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# An estimate of the average cumulative royalty yield in the world mobile phone industry: Theory, measurement and results[☆]

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ABSTRACT

An influential literature argues that dispersed patent ownership may lead to royalty stacking and excessive running royalties, thus increasing the long-run marginal cost of manufacturing phones and their prices. One set of estimates claims that the royalty stack is on the order of 20–40 percent of the value of the average phone. In order to assess this claim, we estimate the average cumulative royalty yield—the sum total of patent royalty payments earned by licensors, divided by the total value of mobile phones shipped— in the world mobile phone industry between 2007 and 2016. We "follow the money" and identify, with varying accuracy, 39 potential licensors in the smartphone value chain. We find that, of these, only 29 charged royalties in 2016, running from a low of $1.6 million to a high of $7.7 billion, summing to $14.2 billion in total, which compares with $425.1 billion in mobile phone sales. The average cumulative royalty yield in 2016 was 3.3 percent or $7.20 per phone. If we restrict this only to smartphones, the result would be $9.60 per phone, roughly 3.4 percent of the average selling price. A sensitivity analysis shows that even under a very restrictive set of assumptions, the average cumulative royalty yield on a smartphone would not exceed 5.6 percent.

> 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 Arrow (2012)

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## 1. Introduction and motivation

### 1.1. How high are royalties in the mobile phone value chain?

By almost any measure the mobile phone industry is a success story. Between 1994 and 2013 the number of mobile phones sold rose 62-fold.[2] In June 2015 there were around 7.5 billion subscriber connections, one for every person on the planet.[3]

The impressive growth of mobile phone sales and penetration has been driven by rapid technological progress, which has produced steadily falling prices. In 1983 the first mobile phone cost the current equivalent of nearly $10,000, was the size of a brick, weighed a kilo, and had a battery which only lasted for a 30 minute call. Eight years later, in 1991, 2G GSM technology was introduced with phones that cost about $1,400 and provided consumers with data rates up to 9.6 kbps. Today, 4G phones cost on average less than $300, and provide data transfer speeds in excess of 100,000 kbps.

Mobile phones integrate a wide array of technologies, from computing to consumer electronics to communications, and from semiconductors to hardware, software and services. The technologies integrated in a smartphone have been developed over time by many different patent holders, some of which license them to semiconductor and phone manufacturers. Thus, there is substantial specialization and vertical separation in the mobile phone value chain.[4] At the same time, technology developers, phone manufacturers, and operators develop the technologies that make phones interoperable in standard development organizations (SDOs).

In any industry prices guide resource allocation, remunerate investments in physical capital and R&D and make decentralization and specialization possible. In the mobile phone industry the royalties paid by manufacturers to technology developers make specialization in technology development possible.[5],[6] Yet a rather large and influential academic literature argues that decentralization and specialization in the mobile phone industry may lead to excessive royalties, and this has given rise to concern by policy makers and antitrust authorities.[7] Some standards development organizations have also tried to change the rules whereby the FRAND commitment is established and assessed, in part to address concerns that royalties might be excessive.[8]

The argument about excessive royalties runs as follows. A standard-compliant phone uses hundreds, if not thousands of standard essential patents (SEPs) owned by a large number of SEP holders.[9] Each SEP holder sets her running royalty rate independently, and the result is that excessive running royalties are piled on top of excessive running royalties—a theoretical construct that is called “royalty stacking.”[10] This royalty stack drives up the marginal cost of manufacturing phones, thereby increasing prices to consumers, and discouraging innovation by manufacturers.[11]

### 1.2. The question asked by the literature and some answers

The question that has been posed by academics, policy makers, and industry practitioners is how high is the royalty stack, and by how much does it increase marginal costs and phone prices? An exact answer would require measurement of the running royalty paid by phone manufacturers at the margin. What have previous studies said about the royalties charged by patent holders in the mobile phone value chain?

In an influential paper, Lemley and Shapiro (2007, pp. 2026–27), suggest that royalties for the entire package of cell phone functionalities are in the range of 20–40 percent of the price of a phone:

> We have seen estimates as high as 30% of the total price of each phone, but those were based on summing royalty demands before any cross-licensing negotiations began. Bekkers (and West, 2006) suggests that the cost of patent licenses for cell phone Internet functionality after cross-licensing offsets is in the range of 20% of the price of the entire phone. […] Thelander suggests that

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[2] See Galetovic and Gupta (2017).

[3] See Mallinson (2016).

[4] See for example, Nenni and Dingee (2015) or Nenni and Mclellan (2013).

[5] Blecker, Sanchez, and Stasik (2016) provides a detailed account of licensing practice in the mobile phone industry. They show that, since the inception of the industry, holders of large patent portfolios have licensed their whole portfolio for a single royalty assessed on the average selling price of each phone.

[6] According to Johnson (2015, p. 198): “A royalty is simply a payment of a fixed fee per item sold ($5 per television set), or a percentage of the licensee's list price for each item, or a percentage of the licensee's receipts from sales […]”. According to the *Oxford English Dictionary* “[A royalty is a] sum paid to a patentee for the use of a patent or to an author or composer for each copy of a book.” See also OECD (2008). A “running royalty” is a payment that varies with the number of units sold. A “lump sum royalty” is a fixed payment that does not vary with the number of units sold.

[7] See, for example, United States Department of Justice and United States Federal Trade Commission (2007), Baer (2015), United States Federal Trade Commission (2003 and 2011), Hesse (2013, 2014), Shapiro (2001: 125), Scott-Morton and Shapiro (2016: 125), Vestager (2016). On court cases, see the recent comprehensive survey by Barnett (2018).

[8] See, for example, Katznelson (2015). FRAND is the acronym of fair, reasonable and non-discriminatory royalties.

[9] Some estimate that there are about 150,000 declared mobile SEPs worldwide (issued and applied for) in the so-called “4G stack,” which includes LTE, WCDMA and GSM/GPRS/EDGE. Of these, about 20,000 are US patents. As Galetovic and Gupta (2017) report, in 2013 there were 128 SEP holders in the 3GPP standard. One should note that it may have been in the interests of patent holders to declare all possible patents as “essential.” One reason is that patentees risk legal penalties for not declaring a patent essential. Also, some firms may have acted on the perception that a large SEP portfolio bolstered their reputation and increased their leverage when negotiating royalties. Moreover, the ETSI IPR database, just lists declared essential patents, but neither ETSI nor anybody else audits those declarations. For these reasons, it is not clear how many of these patents are truly essential. Industry participants often estimate the rate of over-declaration at 50 percent or more. Others think that few SEPs would pass a legal test of essentiality.

[10] Contreras and Gilbert (2015) argue that non-SEPs may also add to the royalty stack.

[11] See Shapiro (2001) and Lemley and Shapiro (2007, p 2013 and Appendix A).

actual royalties may run 22.5% for the WCDMA technology, in addition to the 15–20% for GSM technology if the phone is dual band.

Stasik (2010) compiled rack rates announced by patent holders who contributed to the LTE standard, and estimated an LTE stack of between 10 and 15 percent. Armstrong et al. (2014) built upon Stasik's LTE rack rates, added rack rates for patents that read on other functionalities and estimated "potential patent royalties in excess of $120 on a hypothetical $400 smartphone," which is to say a royalty stack of roughly 30 percent.

Basic arithmetic quickly called these estimates into question. If one takes an average cumulative royalty of $120 per phone, and then multiplies by the roughly 1.5 billion smartphones sold every year, researchers should observe $180 billion in revenues earned by the technology development firms and pools in the smartphone licensing business, with market capitalizations reflecting those revenues. Nevertheless, no one could point to a set of technology firms or pools that could generate revenues anywhere near $180 billion per year.

