragedy of the anticommons claim is that the owners of the patented technologies that allow products to be interoperable obtain monopoly power because their technologies have been accepted as part of an industry standard. On the supply side, manufacturers are locked into particular technologies by their own standard–specific investments. On the demand side, consumers would not switch unilaterally to products that use an alternative technology because their devices would no longer be compatible with those owned by other consumers.[3] Alternative technologies are therefore knocked out of the market. The firms whose patented

Become Essential (Sept. 11, 2015), https://www.justice.gov/opa/speech/assistant–attorney–general–bill–baer–delivers–remarks–19th–annual–international–bar ("In recent years it has become well understood that the competitive process can suffer when the value of a patent is enhanced by becoming essential to a standard and patent holders seek to exploit that added value by failing to keep the commitments they voluntarily make about how they will license these patents."); Renata B. Hesse, Assistant Att'y Gen., U.S. Dep't of Justice, IP, Antitrust and Looking Back on the Last Four Years 16 (Feb. 8, 2013), https://www.justice.gov/atr/file/518361/download [hereinafter Hesse *2013 Speech*] (arguing that standard setting confers market power on standard essential patent holders); Renata B. Hesse, Assistant Att'y Gen., U.S. Dep't of Justice, At the Intersection of Antitrust & High–Tech: Opportunities for Constructive Engagement 9 (Jan. 22, 2014), www.justice.gov/atr/file/517776/download (describing the continuing vigilance of antitrust authorities to prevent that standards are used to restrict competition); Carl Shapiro, *Navigating the Patent Thicket: Cross Licenses, Patent Pools, and Standard Setting*, *in* 1 INNOVATION POLICY AND THE ECONOMY 119, 125 (Adam Jaffe, Josh Lerner, Scott Stern eds., 2001) (describing the danger of paying royalties to multiple patent holders); Fiona Scott Morton & Carl Shapiro, *Patent Assertions: Are We Any Closer to Aligning Reward to Contribution?*, *in* 16 INNOVATION POLICY AND THE ECONOMY 89, 124 (Josh Lerner, Scott Stern eds., 2016) ("For example, the 'Internet of Things' is a new and growing area where royalty stacking and patent holdup appear to be very real dangers."); Margrethe Vestager, European Commissioner for Competition, European Commission, Speech on Protecting Consumers from Exploitation (Nov. 21, 2016) (claiming that smartphone manufacturers pay very high royalties). For court cases, see the recent comprehensive survey by Jonathan M. Barnett, *Has the Academy Led Patent Law Astray*, 32 BERKELEY TECH. L.J. 1313 (2017) (arguing that royalty stacking, patent thickets, and patent holdup theories have influenced policy makers and judges).

3. *See, e.g.*, Suzanne Michel, *Bargaining for RAND Royalties in the Shadow of Patent Remedies Law*, 77 ANTITRUST L.J. 889, 891–92 (2011) ("Accused infringers will pay royalties based on the costs of switching to another technology, but switching costs may be prohibitively high due to the expense of retooling a manufacturing facility or ensuring interoperability with related products."); Jorge Contreras & Richard Gilbert, *A Unified Framework for RAND and Other Reasonable Royalties*, 30 BERKELEY TECH. L.J. 1451, 1468 (2015) ("[T]he patent owner may be able to charge a very high royalty for that patent because . . . [that] standard (and its modifications) are embedded in millions of devices and switching to an alternative technology would be enormously expensive and perhaps infeasible"); Hesse, *2013 Speech*, *supra* note 2, at 16 ("Once a standard becomes established, firms implementing the standard may find switching away more difficult and expensive. This lock–in confers market power on the owners of the incorporated patents.").

technologies have been chosen are free, at least according to the theory, to exploit monopoly power.[4] The dangers of monopoly power are then, according to the theory, multiplied by the number of patent holders who can each assert monopoly power over their standardized patent. Monopoly power is therefore piled on top of monopoly power in a process called "royalty stacking."[5] According to the theory, the resulting high cumulative royalty yield raises the price of products, reduces output, and thereby harms consumers.[6]

This theory of the anticommons has seldom been tested against systematic evidence.[7] This Article therefore a canonical case of a

4. *See, e.g.*, Shapiro, *supra* note 2, at 128; Robert A. Skitol, *Concerted Buying Power: Its Potential for Addressing the Patent Holdup Problem in Standard Setting*, 72 ANTITRUST L.J. 727, 728 (2005) ("The owner [of the patent] can then unilaterally impose onerous license terms . . . an anticompetitive exercise of artificially created seller market power . . . ."); Cary et al., *The Case for Antitrust Law to Police the Patent Holdup Problem in Standard Setting*, 77 ANTITRUST L.J. 913, 921 (2011) ("[T]he opportunistic conduct resulting in patent holdup specifically 'concerns the inefficient acquisition of market power' . . . ."); FTC, EVOLVING IP MARKETPLACE, *supra* note 2, at 192 ("[A] firm with a patent reading on the standard may have market power in the relevant technology market."). Further, Joseph Farrell et al. have explained:

> Ex ante, before an industry standard is chosen, there are various attractive technologies, but ex post, after industry participants choose a standard and take steps to implement it, alternative technologies become less attractive. Thus, a patent covering a standard may confer market power ex post that was much weaker ex ante.

Joseph Farrell et al., *Standard Setting, Patents, and Hold–Up*, 74 ANTITRUST L.J. 603, 607 (2007).

5. Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEX. L. REV. 1991, 2015 (2007) ("The theory of Cournot complements warns us that royalty stacking causes harm based on reduced output, higher prices, and thus deadweight loss.").

6. Here, we use the term "monopoly power" as is standard in the economics literature since Lerner introduced his famous index in 1934. *See generally* A. P. Lerner, *The Concept of Monopoly and the Measurement of Monopoly Power*, 1 REV. ECON. STUD. 157 (1934). We do so because, as we explain below, royalty stacking is explicitly defined as patent holders simultaneously exercising monopoly power as economists understand it. *See infra* Section III.C. For a brief history of the role of the Lerner index in antitrust enforcement, see generally Kenneth G. Elzinga & David E. Mills, *The Lerner Index of Monopoly Power: Origins and Uses*, 101 AM. ECON. REV. 558 (2011). Fisher points out that courts have defined monopoly power as "the power to set prices and exclude competitors." Franklin M. Fisher, *Diagnosing Monopoly*, 19 Q. REV. ECON. & BUS. 7, 14 (1979). This definition is broader and may include conduct in which a monopoly price is not the issue.

7. An exception is Alexander Galetovic & Kirti Gupta, *Royalty Stacking and Standard Essential Patents: Theory and Evidence from the World Mobile Wireless Industry* 18–24 (Hoover Inst. Working Grp. on Intellectual Prop., Innovation, & Prosperity, Working Paper No. 15012, 2016), https://hooverip2.org/wp–content/uploads/ip2–

compatible, interoperable product—smartphones—and asks three questions. First, what is the approximate magnitude of the cumulative royalty yield in the world smartphone value chain predicted by the theory of royalty stacking?[8] This Article parameterizes a standard royalty stacking model with actual data on prices, output, and the number of major patent holders in the world smartphone value chain In 2016 there were twenty–nine identified patent licensors who received royalty revenue, and the predicted cumulative royalty yield is 79.5 percent.[9] That is, almost four out of every five dollars paid for a smartphone should be transferred to the patent holders.

Second, this Article asks what the royalty yield would be if there were no anticommons tragedy and patent holders were allowed to coordinate as a single profit maximizing monopolist. The model indicates that the royalty yield would be approximately sixty–seven percent. That is, two out of every three dollars paid for a smartphone would be transferred to the monopoly patent holder.

Third, this Article asks how much is the actual, observed average cumulative royalty yield from the twenty–nine identified patent licensors. We find that it is 3.4 percent.[10] That is to say, the actual yield is more than

wp15012–paper.pdf (testing the observable implications of the theory of royalty stacking with data from the smartphone industry).

