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"A NEW DATASET ON MOBILE PHONE PATENT LICENSE ROYALTIES"

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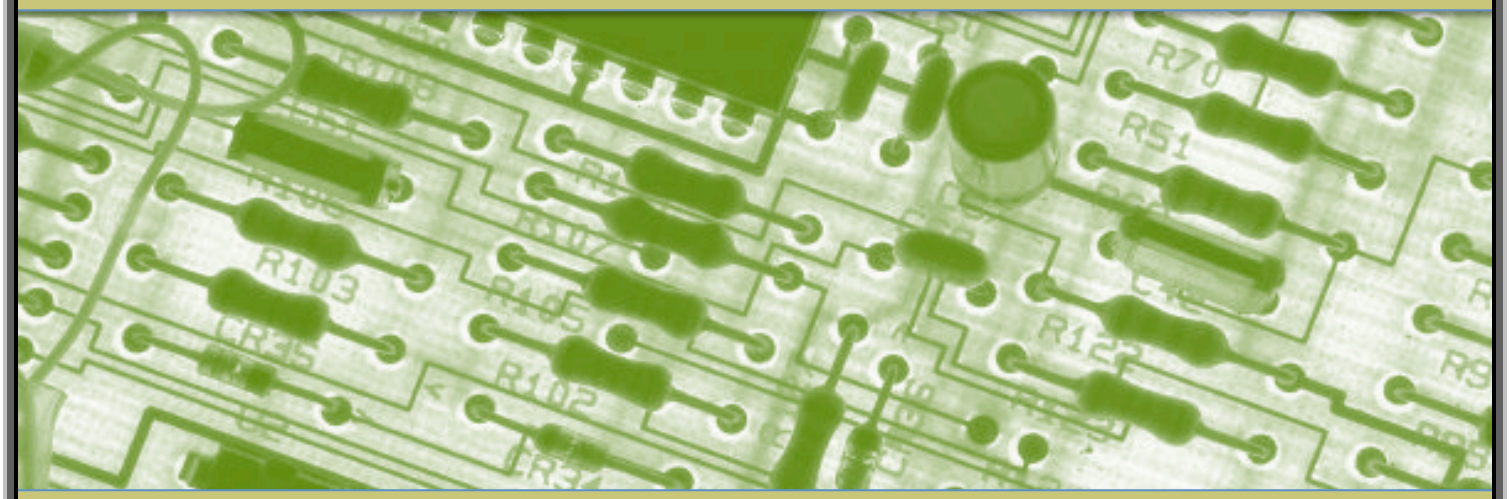

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A New Dataset on Mobile Phone Patent License Royalties[1]
August 2017 Update[2]

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[1] We thank Jonathan Barnett, Anne Layne-Farrar, Tim Long, Keith Mallinson, Jorge Padilla and others who wished to remain anonymous but provided important perspective and helpful comments. Jordan Horrillo provided excellent research assistance.

[2] This note updates the September 2016 release of our database, which now incorporates the full calendar year 2016. We have also widened coverage whenever feasible and improved and completed some estimates of previous years. A detailed description of the changes is in tab *2017 Improvements* in the Excel workbook that accompanies this note.

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His current research focuses on standard essential patents, competition policy and antitrust. Galetovic has been a Research Scholar at the International Monetary Fund, a Tinker Visiting Professor at Stanford and a Rita-Ricardo National Fellow at the Hoover Institution. ***Stephen Haber*** is 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 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, 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.

1. Introduction

Mobile phones integrate a wide array of technologies, from computing to consumer electronics to communications, and from semiconductors to hardware, software and services. This makes them for a large and broad array of patents and licensors. In addition, mobile phones rely on technological standards to make them interoperable. A standard-compliant phone uses hundreds, if not thousands of standard essential patents (SEPs), which are owned by many different patent holders.[4]

While some have claimed that dispersed ownership of SEPs leads to high cumulative royalty rates, the estimates that underpin these claims are based on the simple addition of published handset royalty rates. There are a variety of reasons to be dubious of this method, not the least of which is that it conflates "rack rates" which might not be paid by anybody, with actual market transaction rates. Indeed, just as firms have incentives to declare all possible patents as essential, they also have incentives to post high royalty rates to license their portfolio, even if they never actually earn any licensing revenue from that portfolio.[5]

This note describes the dataset we used to estimate the Average Cumulative Royalty Yield paid in the mobile phone value chain— the sum total of patent royalty

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[4] It is estimated 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. Galetovic and Gupta report that in 2013 there were 128 SEP holders. "Royalty Stacking and Standard Essential Patents: Theory and Evidence from the Mobile Wireless Industry," Hoover IP2 Working Paper 15012, 2017.
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% or more. Others think that few SEPs would pass a legal test of essentiality.