The reason why the studies that used posted rack rates were so far off from what is actually paid is that rack rates are seldom paid. As Judge Selna commented in a recent ruling: "The Court would actually expect that the rates companies publicly declared in 2008–2010 to be artificially high because each company knows that the figure it announces will naturally turn into the ceiling from what it can demand from future licensees" [12], [13]

Mallinson (2015) therefore went beyond the use of posted rack rates by looking at what the major SEP licensors actually earned. He "followed the money," estimating the royalties that each group of mobile communications SEP holders collected in 2014 with varying degrees of accuracy depending on data availability. He then divided that number by the total global mobile phone sales and estimated that the average cumulative royalty yield was at most 5.1 percent of global mobile phone sales revenues in 2013 and 5 percent in 2014.

Sidak (2016c) built upon Mallinson (2015), but took a somewhat different theoretical approach. He first replicated some of Mallinson's estimates of the value of mobile SEP licenses, refined others and estimated an average cumulative royalty yield of 3.5 percent in 2013 and 2014. In addition, however, Sidak (2016c) also estimated the implicit value of cross-licenses of large implementers—the licensing revenue that firms like Samsung, Huawei or Apple would have obtained had they not engaged in cross licensing deals but charged royalties to one another. Sidak's estimates imply an additional $4 billion in non-cash value of cross licenses in 2013 and $3.7 billion in 2014 (roughly one percent of mobile phone sales in each year). The non cash value of cross licenses is neither a revenue or income stream, nor a cash flow, however; hence, it cannot affect running royalties, and pricing decisions at the margin. Sidak's estimate of roughly 4.5 percent is therefore a study of potential IP value, not an estimate of the royalty stack. His estimate that does not include the implicit value of cross licenses, 3.5 percent, is however, a relevant estimate of running royalties.

We are therefore at a crossroad. One set of estimates claims that the royalty stack is on the order of 20–40 percent of the price of the average phone; another set of estimates indicates that it is on the order of five percent; a third set of estimates indicates that it is on the order of 3.5 percent.

Many have pointed out that there is no consensus finding about the magnitude of the mobile phone royalty stack. Layne-Farrar (2014) summarizes the state of knowledge as follows: "Certainly the theories have been developed, but the empirical support is still lacking." Contreras (2015) concurs: "The absence of meaningful and verifiable data on patent royalty rates hobbles the public debate over appropriate policies to govern industry standard setting and patent litigation. To date, far too much of this debate has relied on theoretical argumentation, political preference and positional advocacy, and has given undue weight to the scant data that is available." Blecker, Sanchez and Stasik (2016: 229), state that the magnitude of the royalty stack "[…] is a controversial question about which little hard information is publicly available."[14]

### 1.3. The contributions of this paper

Our goal is therefore three-fold. First, we provide a more accurate and comprehensive estimate, covering a much longer time period, of the patent royalties paid by firms in the mobile phone value chain. Specifically, we improve upon Mallinson (2015) and Sidak (2016c) in the following ways. We estimate patent royalties in the entire mobile phone value chain, including not only mobile SEPs on which Mallinson and Sidak concentrated, but also the value of royalties for audio and video codecs, imaging, operating systems, semiconductors, and the other components that go into a mobile phone. Our estimates cover 39 licensors in the smartphone value chain, including technology development companies, patent assertion entities, and patent pools. In addition, we provide time series coverage so that researchers, practitioners, and policy makers can see if and how mobile phone patent licensing has changed over time. For some firms, we are able to provide coverage from 2000 through 2016. For a group of 16 major licensors, accounting for 78 percent of all royalty revenues in 2016, we are able to go back to 2007. For an expanded group of 22 licensors, which accounted for 93 percent of all royalty revenues in 2016, we are able to go back to 2009. We also compare our estimate of the average cumulative royalty yield to other costs of mobile phone manufacture and to OEM profits. Finally, we develop a systematic method to assess the sensitivity of our estimates to the omission of licensors and the evasion of royalty payments by licensees.

[12] See Selna (2017, p. 24).

[13] Because licensors and licensees keep their royalty agreements confidential, it is not possible to deduce the royalties paid by licensees from rack rates posted by licensors. In point of fact, some posted rack rates generate zero revenue, as phone manufactures simply ignore them. For example, Nortel at one point declared a one percent royalty rate for its LTE portfolio, but appears to have never actually received any LTE licensing revenue.

[14] Many other authors have pointed to the lack of empirical evidence about the magnitude of the royalty stack. See for example, Gerardin and Rato (2007), Geradin, Layne-Farrar and Padilla (2008), Denicolo, Geradin, Layne-Farrar, and Padilla (2008), Epstein, Kieff, and Spulber (2012), Gupta (2013), Layne-Farrar (2014), Sidak (2016a), and Egan and Teece (2015).

Second, we develop a template (and an online Excel workbook) that allows academics and industry participants to replicate and continuously and collaboratively improve both our estimate of royalties paid in the mobile phone value chain and the methodology followed to obtain it.[15] Our online workbook shows the underlying data and sources, and also explains in detail the decisions we made when estimating or approximating values, licensor by licensor over time. The workbook also shows the structure of our estimation process. We classify licensors both according to their mode of organization (public corporations, private corporations, and patent pools), as well as by the degree to which we have been able to verify the accuracy of the available data (which we categorize as confirmed, documented, approximated and researched). We also indicate, and provide background on, potential licensors that may obtain royalty revenue but do not provide any information.

Third, we show that the average cumulative royalty yield in the entire mobile phone value chain—the sum total of patent royalty payments earned by licensors, divided by the total value of mobile phones shipped—is a conservative proxy or upper bound estimate of the unobservable running royalty paid by each licensee.

As the well-known theory of vertical control shows, running royalties will ultimately show up in the marginal cost of manufacturing a phone no matter where they are charged in the value chain. Consequently, there is neither need to identify the exact link in the chain where a licensor charges a running royalty, nor loss in aggregating all running royalties in a single number.

Economic theory and the literature on royalty stacking also show that only running royalties should be included to assess the impact of royalty payments on marginal costs and production decisions and compute the size of the royalty stack.[16] Therefore neither lump sum royalties nor the non-cash value of cross licenses should be included in the royalty stack. Licensing firms do not, however, distinguish between lump-sum and running royalties revenues in their financial statements. Thus, the average cumulative royalty yield is a conservative estimate of the running royalty.

More generally, we try to bias our estimates upwards because some academics, policy makers, and industry participants are concerned about what they deem to be excessive royalties. We note, however, that we take no position as to whether the average cumulative royalty yield we estimate is too high, too low, or just right.

### *1.4. A summary of the results*

We identify 39 potential licensors in the smartphone value chain. We find that, of these, only 29 charged royalties in 2016, running from a low of $1.6 million to a high of $7.7 billion and summing $14.2 billion in total. Because in 2016 original equipment manufacturers (OEMs) sold 1.97 billion mobile phones for $425.1 billion, the average cumulative royalty yield was $7.20 per phone, or 3.3 percent of the average selling price of the average phone. If we exclude feature phone sales from the calculation and assume that only smartphones pay patent licensing royalties, the average cumulative royalty yield would be 3.4 percent or $9.60 per phone. This average cumulative royalty yield seems to be quite stable over time. We have data starting in 2007 for 16 licensors (which accounted for 78.2 percent of all royalty revenues in 2016); and data since 2009 for 22 licensors (which accounted for 92.5 percent of all royalty revenues in 2016). The average cumulative royalty yield of firms with data since 2007 hovers between 2 and 3 percent; the average cumulative royalty yield of firms with data since 2009 hovers between 3 and 3.5 percent. The stability of the average cumulative royalty yield over time is remarkable, given that between 2007 and 2016 sales of mobile phones the share of smartphones in total mobile phone sales increased from less than 20 percent to more than 95 percent and total sales roughly doubled.