8. Following Keith Mallinson, we use the term royalty "yield" rather than royalty "rate." *See generally* Keith Mallinson, *Cumulative Mobile–SEP Royalty Payments No More Than Around 5% of Mobile Handset Revenues*, WISEHARBOR (Aug. 19, 2015), www.wiseharbor.com/pdfs/Mallinson%20on%20cumulative%20mobile%20SEP%20royalties%20for%20IP%20Finance%202015Aug19.pdf. As used herein, "rate" refers to the actual royalty paid by a licensee to a licensor as a percentage of the licensee's sales. "Yield" is the sum total of patent royalty payments divided by the total value of mobile phones shipped, the latter of which might include the production of those who evade patent licenses.

9. Note that each pool may be considered a licensor or licensing entity but represents a multiplicity of patent holders. The pools do not typically own the patents but rather only a right to sublicense them under particular terms and conditions. The natural assumption is that if the patents in the pool would confer monopoly power, each pool would act as a single monopoly when setting pool royalties.

10. *See* Alexander Galetovic et al., *An Estimate of the Average Cumulative Royalty Yield in the World Mobile Phone Industry: Theory, Measurement and Results*, TELECOMM. POL'Y (forthcoming 2018). The August 2017 update of the database, A New Dataset on Mobile Phone Patent License Royalties is available in an Excel workbook that we have posted online. *See* Alexander Galetovic et al., A *New Dataset on Mobile Phone Patent License Royalties: August 2017 Update* (Hoover Inst. Working Grp. on Intellectual Prop., Innovation, & Prosperity, Working Paper No. 18005, 2018), https://hooverip2.org/working–paper/wp18005 [https://perma.cc/QF4E–LJW5].

twenty times lower than either the yield predicted by the anticommons royalty stacking model or the predicted royalty that would be charged by a single profit–maximizing monopolist. The implication is straightforward: patent holders in the world smartphone value chain do not exercise any meaningful monopoly power to raise prices to the levels that monopoly and royalty stacking theory predict.[11]

Could it be the case that patent holders earn monopoly rents through some other mechanism beyond patent licenses themselves, thereby biasing our estimates of actual royalties downwards?[12] The scope of the businesses of most major patent holders in the smartphone value chain is very narrow. In fact, there are only two significant patent holders in our dataset who either manufacture a smartphone (Huawei) or a physical input to a smartphone (Qualcomm).

It is unlikely that Huawei earns significant rents on its intellectual property through phone sales. The smartphone handset business is competitive and, with the exceptions of Apple and Samsung, the operating profits of manufacturers are very small.

The situation is similar for Qualcomm, which produces baseband processors. Not only is this a competitive market, but it is possible for handset manufacturers to license Qualcomm's patents without purchasing its baseband processor. In addition, in 2016 gross revenues from baseband processors across all manufacturers, accounted for only 5.1 percent of the value of the average phone, not two–thirds or more, as would be the case if patent holders were exploiting monopoly power in the world smartphone market through the sale of baseband processors. The implication is that monopoly power is not being exercised in this segment of the industry. In short, the evidence indicates that patent holders do not exploit significant monopoly power in the world smartphone market through the sale of another input or final product.

11. That said, there may be geographic, product, or technology–based segments and niches within the world smartphone market where conditions may differ from those in the broader market. Any such segment would require focused research and analysis to determine whether and to what extent it resembles the world smartphone market. Here, we confine our analysis and conclusions to the world smartphone market.

12. An economic rent is the excess of total revenues over total long–run costs. *See* Roger G. Noll, *"Buyer Power" and Economic Policy*, 72 ANTITRUST L.J. 589, 593 (2005) (offering this definition). In this Article, we use the term "total rent of the smartphone value chain" to denote the difference between consumers' willingness to pay for a smartphone and the total long–run cost of manufacturing a smartphone excluding patent royalties and R&D costs.

Could it be the case that, even if patent holders do not exercise any meaningful monopoly power, the 3.4 percent royalty yield is still "excessive" because of the way that courts tend to compensate patent holders in cases of infringement or for another reason? That is, do the royalties earned by patent holders through the process of negotiation in the shadow of litigation, on average, tend to overcompensate patent holders? This Article briefly explores this issue and observes that making such an argument across the entire market, including all licensors, patent portfolios, licensable products, and licensees would be very challenging.

Part II briefly summarizes the sources and methods used to arrive at the estimate of the observed average cumulative royalty yield. Part III presents the theory of monopoly and royalty stacking. Part IV estimates the magnitude of the royalty yield that would be observed if a tragedy of the anticommons affected the industry and shows that it is much larger than the observed average cumulative royalty yield by a factor of more than twenty. Having shown that patent holders do not exercise monopoly power, Part V asks what facts would need to be convincingly demonstrated to draw the inference that the observed royalty yields are "excessive." In Part VI we offer a partial explanation why patent holders do not exploit monopoly power. Part VII concludes.

II. AN ESTIMATE OF THE AVERAGE CUMULATIVE ROYALTY YIELD IN THE SMARTPHONE INDUSTRY

In their 2018 work, Galetovic, Haber and Zaretzki estimated the average cumulative royalty yield in the smartphone value chain.[13] This estimate is the benchmark that we use below to compare the actual royalties charged by licensors in the smartphone industry against the cumulative royalty predicted by theory when there are multiple patent holders exploiting monopoly power. We now briefly describe how we obtained our estimate.

A. METHODS

Estimating the average cumulative royalty yield is not easy because neither the manufacturers of smartphone inputs (e.g., baseband processors) nor smartphone original equipment manufacturers (OEMs) report their royalty payments. Nevertheless, every dollar spent by a smartphone OEM or its suppliers on a patent license must show up as a dollar earned by a technology company, a patent assertion entity (PAE), or a patent pool on

13. Galetovic et al., *supra* note 10, at 9–10.

their revenue statements.[14] We therefore "followed the money" and identified, with varying degrees of accuracy, thirty–nine potential licensors in the smartphone value chain.[15]

We estimate that, as a group, the thirty–nine licensors had cumulative royalties in 2016 of almost $14.2 billion. Of these thirty–nine potential licensors, ten had licensing revenues of effectively zero or otherwise had royalty income which we could not quantify. The licensing revenue of the remaining twenty–nine licensors ranged from a low of $1.6 million to a high of $7.7 billion.[16]

Our estimates most likely overstate smartphone patent royalty revenues. One reason for the overstatement is that, when we were in doubt, we biased approximations upwards.[17] A second reason is that we assumed that all royalties earned by licensors came from licenses on smartphones, but in actuality some of it came from feature phones, tablets, and even other industries entirely. A third reason is that our estimates probably include some double counting, because in some cases we may have included both the royalty revenues declared by a licensor and the royalty revenues earned by a pool where the licensor is a member.

14. We built on work by Mallinson, who estimated an upper bound of the royalty yield. Mallinson, *supra* note 8, at 1. Sidak built on Mallinson as well, but took a somewhat different theoretical approach, including payments in kind and estimates of the value of cross–licenses. J. Gregory Sidak, *What Aggregate Royalty Do Manufacturers of Mobile Phones Pay to License Standard–Essential Patents?*, 1 CRITERION J. ON INNOVATION 701, 716–19 (2016).

15. This is appropriate, because economic theory suggests that per–unit royalties will affect decisions of manufacturers at the margin no matter where they are charged in the vertical chain. Input manufacturers will pass through per–unit royalties, which will affect manufacturers' marginal costs.

16. The twenty–nine licensors are Qualcomm, Nokia, Philips, Ericsson, Huawei, Interdigital, Rambus, Microsoft, Acacia, Unwired Planet/Panoptis, IBM, Quarterhill, Xperi, AT&T (by virtue of its 802.11 and MPEG4 programs), VirnetX, Tivo, Technicolor, Blackberry, Parker Vision, Broadcom, IPCom, Intellectual Ventures, Conversant, the MPEGLA MPEG4 patent pool, the MPEGLA AVC/H.264 patent pool, the MPEGLA HEVC patent pool, the Via Licensing AAC patent pool, the Via Licensing WCDMA patent pool, and the HEVC Advance patent pool. *See generally* Galetovic et al., *supra* note 10, at Table A1.