[5] At one point in time it became common for the major equipment vendors to publish a declared LTE royalty rate, usually with caveats that it could be adjusted in light of grant backs or for other reasons. For example, Nortel declared a 1% rate, but it appears to have never actually received any LTE licensing revenue.

payments earned by licensors, divided by the total value of mobile phones shipped.[6] We published the first version of this dataset in September 2016. This version improves our estimate in several dimensions.[7]

As in the first version, we build upon earlier work by Mallinson that focused on mobile SEPs.[8] But we go beyond that work by: (i) analyzing patent royalties in the entire mobile phone value chain (i.,e, royalties on mobile SEPs, but also audio and video codecs, imaging, operating systems, semiconductors, and other components); (ii) comparing our results on patent royalties to other costs of mobile phone manufacture and to OEM profits; (iii) generating time series that permit researchers to analyze the stability of the Average Cumulative Royalty Yield back to 2007. For some firms, our coverage goes back to 2000.

Our purpose is to provide as comprehensive and transparent a data source as is practically possible for use by other researchers, industry practitioners, and government officials. Thus, this note should be read as an adjunct to the Excel workbook that we have posted to the web. That workbook shows the underlying data and sources. It also explains the decisions we made when estimating or approximating values.

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[6] Following Mallinson, we use the term royalty "yield" rather than royalty "rate." "Rate" refers to the actual royalty paid by a licensee, typically an OEM or EMs, 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 OEMs that evade patent licenses. Some researchers refer to royalty yield as the "royalty stack," a term we eschew because it is theory-laden and an oxymoron.

[7] We describe the main changes and improvements in *Tab 2017 Improvements* in the Excel workbook.

[8] See Keith Mallinson, "Cumulative Mobile-SEP Royalty Payments No More than Around 5 percent of Mobile Handset Revenues," IP Finance, August 19, 2015. J. Gregory Sidak builds upon Mallinson as well, but takes a somewhat different theoretical approach, including payments in kind and estimates of the value of cross-licenses. Thus, it is a study of potential IP value, rather than the cumulative royalty yield. See J. Gregory Sidak, "What Aggregate Royalty Do Manufacturers of Mobile Phones Pay to License Standard-Essential Patents?" *Criterion Journal on Innovation* **1** (701). An early estimate of royalties paid by licensors is Eric Stasik, "Royalty Rates and Licensing Strategies for Essential Patents on LTE (4G) Telecommunications Standards," Les Nouvelles, September 2010, pp. 114-119.

In this note we do not take a position on whether the estimates of the royalty yield we present in this study are "too high," "too low," or "just right." That is an important debate, but it can only be joined on the basis of evidence.

2. Methods—"Follow the Money"

All methods of analysis depend on an underlying theory, and underlying theories are created in order to answer particular questions of interest. The basic question researchers are asking in this case is how do royalties paid by firms in the mobile phone value chain affect production and decisions at the margin? That is, if royalty rates were X percent points higher, by how much would output fall and prices increase? If they were X' percent points lower, by how much would output rise and prices fall? Microeconomic theory provides a guide to the relevant facts necessary to answer this question; it tells us that we need to approximate paid per-unit royalties.[9]

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 and the value of the payments to each of those licensors. It would then be possible to determine the "IP Bill of Materials (BoM)" paid by each firm in the in the mobile phone value chain. From there, one could calculate a weighted average BoM for every firm in the value chain, with the weights determined by their relative contribution to total mobile phone sales.

[9] One might claim that this approach to data ignores other economic costs borne by manufacturers. For example, we do not include the opportunity cost borne by a manufacturer that buys patents to prevent claims of infringement, or the opportunity cost borne by manufacturers who cross license their patents (in a cross licensing agreement firms may forego some or any royalty payment in exchange for access to another firm's portfolio), or the membership subscriptions paid to defensive aggregators of patents. Such expenditures will increase a firm's fixed costs. They will not, however, affect marginal costs of production, and thus do not affect production and pricing decisions at the margin.