### *1.5. The rest of the paper*

The rest of the paper proceeds as follows. In section 2 we describe the concepts underpinning our estimate and the method we followed to collect the data and estimate the average cumulative royalty yield. In section 3 we present the main results and explore their robustness to alternative treatments of the data. Section 4 concludes.

## 2. Method—"Follow the money" in the entire value chain

### *2.1. Theory*

#### *2.1.1. The cumulative running royalty and marginal costs*

All measurements depend upon an underlying theory, and underlying theories are created in order to answer particular questions of interest. The basic question researchers, policy makers and industry practitioners have asked is how do royalties paid by firms in the mobile phone value chain affect production and decisions at the margin? That is, if the cumulative running royalty were X percentage points higher, by how much would output fall and prices increase? This point is clearly made by Lemley and Shapiro (2007, p. 2013):

> […] higher running royalties will raise the downstream firm's marginal cost, which will raise its price and thus reduce its level of output. This is an example of the effect well known to economists under the label of "Cournot complements." The Cournot-complements effect arises when multiple input owners each charge more than marginal cost for their input, thereby raising the price of the downstream product and reducing sales of that product. Effectively, each input supplier imposes a negative

[15] The August 2017 update of the database is available in an Excel workbook that we have posted to the web at https://hooverip2.org/working-paper/wp18005.
[16] See, for example, Lemley and Shapiro (2007, Appendix A).

> externality on other suppliers when it raises its price, because this reduces the number of units of the downstream product that are sold. As a result, if multiple input owners each control an essential input and separately set their input prices, output is depressed even below the level that would be set by a vertically integrated monopolist. The theory of Cournot complements teaches us that the royalty stacking problem is likely to be worse the greater the number of independent owners of patents that read on a product.

Microeconomic theory provides a guide to the relevant facts necessary to estimate the effect of royalties on downstream manufacturing firms' marginal costs and prices. To see how, consider the simple example depicted in Fig. 1. Let $q$ be the number of mobile phones, $p$ their price and assume that the derived demand for smartphones is a straight line

$$q = S(v - p)$$

In this demand curve, which is shown in Fig. 1, $v$ is the maximum amount that a consumer is willing to pay for a mobile phone and $S > 0$ parameterizes the size of the market. We further assume that a smartphone costs $c$ to produce and sell to customers and that input providers and mobile phone manufacturers compete.[17]

Note that the demand confronted by mobile phone manufacturers is a derived demand created by the demand for mobile communications by consumers.[18] Thus, the source and limit of all surplus in the mobile phone value chain is that consumers value what they can do with a mobile phone. Because of this, neither patents nor components are valuable by themselves. On the contrary, they have value only because they contribute to producing mobile phones for which consumers are willing to pay. A direct implication is that any cumulative running royalty that IP owners may receive from licensing to the manufacturers of inputs, or to phones as final products, is capped by net surplus, which is equal to the difference between the willingness to pay of consumers for a mobile phone, as summarized by the demand curve, and the marginal cost of manufacturing a mobile phone in the entire value chain.

**Result 1**. At the margin, the cumulative running royalty cannot exceed the net value created by mobile phones which is equal to the difference between consumers' willingness to pay and the marginal cost of manufacturing a mobile phone.

Now denote as $R$ the cumulative running royalty charged by all patent holders. $R$ is a unit price; the total royalty amount paid by a licensee varies with the number of mobile phones manufactured and sold. Because input usage (the number of semiconductors, screens, baseband processors, and the like) also varies with the number of manufactured mobile phones, running royalties eventually will affect the marginal cost of manufacturing a mobile phone no matter where in the value chain a patent holder charges a royalty. That is, if a mobile phone manufacturer pays a running royalty, it will be part of that firm's marginal cost. And if an input producer (say, a screen manufacturer) pays a running royalty, then the royalty will be part of its marginal cost, and that cost will be reflected in the equilibrium price paid by the phone manufacturer for that input. Therefore:

**Result 2**. A cumulative running royalty $R$ increases the marginal cost of manufacturing a mobile phone to $\mathrm{C} + \mathrm{R}$. It does not matter where in the value chain licensors charge per-unit royalties.

If the market is competitive, as we assume in Fig. 1, $\mathrm{C} + \mathrm{R}$ is also equal to the equilibrium price, $p$, of a mobile phone. The insight can be traced back at least to Spengler (1950).[19] 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. It follows that part of the economic surplus generated by the smartphone value chain is captured by patent owners through the cumulative running royalty $R$. This is the gridded rectangle in Fig. 1. Note, moreover, that the equilibrium quantity $q$ varies with the cumulative running royalty because $R$ affects the marginal cost of manufacturing a mobile phone.

A corollary of Result 2 is that it doesn't matter whether the royalty base is an input (for example, the baseband processor) or the phone. As far as the marginal cost of manufacturing a mobile phone is concerned, all that matters is the cumulative running royalty. Hence:

**Result 3**. The impact on the marginal cost of manufacturing a mobile phone of a running royalty depends only on its dollar value. It does not depend on whether it is charged on an input or on the mobile phone. [20]

To determine $R$ in equilibrium one needs a theory about the behavior of licensors and licensees; the literature has developed a clear (and testable) theory: royalty stacking. Lemley and Shapiro (2007, pp. 2013 and 2014) explain the intuition of the theory:

> […] the stacking of running royalties for a product sold at a positive margin by the downstream firm combines the inefficiencies associated with two well-known pricing problems in industrial organization: "double marginalization," which arises when input suppliers with market power (here, the patentees) sell to a downstream firm that also has some power over price, and the Cournot-complements effect, which arises when multiple suppliers with market power sell complementary products. Together, these problems cause prices to be higher than would be set by an integrated monopolist who owned all of the patents and sold the downstream product.[21]

[17] Extensions to imperfect competition show that our conclusions do not change. See Galetovic and Gupta (2017).

[18] The rules governing derived demand have been known since Alfred Marshall's *Principles*. For a formal treatment see Bronfenbrenner (1961). See also Stigler (1987) and Whitaker (1991).

[19] See also Tirole (1988, p. 174).

[20] Of course, in practice there are transactions costs and therefore it may matter a great deal what the royalty base is; see Blecker, Sanchez and Stasik (2016).

[21] See also Shapiro (2001).

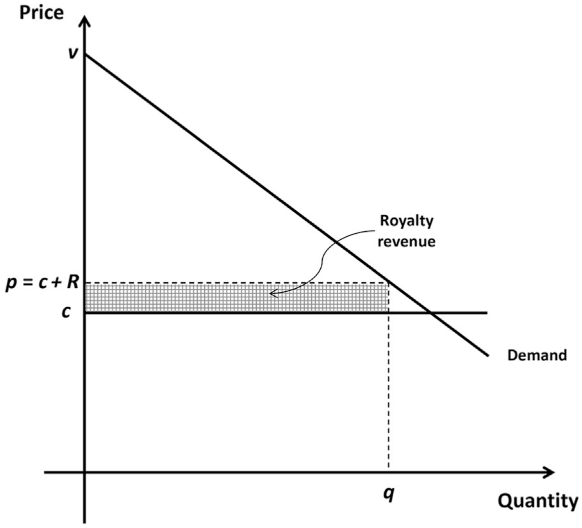


**Fig. 1.** Royalties and the derived demand for mobile phones.

Our aim in this paper is neither to criticize nor test this theory.[22] Rather, our goal is to provide an estimate of one of its key variables, the cumulative running royalty.