17. For example, in the case of Huawei, which is a relatively new licensor whose legal status as a privately owned collective means that it is not subject to the same kind of reporting requirements as a U.S. or European firm, we liberally assumed that its mobile phone royalty revenues were the same as that of a well–established, U.S.–based technology company, Interdigital. In doing so, we assumed that Huawei was earning, on its mobile phone patents alone, roughly 20 percent of all patent revenues earned by all Chinese companies in any line of economic activity.

At the same time, the scope of our dataset is broad. It captures the Standard Essential Patents (SEPs) that enable mobility, the revenues earned from licenses on patents that enable video, imaging, audio, and other functions and the revenues of a major software company who earns royalty revenue from the most popular mobile phone operating system.

B. THE ESTIMATE OF THE AVERAGE CUMULATIVE ROYALTY YIELD

There are three numbers that one needs to know to estimate the average cumulative royalty yield: (i) the mobile phone patent licensing revenue earned by each licensor; (ii) the number of mobile phones sold; (iii) the average selling price of a mobile phone (ASP).

On the basis of publicly available sources, we estimated the total number of smartphones sold in 2016 as 1.474 billion,[18] the total value of smartphone shipments at $415 billion,[19] and total royalty revenues of the twenty–nine major licensors at $14.2 billion.[20] Therefore, if the average wholesale selling price of a smartphone was roughly $281.5 and if the average cumulative royalty paid on each smartphone was $9.60, it follows that in 2016 the average cumulative royalty yield on a smartphone was 3.4 percent.[21]

We performed several robustness checks. Each increased the average cumulative royalty yield somewhat, but none changed the order of magnitude of the estimate. For example, if we assume that thirty percent of all smartphones evade paying any royalties at all, the average cumulative royalty yield of the remaining seventy percent increases to 4.9 percent (from 3.4 percent). If we assume that the eleven licensors for which we could find only limited patent licensing revenue information—or for that matter, other unidentified licensors—earned an additional $2 billion in patent royalties (a very generous, if perhaps fanciful, estimate) and we maintain the thirty percent evasion rate then the cumulative royalty yield would increase to 5.6 percent.[22] Even if we assume that only Apple and Samsung pay royalties to licensors, and that they pay an additional $2 billion in licensing revenues

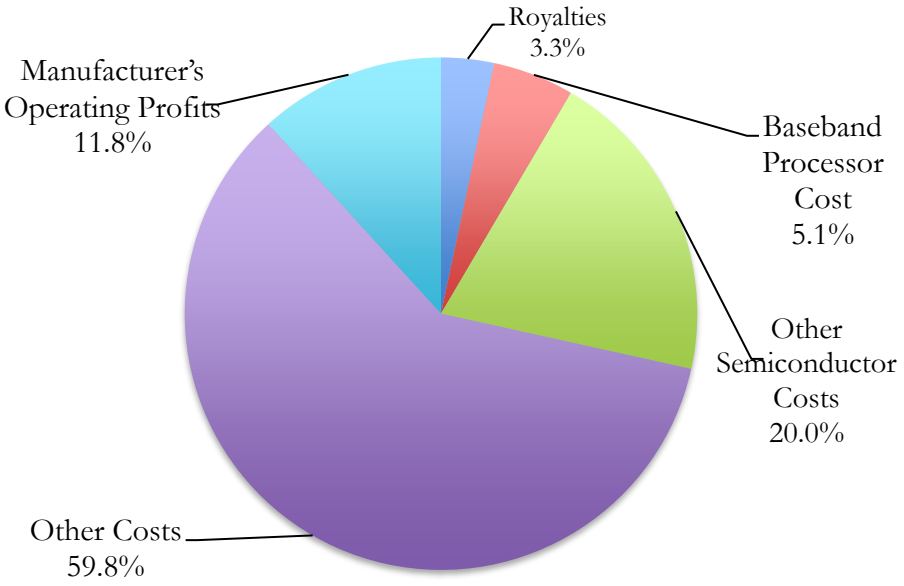
18. Galetovic et al., *supra* note 10, § 1.8 ["Device Sales"].
19. *Id.*
20. *Id.* § 1.7.1 ["Summary by Licensor"].
21. *Id.* § 1.3 ["Royalty Yield Summary 2016"].
22. Note that the magnitude of our estimates is similar to Mallinson's upper bound of about 5.5% and Sidak's upper bound between 4 and 5%. Mallinson, *supra* note 8, at 1; Sidak, *supra* note 14, at 701–02.

beyond our estimate of $14.2 billon, the average cumulative royalty yield would only be 7.2 percent.[23]

C. PUTTING THE ESTIMATE INTO PERSPECTIVE

To put our average cumulative estimate into perspective, Figure 1 decomposes the average selling price of a mobile phone. We estimate the costs of the baseband processor, other semiconductor costs, patent license royalty payments, and operating profits.[24]

Figure 1: Breakdown of the Average Selling Price of a Mobile Phone (2016)



Note that royalty payments are roughly the same magnitude as baseband processor costs, about one–fifth of other semiconductor costs, and less than one–twentieth of other costs.[25] Perhaps more interesting, the average

23. In 2016 Apple and Samsung sold 35.8 percent of all smartphones. Galetovic et al., *supra* note 10, § 1.9 ["OEM Sales"].

24. *See generally id.* § 1 ["Introduction"]. The estimates include both smartphones and feature phones because we could not disaggregate costs and margins. In 2016 smartphones accounted for 97% of all mobile phone wholesale revenues. *Id.* § 1.9 ["OEM Sales"].

25. We included all expenses, both the cost of the goods sold (COGS) and operating costs, such as R&D, and selling, general and administrative costs (SG&A).

cumulative royalty yield is about one–third of the operating profit made by an average mobile phone.[26]

III. MONOPOLY POWER, ROYALTY STACKING AND THE TRAGEDY OF THE ANTICOMMONS

A. THE MARKET FOR SMARTPHONES

How does a 3.4 percent average cumulative royalty yield compare with the yield that would be predicted if all twenty–nine patent holders in our dataset exploited monopoly power independently? How does it compare with the yield that would be predicted if all twenty–nine patent holders joined together into a single, profit–maximizing monopoly?

To answer this question, we develop a simple model based on a seminal paper in the royalty stacking literature by Lemley and Shapiro.[27] Let q be the number of smartphones, p their price and assume that the derived demand for smartphones is a straight line:

$$\textbf{(1)} \qquad q = S \cdot (v - p)$$

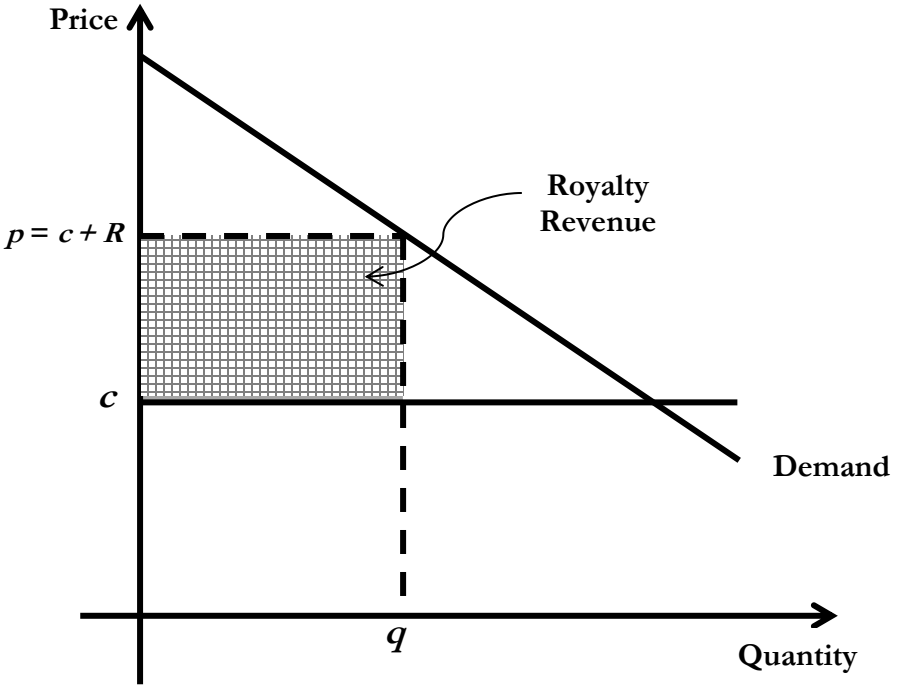
In this demand curve, which is shown in Figure 2, v is the maximum amount that any consumer is willing to pay for a smartphone and $S > 0$ parameterizes the size of the market.[28] We further assume that a smartphone costs c to produce and sell to customers, and that manufacturers compete.