Nevertheless, researchers can never work with the ideal data, and the data on mobile phone patent licenses are not an exception to this rule. The fundamental problem is that licensees have very weak incentives to disclose their patent license royalty payments 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 licensors have strong incentives to disclose their patent licensing 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 the total cost of patent licenses 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.

Therefore, 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 earned by each licensor; (ii) the total number of mobile phones sold; (iii) the average selling (wholesale) price of a mobile phone (ASP).

2A. Estimating the Size of the Market

The number of phones sold and the ASP are easy to come by: a number of data analytics firms estimate them, 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 would not be sensitive to which source is used.[10] These same firms also produce estimates of the quantity and value of tablets. We do not include these in these calculations. If we would include tablets, it would increase the value of device sales, and thus drive down the Average Cumulative Royalty Yield.

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.[11] We use this data in order to estimate the revenues earned by patent pools, which tend to have tiered royalty schedules.

2B. 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. SEC forms 10k and 20-f). Private firms are not obligated 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. Estimating royalty revenue with this information is practical, although it often tends to overestimate royalties. However, that is consistent with our chosen bias, and so we expect it.[12]

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.

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

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

[12] For the data, see *Tab 1.7, Revenues by Licensor,* in the Excel workbook.

They therefore do not break out this revenue as a reportable segment in their public filings. There are also private firms, and these are not obligated to disclose their revenue sources. When it is practicable, we estimate the revenues of both types of firms on the basis of information on their websites, reports in the trade and financial press, and interviews with industry practitioners.[13] When not practicable, we enumerate those firms that may have generated royalty revenue, but for which we have neither data nor a plausible estimate.[14] 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 see robustness of our results.[15] That sensitivity analysis shows that even an upper bound estimate of the cumulative mobile phone patent licensing revenues of these firms would not have a significant effect on the results: if the mobile phone patent licensing revenues for these firms as a group were $2 billion, the Average Cumulative Royalty Yield would increase by roughly 0.5 percentage points.

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. We capture, as well, the revenues of a major software company that earns revenue from its patents that read on the most popular mobile phone operating system.

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[13] For the data, see *Tab 1.7, Revenues by Licensor,* in the Excel workbook.

[14] For the list of firms, see *Tab 6.0, Other Firms,* in the Excel workbook.

[15] See, *Tab 1.6 Sensitivity,* table for mobile phones, in the Excel workbook.

2C. Basic Principles of Data Collection

In following the money we are guided by four 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. Indeed, we invite users of the data in the Excel workbook that accompanies this document to share information with us so that we can improve our estimates. 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 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 their revenues from other products as royalties on mobile phones; (ii) attributing royalties to mobile phones 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; (iv) biasing estimates upwards.[16]

3. 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.[17]

As 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

[16] 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.

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

document that was generated as a legal requirement. Qualcomm, Interdigital, Nokia, and Ericsson, are examples of these licensors. Given the high quality and accountability, 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 revenues.

Other licensors provide sufficient information in publicly available documents to estimate their licensing revenues. In some cases we have to separate licensing revenues from mobile phones from other licensing revenues, based on information in footnotes to SEC 10k's. In other cases, we have licensing fee schedules and the identities of the licensees, and can estimate the licensing revenues of each licensee. 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.[18] We denote these as "Researched." In 2016 this category accounted for 4.3 percent of total royalty revenue.

[18] 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.

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.

4. Results

4.A The 2016 Update

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. We estimate that the 39 licensors as a group had cumulative royalties in 2016 of almost $14.2 billion (see Table 2).[19] Of these 39, 10 have licensing revenues of effectively zero. In 2016 Royalty revenues of the remaining 29 firms vary between $1.6 million and $7.7 billion.

One way to put these numbers into perspective is 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.[20] It follows that the ASP was $215.5, and that the

[19] For the data by licensor, see *Tab 1.7, Revenues by Licensor*, in the Excel workbook.

[20] According to IDC. For the data, see *Tab 1.8, Device Sales*, in the Excel workbook.