*2.1.2. Fixed costs, other licensing costs and cross licensing*

The running royalty paid by each licensor to each patent holder is not directly observable. Therefore, we estimate a proxy, the average cumulative royalty yield in the entire mobile phone value chain— the sum total of patent royalty payments earned by licensors, divided by the total value of mobile phones shipped.

This is a conservative proxy, or upwardly biased, of the unobservable running royalty paid by each licensee. One reason is that licensing agreements may include both a lump-sum and a running royalty. Lump-sum payments do not increase marginal costs, but only fixed and average costs. Therefore, they should not be included in *R*. In practice, it is not possible to separate one from the other in the public financial statement data we gather, which bias our results upwards.

Second, and perhaps more important, we do not add the non-cash value of cross licenses to our estimate of the average cumulative royalty yield.[23] The reason is that cross-licenses reduce running royalties. For example, if firm A and B sign a royalty-free cross licensing agreement and firm B increases production by one unit, its total royalty cost will not increase at all. Hence the non-cash value of a cross license does not affect firm's B marginal cost of producing a mobile phone. By contrast, if firm A charges a running royalty to firm B, and B charges a running royalty to A, and either A or B produces an additional mobile phone, then the firm's royalty payments would increase by the value of the running royalty. [24] Indeed, there is widespread agreement in the literature that cross licensing mitigates royalty stacking. For example, as Gilbert and Shapiro (1997, p. 325) explain:

> Cross-licenses involving intellectual property for technologies that are complements or are in a blocking relationship serve a pro-competitive purpose. They can help solve the complementary monopolists problem identified long ago by Cournot […]. Royalty-free cross-licenses promote the dissemination of technology.

Moreover, as Farrell and Shapiro (2004, p. 70) argue:

> Cross-licenses without running royalties are especially attractive and efficient from an ex post competitive perspective: they permit the diffusion and use of patented technology without elevating the marginal costs of either party. [25]

We do not claim that cross licensing may not hurt OEMs that do not own significant patent portfolios and thus have to pay running

[22] See, however, Galetovic and Haber (2017).

[23] Neither do we add the non-cash value of other forms of IPR value which may appear in agreements (e.g. indemnification, covenants, options, rate collars, floors and ceilings, and the like).

[24] This is similar to the case of access charges to a network studied by Laffont, Rey, and Tirole (1998). If two firms eschew access charges, their marginal cost of access is zero. If each firm charges a positive access charge, the marginal cost of access to the other network is equal to the access charge. Note, moreover, that the non-cash value of a cross license is not a fixed cost either, because it is a bilateral exchange: the opportunity cost is matched by the benefit that the firm get in exchange by not having to pay licenses, so they cancel out. The only effect of a cross licensing agreement is to lower marginal costs.

[25] On cross licenses solving the Cournot complement problem see also Beard and Kaserman (2002), Denicolo et al. (2008), Geradin et al. (2008), Layne-Farrar (2014), Lemley and Shapiro (2007), Shapiro (2001, 2004), United States Federal Trade Commission (2003, p. 33), and United States Department of Justice and Federal Trade Commission (2007, p. 61).

royalties to incumbent OEMs. All things equal, the marginal costs of OEMs that do not own significant patent portfolios and have not secured royalty-free cross licenses are *higher* than the marginal cost of OEMs with large portfolios that grant royalty-free cross licenses to one another, ceteris paribus. This horizontal issue may be of interest to antitrust authorities and policy makers. This is not, however, the question asked by the royalty stacking literature. Moreover, the antitrust issue that would stem from royalty-free cross licensing is about the competitive advantage obtained by implementing firms by virtue of the fact that cross licensing *lowers* their marginal costs.

### 2.2. From theory to measurement

In an ideal world for researchers, mobile phone Original Equipment Manufacturers (OEMs), Electronics Manufacturer Services (EMSs), Original Design Manufacturers (ODMs) and component manufacturers in the mobile phone value chain would report the identities of the IP holders from whom they license, the value of the payments to each of those licensors and which royalties are lump sum and which are running royalties. It would then be possible to determine the "IP Bill of Materials (IP BoM)" paid by each firm in the mobile phone value chain. From there, one could exclude fixed payments, and calculate a weighted average IP BoM for every firm in the value chain, with the weights determined by their relative contribution to total mobile phone sales. Unfortunately, licensees have very weak incentives to disclose their patent license royalty payments, and so most of them do not disclose them.

As a matter of accounting, however, payments by licensees must show up as revenues for licensors, and many licensors may have market-based incentives to disclose some information. This allows the estimation of approximate royalty revenues. For publicly-traded firms with licensing revenues that are a non-trivial component of their total revenues, those incentives are legal and regulatory; the sources of revenue must be disclosed to investors. Even licensors without legal and regulatory incentives to disclose their revenues, however, such as patent pools administered by firms that specialize in pool administration, have market-based incentives to disclose, and this allows the estimation of approximate royalty revenues.

It is therefore possible to estimate total royalty payments received by patent holders in the mobile phone value chain by identifying the major licensors and retrieving the information necessary to estimate their licensing revenues. One can then divide the sum of these revenues across all licensors by the total value of mobile phones sold to obtain an average cumulative royalty yield.

### 2.3. The measurement of the average cumulative royalty yield

There are three numbers that one needs to know in order to estimate the average cumulative royalty yield: (i) the mobile phone patent licensing revenue of each licensor; mobile phone (ASP). We now explain how to estimate each number.

#### 2.3.1. Estimating patent licensing revenue

Estimating patent licensing revenue is straightforward in principle, though it can be difficult in practice. Firms that earn significant revenues from patent licensing report those figures in financial reports (e.g. US SEC forms 10 K and 20 F). Private firms do not typically have an obligation to disclose such information about their operations. In these cases, we estimate revenues based on information that firms make publicly available. For example, successful patent pools typically disclose the identities of their licensors and licensees, the patents covered by the pool, and the fee schedule for licensees.[26]

There are some public firms that earn patent licensing revenue in the mobile phone value chain but in amounts that are modest relative to their other revenue sources. They therefore do not break out this revenue as a reportable segment in their public filings. There are also private firms, and these do not have an obligation to disclose their revenue sources. When practicable, we estimate the revenues of both types of firms with information on their websites, reports in the trade and financial press, and interviews with industry practitioners.[27] When not practicable, we enumerate those firms that may have generated royalty revenue, but for which we have neither data nor a plausible estimate.[28] We then do a sensitivity analysis in which we assign a series of plausible total revenues for these firms as a group in order to check the robustness of our results. [29]

The core of our method, then, is to "follow the money." In following the money, we make no distinctions as to where a licensor is earning revenues in the mobile phone value chain, nor do we make distinctions among the different patented technologies in a mobile phone. We capture, for example, revenues earned from licenses taken by semiconductor and baseband chip producers, as well as the OEMs and EMSs that assemble phones. We also capture revenues earned from licenses on patents that enable video, imaging, audio, and other functions, as well as the SEPs that enable mobility. Last, we capture the revenues of a major software company that earns revenue from its patents that read on the most popular mobile phone operating system.[30]

[26] For the data, see *Tab 1.7, Revenues by Licensor,* in the Excel workbook.
[27] For the data, see *Tab 1.7, Revenues by Licensor,* in the Excel workbook.
[28] For the list of firms, see *Tab 6.0, Other Firms,* in the Excel workbook.
[29] See, *Tab 1.6 Sensitivity,* table for mobile phones, in the Excel workbook.
[30] We do not include the revenues of ARM, or firms like it, that design chip architectures (IP cores) and license them to manufacturers of baseband processors or Wi-Fi chipsets that implement those architectures. While designs are IP products, their royalties are not revenues for patents, and have never been mentioned in the literature as forming part of a patent royalty stack. Nevertheless, even if we were to include the revenues of ARM, it would not materially affect our results: ARM's total revenues are less than $1 billion per year, roughly seven percent of our cumulative royalty yield estimate.