26. According to industry analysts, in 2016 about 79 percent of all profits made by selling smartphones accrued to Apple and the rest to Samsung. *See*, *e.g.*, Husain Sumra, *Apple Captured 79% of Global Smartphone Profits in 2016*, MACRUMORS (Mar. 7, 2017), https://www.macrumors.com/2017/03/07/apple–global–smartphone–profit–2016–79/.

27. Lemley, *supra* note 5.

28. We use a linear demand curve because it is simple, and because Lemley and Shapiro use it. *See id*. at 2046. All results carry through with a far more general, log–concave demand curve. In particular, the magnitude of the predicted royalty yield is the same. *See* Galetovic & Gupta, *supra* note 7, at 3–5.

Figure 2: Royalties and the Derived Demand for Smartphones



Note that the demand for smartphones confronted by manufacturers is a derived demand as it is indirectly created by the demand for mobile communications by users.[29] Thus, the source and limit of all surplus in the smartphone value chain is that users value what they can do with a smartphone. Because of this, neither patents nor components are valuable by themselves. On the contrary, they have value only in as much as they contribute to producing smartphones for which consumers are willing to pay.

We denote the cumulative royalty charged by all patent holders as *R*, and other manufacturing costs, including normal industry profits, as *c*. Thus, the marginal cost of providing a smartphone to a customer is: $c + R$, which

29. The rules governing derived demand have been known since Alfred Marshall's Principles. For a formal treatment see generally M. Bronfenbrenner, *Notes on the Elasticity of Derived Demand*, 13 OXFORD ECON. PAPERS 254 (1961) (which formally derives the properties of derived demand). *See also* GEORGE STIGLER, THE THEORY OF PRICE 252 (4th ed. 1987) (defining derived demand); J.K. Whitaker, *Derived Demand*, *in* 2 THE NEW PALGRAVE DICTIONARY OF ECONOMICS 1345–46 (Steven N. Durlauf & Lawrence E. Blume eds., 2d ed. 2008) (tracing the history of the concept).

is also equal to the equilibrium price, *p*, of a smartphone, because this is a competitive market.[30] Therefore, as can be seen in Figure 2, when fixing royalty *R*, patent holders determine the downstream equilibrium price of a smartphone. Because downstream manufacturers compete, the cumulative royalty *R* is equal to the price–cost margin ($p - c$) of the entire value chain. It follows that, in this model, all rent generated by the smartphone value chain is captured by patent owners through royalty *R*. This rent is the gridded rectangle in Figure 2.[31]

We cannot stress strongly enough that, as Figure 2 shows, the rent that patent holders can capture is bounded by the difference between the price paid by consumers and the cost of making a smartphone. Regardless of how patent holders capture this rent, be it as a royalty or embedded in the price of an input, the total amount they can extract is constrained by the difference between willingness to pay and the producer's costs.[32]

B. THE ROYALTY SET BY A PATENT MONOPOLY

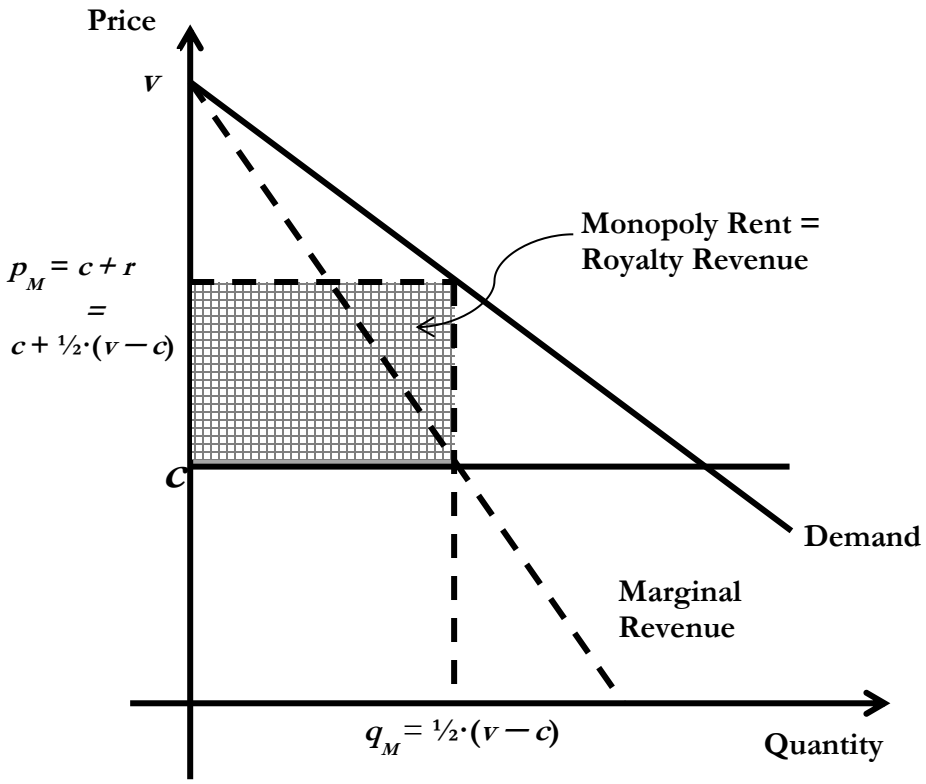
The tragedy of the anticommons occurs when many monopolists simultaneously exploit their monopoly power. For purposes of exposition, let us begin by explaining what happens to a market if there would be a single firm which owns all relevant patents and charges for them as a profit–maximizing monopolist. As can be seen in Figure 3, standard textbook theory implies that the monopolist will charge a royalty such that the market's marginal revenue equals marginal cost *c*.

30. This is a simplifying assumption. Results do not change if we assume imperfect competition among smartphone manufacturers. *See* Galetovic & Gupta, *supra* note 7, at 9.

31. The mechanics is that consumers pay for the phones and manufacturers pass through royalties to patent owners.

32. The insight can be traced back at least to Joseph J. Spengler, *Vertical Integration and Antitrust Policy*, 58 J. POL. ECON. 347, 348–49 (1950). When manufacturers use an input in fixed proportions to produce a final good and the downstream segment of the industry is competitive, the equilibrium price is equal to the unit marginal cost of production plus all charges made by the producers of intermediate goods.

Figure 3: A Single Patent Holder Exploits Market Power



Furthermore, it can be shown that with a linear demand curve like (1) the profit–maximizing royalty of an individual patent holder acting as a monopolist (r_m) is:

$$r_m = \frac{1}{2} \cdot (v - c)$$

The equation says that a profit–maximizing single patent holder would charge a royalty equal to half the difference between the maximum willingness to pay for a smartphone (v) and the cost of manufacturing that smartphone (c). Therefore:

$$p_m = \mathrm{c} + \frac{1}{2} \cdot (v - c)$$

Standard monopoly theory thus shows that a monopolist chooses price so that:

$$\frac{p_m - c}{p_m} = \frac{1}{\eta}$$

where, η is the price elasticity of demand and the left–hand side is the famous Lerner margin. Because $r_m = p_m - c$, it follows that the royalty yield is equal to:

$$\textbf{(2)} \qquad \frac{r_m}{p_m} = \frac{p_m - c}{p_m} = \frac{v - c}{v + c}$$

Therefore, it is apparent from the first equality in (2) that the royalty yield set by a monopolist patent holder (the ratio of the royalty to the price) equals the Lerner margin.