### 2.3.2. Estimating the size of the market

A number of data analytics firms estimate the number of phones sold and the average selling price, and issue press releases that they post to the web. Firms such as IC Insights, IDC, Gartner, and GFK produce these estimates. The estimates tend to be within a few percentage points of one another such that results are not sensitive to which source is used.[31]

These same entities also estimate device sales and prices by major OEMs, and provide this data in press releases, which they post to the web. These estimates also tend to be within a few percentage points of one another.[32] We use this data to estimate the revenues earned by patent pools, which tend to have tiered royalty schedules.

### 2.3.3. Principles of data collection: biasing the estimate upwards

In following the money we are guided by three principles. First, to the extent that it is possible, the estimates should use publicly-available sources so that our results can be replicated and improved upon by other researchers. Second, our aim is to have as long a time series for each licensor as is practically possible. Third, decisions about how to treat data should bias in favor of obtaining a larger average cumulative royalty yield. This implies that we err on the side of: (i) including licensors that license to a variety of industries, not just mobile phones, which means that we may be counting some of their revenues from other industries as royalties on mobile phones; (ii) attributing to mobile phones royalties that may have been paid on other mobile products, such as tablets; (iii) double counting, which means that we may be including both the royalty revenues declared by a licensor and the royalty revenues earned by a pool where the licensor is a member.[33]

### 2.3.4. Data quality

The quality of data varies across licensors. We classify licensors in four categories according the accuracy of their licensing data: Confirmed, Documented, Approximated, and Researched. Table 1 shows the licensors classified in each category.[34]

As a general rule, the largest licensors are also those which report licensing revenues separately from other revenues, and for which we have a primary source document that was generated as a legal requirement. Qualcomm, Interdigital, Nokia, and Ericsson, are examples of these licensors. Given the high quality and accountability of their reports, their knowledge of their operations and their reporting under SEC auspices, we consider these figures "Confirmed." In 2016 this category accounted for 75.2 percent of total estimated royalty revenues.

Other licensors provide sufficient information in publicly available documents to estimate their licensing revenues. In some cases, we separate licensing revenues from mobile phones from other licensing revenues, based on information in footnotes to SEC 10 K's. In other cases, we have licensing fee schedules and the identities of the licensors, and can estimate the licensing revenues of each licensor. We denote these as "Documented." Entities in this category include the major patent pools such as MPEGLA MPEG4; MPEGLA AVC/H.264, and Via Licensing's AAC pool. It also includes Microsoft, which licenses its patents that read on the Android Operating System to OEMs. In 2016 this category accounted for 8.5 percent of total revenues.

There are some entities that are non-trivial mobile phone value chain licensors for which we have information about their total licensing revenues. We have to make assumptions, however, based on other data or interviews, about the percentage of their total licensing revenues that come from the mobile phone value chain. We denote these as "Approximated." They include Xperi (formerly Tessera), Quarterhill (formerly WiLAN) and Rambus. In 2016 this category accounted for 11.9 percent of total revenues.

Finally, there are some entities with little or no disclosure, but upon examination it seems that they have very modest, sometimes zero, revenues.[35] We denote these as "Researched." In 2016 this category accounted for 4.3 percent of total royalty revenue.

In addition, there are firms that appear to earn some patent licensing royalties from the mobile phone value chain, but there is limited information in the public domain about the magnitudes. Some large, public companies (some of which are mobile phone OEMs) earn some patent licensing revenues, but their licensing activities are not significant enough to be a reportable segment in their financial statements. Some of these firms, or EMSs that produce for them, are also major sources of licensing revenue for other firms covered in this study. There are also small private companies that appear to earn some patent licensing royalties from the mobile phone value chain, but the publicly available information about their revenues and operations is fragmentary. We call those "Other identified firms." The available evidence does not suggest any one of these firms—public or private—individually has licensing revenues significant enough that its addition would have a material effect on the overall magnitude of the cumulative royalty yield.

[31] For the data, see *Tab 1.8, Device Sales*, in the Excel workbook.

[32] For the data, see *Tab 1.9, OEM Sales*, in the Excel workbook.

[33] 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 reporting requirements as U.S. or European firms, we liberally assume that its mobile phone royalty revenues are the same as a well-established, U.S.-based technology company, Interdigital. In doing so, we assume that Huawei is earning, on its mobile phone patents alone, roughly 30 percent of all patent revenues earned by all Chinese companies in any line of economic activity. See the discussion in *Tab 5.6, Huawei* in the workbook.

[34] Also see *Tab 6.0, Others*, in the Excel workbook.

[35] The one exception to the generalization about size and data quality is Intellectual Ventures. In this case, we have estimated its total revenues from information on its own website over time (using the web-tools that allow researchers to look at archived webpages) and from information in the trade press about its financial performance. We have to approximate the percentage of this revenue from the mobile phone value chain based on information on the firm's website about its patent portfolio, as well as interviews with industry practitioners.

**Table 1**
Types of licensors classified by type and the quality of their data.

| | Confirmed | Documented | Approximated | Researched | Other identified firms |
|---|---|---|---|---|---|
| Type 1 Public corporation | ***Qualcomm (2.1)***<br>***Ericsson (2.2)***<br>***Nokia (2.3) (incl. Alcatel-Lucent, 2.3.1)***[1]<br>***Interdigital (2.4)***<br>**Parker Vision (3.9)**<br>**Unwired Planet (3.10)**[2]<br>**VirnetX (3.11)** | ***Microsoft (2.5)*** | **Philips (3.1)**[3]<br>**Xperi (3.5)**[4]<br>**Rambus (3.6)**<br>**Acacia Technologies (3.7)**<br>**Quarterhill (3.8)**[5]<br>**Marathon Patent Group (3.12)**<br>**IBM (3.13)**<br>**Tivo (3.14)**<br>**Technicolor (3.15)**<br>**Blackberry (3.16)** | **AT&T 802.11 (3.2)**<br>**AT&T MPEG4 (3.3)**<br>**Broadcom (3.4)** | Apple (6.0)<br>Google (6.0)<br>Infineon (6.0)<br>Samsung Electronics (6.0)<br>Siemens (6.0)<br>Texas Instruments (6.0)<br>Sony Corp (6.0)<br>LG Electronics (6.0) |
| Type 2 Private corporation | | | ***Huawei (5.6)*** | **SISVEL Wireless (5.1)**<br>**IP Com (5.2)**[7]<br>**PanOptis-Optis (5.3)**[2]<br>**IP Bridge (5.4)**<br>**Intellectual Ventures (5.5)**<br>**Conversant (5.7)**[8] | Form Holdings (6.0)[11]<br>France Brevets (6.0)[12]<br>ETRI (6.0)[13]<br>ITRI (6.0)[14]<br>Longitude Licensing (6.0)[15]<br>Mobile Media Ideas (6.0)<br>Rockstar (6.0)<br>VoiceAge (6.0)<br>Round Rock (6.0) |
| Type 3 Patent Pool | | **Via Licensing AAC (4.1)**<br>**MPEGLA MPEG4 (4.3)**<br>**MPEGLA AVC H.264 (4.4)**<br>**MPEGLA HEVC (4.9)**<br>**HEVC Advance (4.10)** | **Via Licensing LTE (4.2)**[6] | **SISVEL LTE (4.5)**<br>**SISVEL WiFi (4.6)**<br>**Via Licensing WCDMA (4.7)**[9]<br>**Vectis WiFi (4.8)**[10]<br>**Velos Media HEVC (4.11)** | |

(Tabs in the Workbook in parentheses.) Licensors included in the Cumulative Royalty Yield estimate in boldface. *Technology leaders in italics.*
Notes to Table 1.
(1) Nokia acquired Alcatel-Lucent in January 2016.
(2) PanOptis recently purchased Unwired Planet. Both license part of Ericssons's patent portfolio.
(3) Philips is a major licensor, but is more diversified with major trademark/brand licensing operations, and also major digital A/V licensing which includes major pool participation. However, it has some mobile SEP licensing business.
(4) Xperi is the former Tessera. It changed its name in February 2017.
(5) Quarterhill is the former WiLAN. It changed its name in April 2017 after a corporate reorganization, but its licensing business still operates under WiLAN.
(6) Google licenses its LTE patents through Via. Dolby owns Via Licensing.
(7) IP Com manages the former Bosch mobile patents.
(8) Core Wireless/Conversant licenses part of Nokia's patent portfolio.
(9) Via Licensing replaced Siprolab as administrator of the WCDMA pool.
(10) Vectis licenses some of Ericssons's Wi-Fi patents.
(11) Form Holdings is the former Vringo.
(12) France Brevet is a French sovereign fund with a portfolio including near-field communication (NFC) patents.
(13) ETRI is a South Korean research institute.
(14) ITRI is a Taiwanese research institute.
(15) Longitude Licensing represents Sandisk and other major tech companies. It was acquires by Vector Capital in 2016.
Source: see tab *1.7 Revenues by Licensor,* in the Excel workbook.

## 3. Results

### 3.1. The average cumulative royalty yield

We are able to estimate, with varying degrees of accuracy, the mobile phone patent licensing revenues of 39 licensors in the mobile phone value chain. Table 2 shows that the 39 licensors as a group had cumulative royalties in 2016 of almost $14.2 billion.[36] Of these 39, 10 have licensing revenues of effectively zero. In 2016, the royalty revenues of the remaining 29 firms varied between $1.6 million and $7.7 billion. As can be seen in the last column of Table 2, 91.1 percent of these revenues come from public corporations. By contrast, only $466 million (3.3 percent) of royalties are charged by patent pools.

One way to put these numbers into perspective is to compare them with the value of mobile phone shipments. In 2016 original equipment manufacturers (OEMs) sold 1.97 billion mobile phones for $425.1 billion.[37] It follows that the ASP was $215.5, and that the Average Cumulative Royalty per phone was $7.20. The average cumulative royalty yield is total patent royalties divided by the value of

[36] For the data by licensor, see *Tab 1.7, Revenues by Licensor*, in the Excel workbook.
[37] According to IDC. For the data, see *Tab 1.8, Device Sales*, in the Excel workbook.

**Table 2**
Cumulative royalty yield classified by the quality of the data (in 2016).

| | Confirmed | Documented | Approximated | Researched | Total |
|---|---|---|---|---|---|
| Type 1 Public company | *$10,679,127,886 (75.2%)* | *$828,185,000 (5.8%)* | *$1,035,503,336 (7.3%)* | *$382,000,000 (2.7%)* | *$12,924,816,222 (91.1%)* |
| Type 2 Private company | - | – | $655,360,000 (4.6%) | $145,683,346 (1.0%) | $801,043,346 (5.6%) |
| Type 3 Patent Pools | - | $378.780.681 (2.7%) | – | $86,982,900 (0.6%) | $465.763.581 (3.3%) |
| **Total** | *$10,679,127,886 (75.2%)* | $1.206.965.681 (8.5%) | $1,690,863,336 (11.9%) | $614,666,246 (4.3%) | $14.191.623.148 (100%) |

Source: See tab *1.7 Revenues by Licensor*, in the Excel workbook.

total phone shipments, or 3.3 percent.[38]

Yet another way to put these numbers into perspective is to ask how they compare with those from earlier years. Because we take a time-series approach, some of our firm-level revenue estimates go back to 2000. As can be seen in Appendix Table, by 2007 we have data for 16 licensors, which accounted for 78.2 percent of all royalty revenues in 2016. By 2009, we have data on 22 licensors, and these accounted for 92.5 percent of all royalty revenues in 2016 [39]. As Fig. 2 shows, both series are remarkably stable. The average cumulative royalty yield of firms with data since 2007 hovers between 2.1 and 3 percent; the average cumulative royalty yield of firms with data since 2009 hovers between 3 and 3.5 percent, falling only marginally during the last three years.[40] Note that, as can be seen in Fig. 3, the composition of sales between feature and smartphones changed significantly during the period and the value of sales roughly doubled, and yet the average cumulative royalty yield remained stable.

Yet another way to put these data into perspective is to ask how they compare to estimates that other researchers have made about the rest of the costs incurred to manufacture phones, such as semiconductors and baseband processors, as well as OEM operating margins on mobile phones. Fig. 4 presents that data. The results indicate that patent licensing is the smallest of the categories: somewhat lower than the cost of baseband processors, slightly less than one-seventh of the cost of semiconductors, and about one-fourth of OEM operating margins.[41]

### *3.2. Sensitivity analysis*

Our results do not seem to be very sensitive to how one treats the data. For example, assume that only smartphones paid royalties and all feature phones paid no royalties at all. In that case, all the cumulative royalties of $14.2 billion in 2016 would be spread across 1,474 million smartphones with a total value of $415.2 billion (instead of 1.97 billion smart and feature phones with a value of $425.1 billion). The average cumulative royalty per smartphone would rise from $7.20 per phone to $9.60and the average cumulative royalty yield would rise only slightly, from 3.3 percent to 3.4 percent.[42]

Neither are our results sensitive to imputing the aggregate royalties earned by firms in "Other" un-enumerated category, which do not provide enough information for us to estimate their revenues on a firm by firm basis. If we assume that these firms as a group earned $1 billion in licensing revenues in 2016, then the average cumulative royalty yield on a smartphone would increase from 3.4 percent to 3.7 percent (see the first row in Table 3). If we make the rather extreme assumption that the combined royalties of these firms came to $2 billion, then the average cumulative royalty yield would still only be 3.9 percent.

The results are only marginally sensitive to relaxing the assumption that every smartphone shipped in 2016 paid licensing royalties. We estimate an upper-bound evasion rate of 30 percent.[43] We then calculate the average cumulative royalty yield assuming that only 70 percent of smartphones paid licensing royalties. The last row in Table 3 shows the results. Under the assumptions that: (i) all royalties are charged on smartphones (none on feature phones); and (ii) that 30 percent of smartphone production evades royalties, the average cumulative royalty rate on a smartphone would increase from 3.4 percent to 4.9 percent.

Last, assume that all royalties are earned on smartphones, that the evasion rate is 30 percent, and the royalties of firms in the "Other" un-enumerated category in 2016 equaled $2 billion. Then, as Table 3 shows, the average cumulative royalty yield would be 5.6 percent.

[38] For the calculations, see *Tab 1.3, Royalty Yield Summary*, in the Excel workbook.
[39] Some of these firms do not report any revenues.
[40] For the data, see *Tab 1.4, Royalty Yield Series,* in the Excel workbook.
[41] For the data and sources, see *Tab 1.5, Economic Analysis*, in the Excel workbook.
[42] See *Tab 1.3 Royalty Yield Summary*, in the Excel workbook.
[43] For a discussion of how we estimated that upper-bound evasion rate, see the footnote in *Tab 1.6, Sensitivity*, in the Excel workbook.