The second equality in (2) shows that the royalty yield depends on the ratio of the unit cost of production to the maximum amount that a consumer is willing to pay for a unit of the good, *v*. For example, if the maximum amount that a consumer is willing to pay for a unit of the good is twice as much as the cost of manufacturing it ($v = 2c$), then the royalty yield will be ⅓ or 33.3 percent. If the maximum willingness to pay is five times the cost of manufacturing the good ($v = 5c$), then the royalty yield will be ⅔ or 66.6 percent. Therefore, if one firm owns all patents, and that firm operates as a profit–maximizing monopolist, it will appropriate a substantial fraction of the final price paid by consumers for a smartphone, with that fraction determined by the ratio of the maximum willingness to pay divided by the marginal cost of manufacturing a smartphone.

A profit–maximizing monopolist will, of course, drive up the final price of a phone. As the price increases, the output of phones will fall, because consumers will purchase fewer of them. If there were no royalties being earned, smartphone manufacturers would charge *c* and their unit sales would be given by $v - c$. With a monopoly controlling all patents, the effect on output is given by:

$$q_M = S \cdot \frac{v - c}{2}$$

Therefore, compared with a hypothetical situation with no royalty, a monopoly patent holder would reduce output by half, assuming a linear

demand curve. This effect of a monopoly in the smartphone value chain would therefore be quite large.

C. ROYALTY STACKING AND THE TRAGEDY OF THE ANTICOMMONS

To this point, we have assumed that there is a single patent holder, but what would happen if there were many patent holders, each of which is independently exercising monopoly power? In 1838, Augustin Cournot asked a similar question: what if two upstream monopolists, each producing a different input for a downstream firm, post unit prices independently of the other?[33] He found that they would post higher prices and sell less than if they collude and choose a single, profit–maximizing price for both inputs. Consequently, the downstream firm would charge consumers a higher price than with a single monopoly supplier, and sell less. This is known as the Cournot Complement problem, and it can be summarized by the aphorism "two monopolists are worse than one."[34]

Royalty stacking theory is an application of Cournot's Complements problem to industries with multiple patent holders. The question that motivates the theory is: what happens if multiple patent holders simultaneously and independently exercise monopoly power?[35]

33. *See* AUGUSTIN COURNOT, RESEARCHES INTO THE MATHEMATICAL PRINCIPLES OF THE THEORY OF WEALTH ch. 9 (Nathaniel T. Bacon trans., Macmillan Co. 1897) (1838)

34. Spulber shows that the Cournot Complements problem emerges only if input monopolists independently post linear unit prices (a "linear price" is a unit price that does not vary with the quantity purchased). *See* Daniel F. Spulber, *Complementary Monopolies and Bargaining*, 60 J.L. & ECON. 29, 57 (2017). It disappears, for example, if manufacturers and input providers bargain bilaterally. *See* Daniel F. Spulber, *Patent Licensing and Bargaining with Innovative Complements and Substitutes*, 70 RES. ECON. 693, 710 (2016) [hereinafter Spulber, *Patent Licensing*].

35. The original statement of the problem is by Carl Shapiro. *See* Shapiro, *supra* note 2, at 120–23. Lemley and Shapiro use the term "royalty stacking." *See* Lemley & Shapiro, *supra* note 5, at 1992; *see also* Contreras & Gilbert, *supra* note 3, at 1468; Vincenzo Denicolò et al., *Revisiting Injunctive Relief: Interpreting* eBay *in High–Tech Industries with Non–Practicing Patent Holders*, 4 J. COMPETITION L. & ECON. 571 (2008); Einer Elhauge, *Do Patent Holdup and Royalty Stacking Lead to Systematically Excessive Royalties?*, 4 J. COMPETITION L. & ECON. 535 (2008); Galetovic & Gupta, *supra* note 7, at 18–24; Galetovic et al., *supra* note 10; Damien Geradin et al., *The Complements Problem Within Standard Setting: Assessing the Evidence on Royalty Stacking*, 14 B.U. J. SCI. & TECH. L. 144 (2008). For a comprehensive survey of the literature, see Edward J. Egan & David J. Teece, *Untangling the Patent Thicket Literature* (Tusher Cent. for Mgmt. of Intellectual Capital, Working Paper No. 7, 2015), http://innovation–archives.berkeley.edu/businessinnovation/documents/Tusher–Center–Working–Paper–7.pdf. Spulber shows that royalty stacking emerges only if patent holders post linear royalties and disappears if parties bargain for royalties. *See* Spulber, *Patent Licensing*, *supra* note 34, at 710–11.

To see what happens if there are multiple patent holders, each exercising monopoly power, let *N* be the number of patent holders. Each patent holder now sets a profit–maximizing royalty equal to:

$$r_N = \frac{1}{1+N} \cdot (v - c)$$

Note that with $N \geq 2$ the individual, profit maximizing royalty is smaller than the royalty charged by a single monopoly patent holder by a factor of $(2/(1+N))$. But because there are *N* patent holders, the cumulative royalty is:

$$N * r_N = R_N = \frac{N}{1+N} \cdot (v - c)$$

The implications are straightforward. As the number of patent holders increases, individual royalties earned fall. Each patent holder is effectively applying a tax on all other patent holders, as well as on the downstream firm. The cumulative royalty, however, grows with each patent holder, such that it exceeds the royalty that would be charged by a single monopolist by a factor of $(2N/(1+N))$. It follows that if there are more than a few patent holders, the cumulative royalty will be close to $v - c$ (the difference between the maximum amount that a consumer is willing to pay for a smartphone and the cost of providing the device). That is, if *N* is large, the patent holders will extract nearly all surplus created in the smartphone value chain.

What is the magnitude of this effect? A little algebra shows that with *N* patent holders the equilibrium downstream price is:

$$p_N = c + \frac{N}{1+N} \cdot (v - c)$$

Therefore, with *N* patent holders the price–cost margin is:

$$\textbf{(3)} \qquad \frac{p_N - c}{p_N} = \frac{R_N}{p_N} = \frac{v-c}{v+\frac{c}{N}}$$

For example, if $N = 3$ and the maximum amount that a consumer is willing to pay for a smartphone is five times the cost of manufacturing it ($v = 5c$), then the royalty yield would be 75 percent. If $N = 29$ (the number of licensors that we estimate charge royalties in the smartphone value chain in Part II), then the royalty yield would be 79.4 percent. That is, the theory of royalty stacking predicts that if there are twenty–one patent holders almost 80 percent of the price of a smartphone will be appropriated by them.

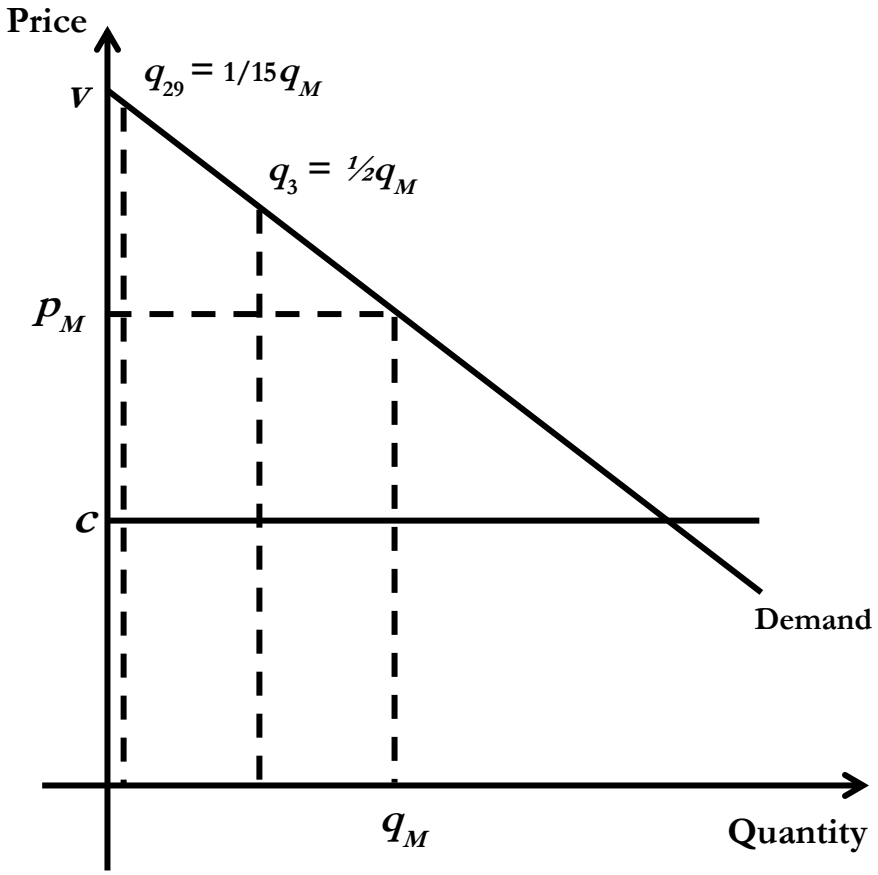
It is useful to relate equation (3) to the theory of monopoly and Cournot Complements. Shapiro[36] showed that with royalty stacking the equilibrium price–cost margin in (3) is equal to:

$$\frac{p_N - c}{p_N} = \frac{\mathrm{N}}{\eta}$$

Therefore, royalty stacking multiplies the Lerner margin by the number of patent holders charging royalties, *N*.