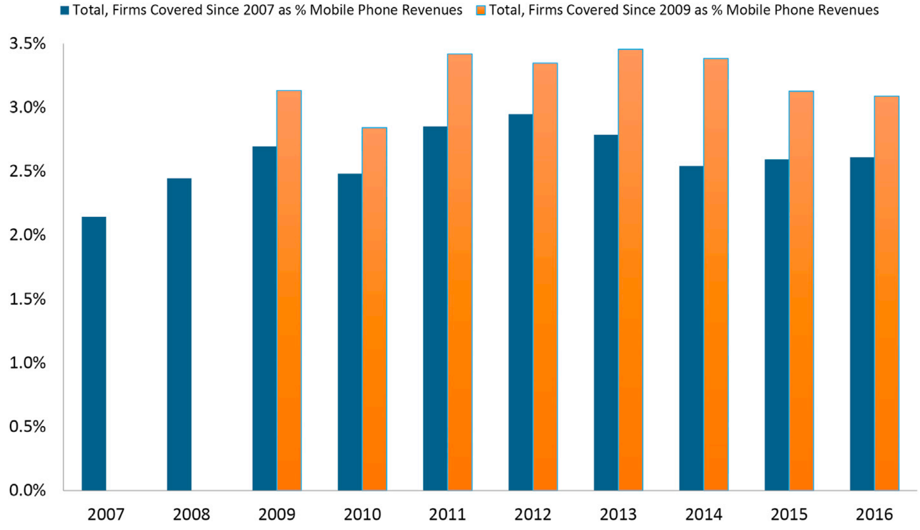


**Fig. 2.** Patent royalties as percentage of the value of mobile (smart and feature) phones shipped, 2007–2016.

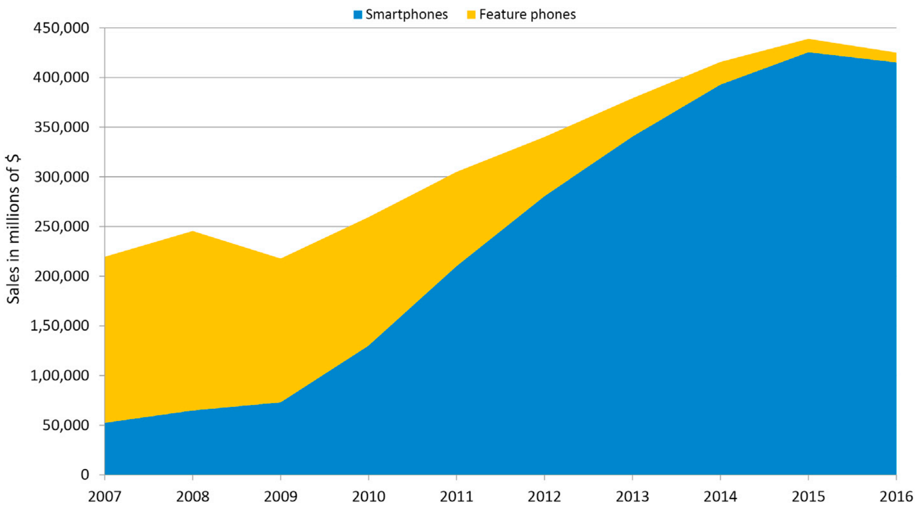


**Fig. 3.** The composition of mobile (smart and feature) phone revenues, 2007–2016.

## 4. Concluding remarks

In this paper we do not take a position on whether the estimates of the average cumulative royalty yield are "too high," "too low," or "just right." Similarly, it is not our purpose to define what a FRAND royalty and level is. Nevertheless, an accurate estimate of the average cumulative royalty yield is a modest, yet necessary, first step in order to assess whether royalties are "too high," "too low," or "just right," test for a possible royalty stack, or speculate about what a FRAND royalty rate should be. [44] These important debates can only be joined on the basis of quantitative evidence on actual royalties charged by IP owners. Indeed, recently, Maureen Ohlhausen, Chairwoman of the FTC, called for antitrust in IP to be guided by evidence.[45]

We have shown how information from financial statements can be consistently used to inform these debates. One contribution of our estimate to this debate is to show and confirm that several widely-cited claims that the royalty stack is on the order of 20–40 percent of the value of the average phone are off by almost an order of magnitude. Consequently, these estimates should not be used to inform

[44] On FRAND see, for example, Sidak (2013, 2016a,b).

[45] See Ohlhausen (2017).

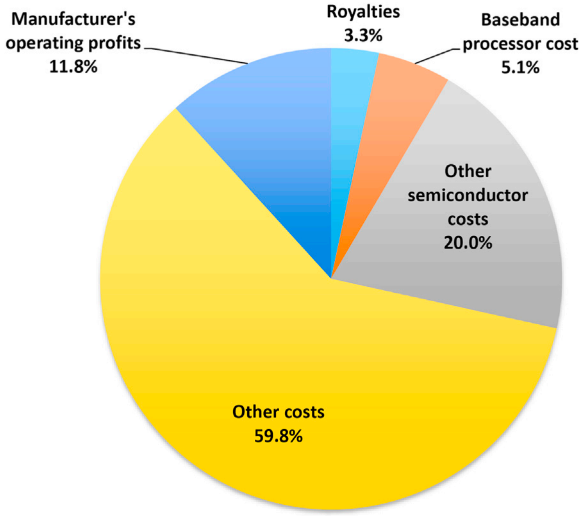


**Fig. 4.** Breakdown of the average selling wholesale price of a mobile phone (in 2016).

**Table 3**
A sensitivity analysis of the average cumulative royalty yield (2016, smartphones only).

| % Unlicensed | Effective Smartphones Royalties Charged by "Other" licensors as a group ($m) | | | | |
|---|---|---|---|---|---|
| Phones | $0 | $500 | $1000 | $ 1500 | $ 2000 |
| 0% | 3.4% | 3.5% | 3.7% | 3.8% | 3.9% |
| 5% | 3.6% | 3.7% | 3.9% | 4.0% | 4.1% |
| 10% | 3.8% | 3.9% | 4.1% | 4.2% | 4.3% |
| 15% | 4.0% | 4.2% | 4.3% | 4.4% | 4.6% |
| 20% | 4.3% | 4.4% | 4.6% | 4.7% | 4.9% |
| 25% | 4.6% | 4.7% | 4.9% | 5.0% | 5.2% |
| 30% | 4.9% | 5.1% | 5.2% | 5.4% | 5.6% |

Source: see Tab 1.6 *Sensitivity* in the workbook.

policy or judicial decisions.

Our estimate of average cumulative royalty yield in the mobile phone value chain reveals that those who own large portfolios of patents that read on the relevant technologies—mostly technology companies—earn most patent royalties. By contrast, patent pools and PAEs are comparatively small players in licensing and many patent holders do not charge licensing at all. Moreover one of our findings is that the revenues of patent pools are quite a bit lower than the estimates made by Mallinson (2015) and Sidak (2016c). Indeed, even among technology companies the distribution of royalty revenues is skewed, a fact which is consistent and seems to confirm the claim that not all patents and patent portfolios are equally valuable[46] The asymmetry among licensors and patent holders has relevant implications for judicial decisions. For example, in a recent ruling the court assumed that all SEPs were equally valuable.[47]

Last, our time series of royalties suggests remarkable stability of the year-to-year average cumulative royalty yield. In view of the large variety of licensors and licensing strategies, and the year-to-year changes in the revenues of individual licensors, an intriguing but important question is what equilibrium mechanism causes this parsimonious outcome and "market" average cumulative royalty yield. A theory that satisfactorily explains this observed fact would probably have important implications for the determination of royalty rates in litigation and inform what a reasonable or market royalty is.

## Appendix A. Supplementary data

Supplementary data related to this article can be found at https://hooverip2.org/working-paper/wp18005.

[46] See for example, Leonard and López (2014) and Sidak and Skog (2017).

[47] See Selna (2017).

## Appendix

**Table A1**

Royalty revenues per Licensor, 2000–2016 (in $mm).

| Revenues by Licensor, in $ mm | | | | | Begin coverage | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2.1 | Qualcomm | Confirmed | Public Corp | 2000 | 705 | 782 | 847 | 1000 | 1331 | 1839 | 2467 | 2772 | 3622 | 3605 | 3659 | 5422 | 6327 | 7554 | 7569 | 7947 | 7664 |
| 2 | 2.2 | Ericsson | Confirmed | Public Corp | 2004 | | | | | 339 | 517 | 718 | 1023 | 1371 | 1071 | 1164 | 1758 | 1793 | 1620 | 1433 | 1701 | 1165 |
| 3 | 2.3 | Nokia | Confirmed | Public Corp | 2009 | | | | | | | | | | 698 | 753 | 1323 | 687 | 703 | 835 | 1133 | 1161 |
| 4 | 2.3.1 | Alcatel-Lucent (Nokia) | Confirmed | Public Corp | 2009 | | | | | | | | | | 255 | 182 | 176 | 148 | 106 | 67 | 61 | – |
| 5 | 2.4 | Interdigital | Confirmed | Public Corp | 2004 | | | | | 103 | 144 | 474 | 231 | 217 | 288 | 370 | 295 | 661 | 264 | 405 | 432 | 655 |
| 6 | 2.5 | Microsoft | Documented | Public Corp | 2009 | | | | | | | | | | – | – | 226 | 513 | 1713 | 2535 | 1135 | 828 |
| 7 | 3.1 | Philips | Approximated | Public Corp | 2015 | | | | | | | | | | | | | | | | 178 | 178 |
| 8 | 3.2 | ATT 802.11 | Approximated | Public Corp | 2009 | | | | | | | | | | – | – | – | – | – | – | – | 13 |
| 9 | 3.3 | ATT MPEG4 | Approximated | Public Corp | 2012 | | | | | | | | | | | | | 17 | 17 | 17 | 17 | 23 |
| 10 | 3.4 | Broadcom | Researched | Public Corp | 2007 | | | | | | | | 37 | 174 | 219 | 228 | 229 | 244 | 144 | 137 | 245 | 382 |
| 11 | 3.5 | Xperi | Approximated | Public Corp | 2007 | | | | | | | | 48 | 63 | 80 | 79 | 64 | 58 | 45 | 76 | 76 | 72 |
| 12 | 3.6 | Rambus | Approximated | Public Corp | 2007 | | | | | | | | 51 | 42 | 36 | 106 | 99 | 76 | 90 | 79 | 96 | 113 |
| 13 | 3.7 | Acacia Technologies | Approximated | Public Corp | 2007 | | | | | | | | 53 | 48 | 67 | 132 | 176 | 210 | 121 | 131 | 125 | 153 |
| 14 | 3.8 | Quarterhill | Approximated | Public Corp | 2007 | | | | | | | | 103 | 98 | 88 | 88 | 105 | 46 | 35 | 27 | 61 | 27 |
| 15 | 3.9 | ParkerVision | Confirmed | Public Corp | 2005 | | | | | | – | – | – | – | – | – | – | – | – | – | – | 4 |
| 16 | 3.10 | Unwired Planet | Confirmed | Public Corp | 2009 | | | | | | | | | | – | – | 4 | 15 | 0 | 36 | 5 | 28 |
| 17 | 3.11 | VirnetX | Confirmed | Public Corp | 2007 | | | | | | | | – | – | – | – | – | – | 2 | 1 | 2 | 2 |
| 18 | 3.12 | Marathon Patent Group | Approximated | Public Corp | 2013 | | | | | | | | | | | | | | – | – | – | – |
| 19 | 3.13 | IBM | Approximated | Public Corp | 2007 | | | | | | | | 127 | 163 | 150 | 129 | 130 | 144 | 126 | 103 | 105 | 354 |
| 20 | 3.14 | Tivo | Approximated | Public Corp | 2013 | | | | | | | | | | | | | | – | 1 | 1 | 4 |
| 21 | 3.15 | Technicolor | Approximated | Public Corp | 2007 | | | | | | | | – | – | – | – | 3 | 20 | 37 | 55 | 88 | 64 |
| 22 | 3.16 | Blackberry | Approximated | Public Corp | 2015 | | | | | | | | | | | | | | | | 123 | 35 |
| 23 | 4.1 | Via Licensing AAC | Documented | Pool | 2007 | | | | | | | | 119 | 61 | 111 | 118 | 159 | 174 | 166 | 145 | 135 | 120 |
| 24 | 4.2 | Via Licensing LTE | Approximated | Pool | 2015 | | | | | | | | | | | | | | | | – | – |
| 25 | 4.3 | MPEGLA MPEG4 | Documented | Pool | 2007 | | | | | | | | 53 | 52 | 52 | 67 | 82 | 91 | 109 | 106 | 111 | 111 |
| 26 | 4.4 | MPEGLA AVC H.264 | Documented | Pool | 2007 | | | | | | | | 29 | 31 | 33 | 41 | 52 | 55 | 63 | 64 | 66 | 68 |
| 27 | 4.5 | SISVEL LTE | Researched | Pool | 2015 | | | | | | | | | | | | | | | | – | – |
| 28 | 4.6 | SISVEL WiFi | Researched | Pool | 2015 | | | | | | | | | | | | | | | | – | – |
| 29 | 4.7 | Via Licensing WCDMA | Researched | Pool | 2015 | | | | | | | | | | | | | | | | 87 | 87 |
| 30 | 4.8 | Vectis WiFi | Researched | Pool | 2015 | | | | | | | | | | | | | | | | – | – |
| 31 | 4.9 | MPEGLA HEVC | Documented | Pool | 2016 | | | | | | | | | | | | | | | | | 50 |
| 32 | 4.1 | HEVC Advance | Documented | Pool | 2016 | | | | | | | | | | | | | | | | | 30 |
| 33 | 4.11 | Velos Media HEVC | Researched | Pool | 2017 | | | | | | | | | | | | | | | | | – |
| 34 | 5.1 | SISVEL Wireless | Researched | Private Corp | 2015 | | | | | | | | | | | | | | | | – | – |
| 35 | 5.2 | IPCom | Researched | Private Corp | 2015 | | | | | | | | | | | | | | | | – | – |
| 36 | 5.3 | PanOptis-Optis | Researched | Private Corp | 2015 | | | | | | | | | | | | | | | | 2 | 2 |
| 37 | 5.4 | IP Bridge | Researched | Private Corp | 2015 | | | | | | | | | | | | | | | | – | – |
| 38 | 5.5 | Intellectual Ventures | Researched | Private Corp | 2000 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 231 | 95 | 95 | 95 | 108 | 108 | 108 |
| 39 | 5.6 | Huawei | Approximated | Private Corp | 2013 | | | | | | | | | | | | | | 264 | 405 | 432 | 655 |
| 40 | 5.7 | Conversant IP | Researched | Private Corp | 2007 | | | | | | | | 17 | 19 | 23 | 24 | 26 | 26 | 27 | 29 | 34 | 35 |
| | | | | Total | Firms | 2 | 2 | 2 | 2 | 4 | 5 | 5 | 16 | 16 | 20 | 21 | 21 | 22 | 26 | 26 | 37 | 39 |
| | | | | Total | Royalties | 748 | 825 | 890 | 1043 | 1817 | 2543 | 3702 | 4705 | 6003 | 6819 | 7372 | 10,425 | 11,398 | 13,300 | 14,364 | 14,506 | 14,192 |

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