36. Shapiro, *supra* note 2, at 149–50.

Figure 4: Royalty Stacking and the Tragedy of the Anticommons



The consequences of this tragedy of the anticommons are perhaps best appreciated by examining the effect that an estimated 79 percent royalty would have on the output of smartphones. Because the downstream equilibrium price of a smartphone rises with the number of patent holders, output is a decreasing function of *N*:

$$q_N = \frac{1}{1+N} \cdot S \cdot (v - c)$$

The implications can be seen in Figure 4. For example, with $N = 3$ output is one–half of the level with a single patent holder. With $N = 29$ output is

one fifteenth of the output level with a single patent holder, q_M. Therefore, it takes only a few patent owners to drastically reduce output.[37]

It is crucial to note that patent holders are hurt by royalty stacking. As the cumulative royalty yield rises, total royalty revenues fall, because the number of smartphones sold declines precipitously. As the number of patent holders grows, each licensor progressively gets a smaller share of a smaller pie. This effect is, in fact, what makes royalty stacking a tragedy of the anticommons: everyone, including the patent holders, are worse off than if there was only a single monopolist.

IV. ESTIMATING THE ROYALTY YIELD WHEN PATENT HOLDERS EXERCISE MONOPOLY POWER

We can now estimate how much patent holders would charge if they were exploiting monopoly power in the smartphone value chain. We do this in three steps.

Step 1: As we have seen, the profit–maximizing royalty yield depends on the relationship between the cost, c, and the maximum amount that a consumer is willing to pay for a smartphone, v. To operationalize this relationship, let $v \equiv \lambda c$. While we do not know the long run marginal cost of producing a smartphone, we can provide a conservative estimate by subtracting a rough estimate of the cumulative average cost of patent licenses to produce a smartphone ($9.60) from a rough estimate of the average selling price of a smartphone in 2016 ($281.60).[38] We therefore conservatively estimate the marginal cost, c, at $\$281.60 - \$9.60 \approx \$272$.[39] We can also estimate the maximum price that a consumer is willing to pay for a smartphone as the inflation-adjusted price of a 2G phone when that technology was introduced in 1992, which is $1,400 in 2016 dollars.[40]

37. The effect is the same with nonlinear demand. *See* Galetovic & Gupta, *supra* note 7, at 3.

38. Galetovic et al., *supra* note 16, § 1.8.

39. Note that, as we mentioned before, almost all profits in the industry accrue to Apple and Samsung. The rest of the smartphone manufacturers barely cover their costs. Hence, the average selling price less royalties paid is a reasonable estimate of the marginal cost of production, even though the average cost is somewhat lower. In any case, our conservative approach biases against the hypothesis that there is a big difference between predicted and actual cumulative royalty yields. If we assume that the marginal cost of producing a smartphone is lower, the slope of the demand curve would increase, which would push up the marginal impact of each additional royalty stacker, thereby producing an even higher predicted cumulative royalty yield.

40. See Galetovic & Gupta, *supra* note 7, at fig. 7.

Thus, the maximum willingness to pay for a phone equals five times the cost of providing a smartphone:

$$\lambda \equiv \frac{v}{c} = \frac{1{,}400}{272} \approx 5$$

Note that our estimate of consumers' maximum willingness to pay for a smartphone with current data capabilities is conservative and almost surely underestimates its actual value, because it is based on the market wholesale price of a phone that was not smart. Indeed, when 2G phones were introduced around 1992, they lacked data service beyond SMS and could not send emails; data services were not introduced until years later when services such as CDPD, iMode, and GPRS/EDGE arrived. This conservative assumption biases against the hypothesis that there is a large difference between predicted and actual cumulative royalty yields. If we assume that the marginal cost of producing a smartphone is lower, the slope of the demand curve would increase, which would push up the marginal impact of each additional royalty stacker, thereby producing an even higher predicted cumulative royalty yield.[41]

Step 2: The second step is to obtain an expression for the predicted royalty yield. Some algebra implies that:

$$R_N = \frac{N(\lambda - 1)}{1 + N} \cdot c$$

And,

$$p_N = \frac{1 + \lambda N}{1 + N} c$$

Hence,

41. One might also take the inflation–adjusted price of the first 1G phone introduced in 1983, the Motorola Dynatac, as the maximum willingness to pay, which would be about $10,000 in current dollars ($4,000 in 1983). *See* Steward Wolpin, *The First Cellphone Went on Sale 30 Years Ago for $4000*, MASHABLE (Mar. 13, 2014), https://mashable.com/2014/03/13/first–cellphone–on–sale/. Either would bias in favor of finding an even higher predicted cumulative royalty yield, and thus bias in favor of finding an even larger difference between the predicted cumulative royalty yield and the actual cumulative royalty yield. Therefore, again we bias our calculation against the hypothesis that there is a large difference between predicted and actual cumulative royalty yields.

$$\frac{p_N - c}{p_N} = \frac{R_N}{P_N} = \frac{(\lambda - 1)N}{1 + \lambda N} = \frac{4N}{1 + 5N}$$

is the predicted royalty yield.

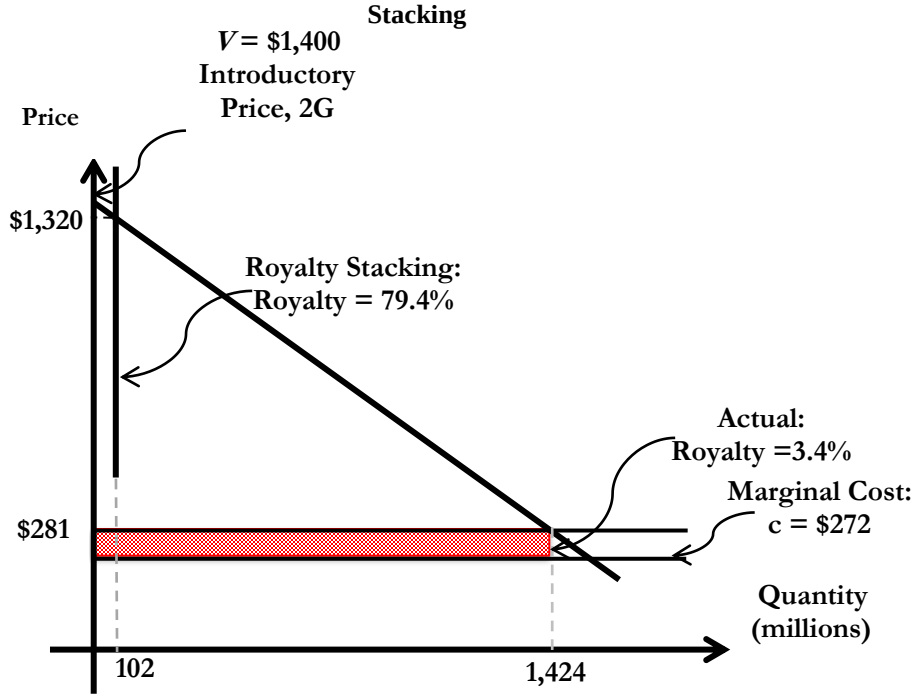
Step 3: As we showed in Part II, we identified twenty–one technology companies, patent assertion entities, and patent pools that earned positive royalties in the smartphone value chain in 2015. If each exploited monopoly power, the average cumulative royalty yield would have been:

$$\frac{R_{29}}{p_{29}} = \frac{(5 - 1) \cdot 29}{1 + 5 \cdot 29} \approx 79.4\%$$

That is, theory predicts that almost eighty percent of the good's final price would be collected as royalties. The actual royalty yield, however, was 3.4 percent. In short, the cumulative royalty yield predicted by royalty stacking theory is around twenty–three times the actual royalty yield.

What would be the effect on the price and quantity of smartphones sold if the royalty yield were the 79.4 percent predicted by the theory of royalty stacking, rather than the 3.4 percent that obtains in reality? Figure 5(a) shows the results. The equilibrium price of a smartphone in 2016 would have been $1,320, more than four times the actual price of $281, and smartphone sales would have been only 102 million, instead of the 1.474 billion that were actually sold.

Figure 5(a): Actual Royalty in the Smartphone Industry Compared with Royalty Stacking



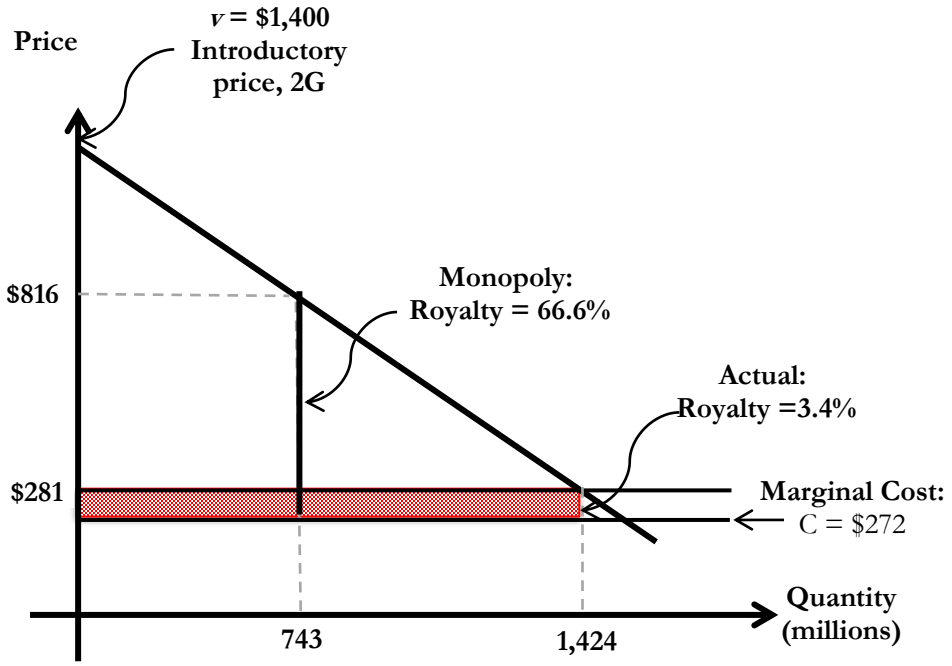
Perhaps it is the case that some of the 21 firms, pools, and PAEs charge for their patents as if monopolists, while the others do not. Perhaps that explains the difference between the predicted royalty yield of 79.2 percent and the actual royalty yield of 3.4 percent? This hypothesis is easy to test. All we need to do is ask what the royalty yield would be if twenty of the firms charged zero, and only one firm exploited its monopoly power. The predicted royalty yield of the single monopolist would be:

$$\frac{R_m}{P_m} = \frac{5-1}{5+1} \approx 66.6\%$$

That is, two–thirds of the price of a smartphone would go to pay royalties—still almost twenty times the actual rate. Therefore, the observed average cumulative royalty yield also rejects the hypothesis that any single patent holder, or a group of patent holders who are coordinating among themselves, set prices as if a monopolist. In fact, if there was a single monopolist, theory would predict much lower levels of output and much higher prices for smartphones. As Figure 5(b) shows below, if there was a single monopolist, the equilibrium price of a smartphone in 2016 would

have been $816, almost three times the actual price, and only 743 million smartphones would have been sold, about half of the quantity actually sold. In short, there is no reason to think that patent holders in the smartphone industry exploit monopoly power to raise smartphone prices materially.

Figure 5(b): Actual Royalty in the Smartphone Industry Compared with Monopoly



V. CAN THE "MONOPOLY ROYALTY" CLAIM BE SAVED?

Given the difference between the predicted royalty and the observed royalty, it is worth considering if there is any way to reconcile these differences.

A. WHAT IF THE OBSERVED ROYALTY IS GENERATED BY A PROCESS OF ROYALTY STACKING AFTER ALL?

A skeptical reader might be inclined to think that that the stark discrepancy between the royalty yield predicted by the theory of royalty stacking and the actual, observed royalty yield may stem from the particular demand function we that we used to obtain our estimates. Perhaps the observed average cumulative royalty yield is generated by a process of royalty stacking, but the parameters of our simple linear demand function are wrong.

One can check the calculation by asking what the elasticity of the derived demand for smartphones consistent with a 3.4 percent equilibrium royalty yield would be. As we have already seen, in an equilibrium with royalty stacking and perfect competition downstream:

$$\frac{R_N}{p_N} = \frac{p_N - c}{p_N} = \frac{\mathrm{N}}{\mathrm{\eta}}$$

That is, royalty stacking multiplies the traditional Lerner margin by the number of patent holders who exploit monopoly power. Simple arithmetic shows that if $N = 29$ and the royalty yield is 3.4 percent, then $\eta = 853$. That is, if the price of a smartphone falls by 10 percent, an elasticity of demand of 853 implies that the quantity of phones sold would increase by 8,530 percent. This is an absurd prediction. We know, for example, that the price of a smartphone fell by 11 percent between 2013 and 2015, while smartphone sales increased by 47 percent. One does not need algebra to show that the difference between 8,530 percent and 47 percent is large.

B. BUNDLING PATENTS WITH OTHER COMPONENTS

An even more skeptical reader might wish to argue that the observed royalty rate might conceal the exploitation of monopoly power by patent holders who bundle their patents with other components. Could it be the case that patent holders earn monopoly rents through some other mechanism beyond patent licenses themselves, thereby biasing our estimates of actual royalties downward?

As we discussed in Part III, any claim of this nature must deal with the fact that the total rent that can be extracted by patent holders is limited by the difference between consumers' willingness to pay as reflected in the derived demand for smartphones and the physical cost of providing them (see Figure 2). A patent holder may exploit monopoly power by setting the royalty for her patents, the price of a manufactured input (if she also produces a physical input to a smartphone), or the price of a phone (if she is a smartphone OEM in addition to being a patent holder). Theoretically, if a patent holder also produced inputs and smartphones, she could exploit monopoly power through all three mechanisms. Regardless of the combination, however, there is only one profit–maximizing margin for the firm. There are not different margins for different inputs; the amount of surplus is bounded by the market demand curve.

As a practical matter, the scope of the businesses of major patent holders in the smartphone value chain is rather narrow. Indeed, there are only two

significant patent holders in our dataset that either act as a smartphone OEM (i.e. Huawei) or provides a physical input to a smartphone (i.e. Qualcomm).

We think that it is unlikely that Huawei earns significant economic rents on its intellectual property by selling phones. The smartphone handset business is competitive and, with the exception of Apple and Samsung, the operating profits of manufacturers are small.[42]

The situation is similar in the case of Qualcomm, which produces baseband processor chips. The world baseband processor market is highly competitive. In addition, handset manufacturers can license Qualcomm's patents without purchasing its baseband processor.[43] Finally, as can be seen in Figure 1, gross revenues from baseband processors across all manufacturers account for only 5.1 percent of the value of the average phone, not two–thirds or more, as would be the case if any one of five major baseband processor manufacturers were able to exploit monopoly power. The implication is straightforward: monopoly power over prices is not being exercised upon the world smartphone market through the sale of baseband processors.

C. EXCESSIVE ROYALTIES AND THE NEXT–BEST TECHNOLOGY

We have shown that patent holders do not exercise any meaningful monopoly power as conventionally defined in economics. Nevertheless, could it be the case that the 3.4 percent royalty yield is still "excessive" because of the way that courts tend to compensate patent holders in cases of infringement? That is, the royalties earned by patent holders are the product of negotiations in the shadow of litigation. Do the results of that process tend to overcompensate patent holders?

A long line of legal scholarship argues that a patent holder is entitled at most to the incremental difference between the value of his technology and that of the next–best alternative.[44] They postulate that the "appropriate price" for a technology is what patent holders would have charged had there been ex ante price competition between the technology that was adopted

42. *See* Chuck Jones, *No Surprise That Apple's iPhone Dominates Smartphone Profits*, FORBES (Nov. 20, 2017, 12:20 PM), https://www.forbes.com/sites/chuckjones/2017/11/20/no–surprise–that–apples–iphone–dominates–smartphone–profits/.

43. *See generally Qualcomm Technology Licensing*, QUALCOMM, https://www.qualcomm.com/invention/licensing (last accessed Mar. 8, 2018).

44. *See* Cary et al., *Antitrust Implications of Abuse of Standard–Setting*, 15 GEO. MASON L. REV. 1241, 1258–59 (2008); Cary et al., *supra* note 4, at 915; Contreras & Gilbert, *supra* note 3, at 1468–69.

into a standard and the technology that was rejected.[45] This formulation has been accepted by the Federal Trade Commission:

> Courts should recognize that, when it can be determined, the incremental value of the patented technology over the next-best alternative establishes the maximum amount that a willing licensee would pay in a hypothetical negotiation. Courts should not award reasonable royalty damages higher than this amount.[46]

In theory, one might be tempted to carry out such an analysis, but the fact that the observed cumulative royalty yield is only 3.4 percent would create a very steep hill for a researcher to climb. In the first place, the FTC's formulation requires researchers to compare observed royalties with a theoretical construct. There is, in fact, no price data to assess the value of technologies that were rejected before any products were actually created.

Second, sustaining a claim of excessive royalties would require a researcher to demonstrate that the group of technologies that were chosen as the standard added less than 3.4 percentage points to the value of smartphones in excess of the value that would have been created by the group of patented technologies that were rejected. It would imply that the researcher had the capacity to make extremely fine-grained engineering and marketing analyses. Indeed, he or she would have to be able to measure the difference in quality, as both an engineering and consumer preference matter, across each adopted and rejected technologies. And he or she would have to be able to do so with minute precision, because the differences across individual adopted and rejected technologies would be priced on the order of pennies per smartphone.

VI. WHY IS THE OBSERVED AVERAGE CUMULATIVE ROYALTY YIELD SO LOW?

We have seen that patent holders have either chosen not to exploit conventional monopoly power or have been prevented from doing so, raising the question as to why we do not see monopoly royalty levels that some observers expect. Possible explanations could involve potential competition of substitute technologies, industry business practices, patent law, patent damages law, and more. Here we explore the possibility that monopoly power exploitation is prevented by the manner in which licensors and licensees typically arrive at royalty pricing.

45. *See supra* note 45.
46. FTC, EVOLVING IP MARKETPLACE, *supra* note 2, at 22.

When a smartphone OEM produces an infringing device, a licensor may approach it to negotiate an agreement, typically a nonexclusive patent license. The licensor knows that it can pursue licensing negotiations, and that if those fail it may resort to patent litigation to obtain compensation. Likewise, the licensee knows that if the licensor asks for an "excessive" royalty it can litigate to obtain a more reasonable royalty rate or avoid royalties altogether. In other words, patent litigation is the ultimate forum for price discovery in this market. As this is common knowledge, each party makes efforts to ascertain the likely scenarios in litigation and works backwards to create bids and asks. It seems that the systematic outcomes of this game are royalty yields which are far from what any standard monopolist would charge.

How have courts informed these estimations of royalties? The value of a smartphone depends upon an array of technologies, nontechnological inputs, as well as the business capabilities of the smartphone OEM. The technologies involved may include those which are patented, others which cannot be patented, and still others which were previously patented but for which the patents are no longer in force. Non-technological inputs can include the use of materials ranging from cardboard packing to precious metals embedded for aesthetic purposes. The business capabilities add further commercial value to the smartphone through branding, marketing, distribution, support, and the like.

As an example, one can compare Apple's iPhone 7 Plus (currently $669 in its most expensive configuration)[47] with the Vertu Signature Touch Pure Jet Red Gold (currently $23,100 in its most expensive configuration).[48] The iPhone arguably features many of the finest technologies, including components, system and application software. The Vertu, by contrast, features "Quilted Jet Calf Leather," "Polished Red-Gold detailing," and a "Sapphire Crystal Screen."[49] Most of the additional value and willingness to pay for the Vertu does not stem from the technology but from the expensive nontechnological inputs. A patent licensor should find it difficult to appropriate the incremental value created by these Vertu features because

47. *See iPhone* 7, APPLE, https://www.apple.com/shop/buy–iphone/iphone–7 [https://perma.cc/A28N–4AVW] (last visited Feb. 23, 2018) (showing $669 for a 5.5–inch display and 128GB capacity).

48. *See* Cory McNutt, *At $23,100, Vertu Signature Touch's Newest Smartphone Really is Pure Jet Red Gold*, ANDROID HEADLINES (Feb. 17, 2015), www.androidheadlines.com/2015/02/23100–vertu–signature–touchs–newest–smartphone–really–pure–jet–red–gold.html.

49. *See Pure Jet Red Gold*, VERTU, http://vertu.com/product/pure–jet–red–gold/ (last visited Feb. 23, 2018).

their value does not stem from the patent portfolio. A court would probably agree.

Consequently, patent licensors and licensees will seek bids and asks based upon their positions regarding each portfolio's proportional value to the smartphones to be licensed, and these bids and asks will be substantially less than the royalty rate that would be charged by monopolies. Hence, we should not be surprised to find that we do not observe patent licensors who obtain the expected monopolist royalty yield.

Of course, royalty yields far below those that monopoly theory predicts suggest that patent holders are not monopolists, and that they confront competitive pressure, perhaps from other technologies. Indeed, to act as a classical monopolist in the smartphone market, an owner of a substantial patent portfolio would probably need to vertically integrate into manufacturing and sales, just as, for example, pharmaceutical companies do. But to do this such a company would need a comprehensive array of capabilities from technology development to design, manufacturing, marketing, branding, distribution, sales and more. In practice, patent licensors typically lack many of these capabilities by design, having chosen deliberately to specialize in a subset of capabilities such as technology development and licensing, where they are strongest or see most advantage for their own enterprises. In doing so, they reduce or eliminate their ability to seek comprehensive lost profits in patent litigation, which would otherwise provide a direct way toward obtaining a monopolist royalty yield.

None of this is a secret to typical smartphone OEMs and patent holders; all can be expected to backward induct, so patent holders should not seek to charge as if monopolists, and OEM's therefore should not face substantial likelihood of paying a monopoly price. There is no Cournot Complements problem at all.

VII. CONCLUSION

What, then, are we to make of the claims of some public officials and academics that there is an anticommons problem in the smartphone industry in need of government intervention? Looking at the data, we are led to conclude that the smartphone market is an unlikely ecosystem in which to find a tragedy of the anticommons. This raises an interesting political economy question: why did public officials decide to turn their attention to this unlikely industry? Though this Article does not attempt to answer that question, it makes clear that smartphone patent holders do not exercise meaningful monopoly power upon prices in the world smartphone market. While royalty stacking theory predicts a cumulative royalty yield of nearly

eighty percent, actual data from licensors in the smartphone value chain demonstrates that in 2016, the cumulative royalty yield in the world smartphone value chain was only approximately 3.4 percent of the average selling price of a smartphone. This result dispels the notion that there is an anticommons tragedy in the smartphone industry.