Average Cumulative Royalty per phone was $7.2. The Average Cumulative Royalty Yield is total patent royalties divided by the value of total phone shipments, or 3.3 percent.[21]

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. By 2007, we have data for 17 licensors, which accounted for 78.2 percent of all royalty revenues in 2016. By 2009, we have data on 22 firms, and these accounted for 92.5 percent of all royalty revenues in 2016[22]. As Figure 1 shows, both of those series are remarkably stable. The 2009-2016 series, for example, hovers at around 3 percent, falling only marginally during the last three years.[23]

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. Figure 2 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.[24]

4.B. 2016 and 2015 Compared

As can be seen comparing Figures 2 and 3, the Average Cumulative Royalty Yield it is still 3.3 percent---it did not vary between 2015 and 2016. Nevertheless, the share of manufacturers' profits in the average selling price of a phone fell from 14.9 percent to 11.8 percent, and semiconductor costs (baseband processors and other semiconductors) rose

[21] For the calculations, see *Tab 1.3, Royalty Yield Summary*, in the Excel workbook.

[22] Some of these firms do not report any revenues.

[23] For the data, see *Tab 1.4, Royalty Yield Series,* in the Excel workbook.

[24] For the data and sources, see *Tab 1.5, Economic Analysis*, in the Excel workbook.

from 19.1 percent to 25.1 percent. Last, the share of other costs fell from 62.6 percent to 59.8 percent.

Tables 2 and 3 decompose the cumulative royalty yield by quality of data and type of licensor in 2015 and 2016. While the total cumulative yield fell from $14.5 billion in 2015 to $14.2 billion in 2016, the composition barely changed.[25] At the same time, the royalty yields of some individual licensors varied a lot from 2015 to 2016. For example, Ericson's royalty yield fell by $536 million, from $1,701 million in 2015 to $1,165 million in 2016. Interdigital's royalty yield, by contrast, rose by $223 million, from $432 million in 2015 to $655 million in 2016.

5. Sensitivity Analysis

Our results do not seem to be sensitive to how one treats the data. For example, what would happen if we assume that only smartphones paid royalties and all feature phones paid no royalties at all? Then 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 $9.60 and the Average Cumulative Royalty Yield would rise from 3.3 percent to 3.4 percent.[26]

What would happen if we imputed the royalties of firms that we know earn some licensing revenues, but that do not provide enough information for us to estimate those revenues on a firm-by-firm basis? As Table 4 shows, the results would be a modest

[25] The numbers reported in Table 3 are slightly different of what we reported about 2015 in our September 2016 release of the data base. The reason is that in this update we have corrected some of our initial estimates for 2015 and added patent holders into the data base.

[26] See *Tab 1.3 Royalty Yield Summary*, in the Excel workbook.

increase in the Average Cumulative Royalty Yield of smartphones.[27] For example, if we assume that these firms as a group earned $1 billion in licensing revenues in 2016, which would be a generous assumption, then the royalty yield on a smartphone would increase from 3.4 percent to 3.7 percent (see the first row in Table 4). If we make the extremely generous assumption that the combined royalties of these firms came to $2 billion, then the cumulative average royalty yield would still only be 3.9 percent.

What happens if we relax the assumption that every smartphone shipped in 2016 paid licensing royalties? What if it was the case that some OEMs evaded licenses, such that the $14.2 billion is actually spread across fewer than 1,473 million smartphones? As a first step, we find determine an upper-bound evasion rate, which we put at 30 percent.[28] We then calculate the Average Cumulative Royalty Yield assuming that only 70 percent of smartphones paid licensing royalties. The last row in Table 4 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.

What if we pushed harder still, and made three strong assumptions: all royalties are earned on smartphones; the evasion rate is 30 percent; and the royalties firms in the "Other" un-enumerated category in 2016 equaled $2 billion? How high could we push the estimate of the Average Cumulative Royalty Yield? As Table 4 shows, the answer is 5.6 percent.

6. Concluding Remarks

[27] See *Tab 1.6, Sensitivity*, in the Excel workbook.

[28] For a discussion of how we estimated that upper-bound evasion rate, see the footnote in *Tab 1.6, Sensitivity*, in the Excel workbook.

A crucial input to any academic inquiry, policy debate, or industry study is the facts, dispassionately gathered. Our purpose in creating the dataset we outline in this note is to do that. The information in this dataset is therefore not meant as a judgment of any sort upon the merits or effectiveness of any entity or its operations. We invite users of this dataset to share their ideas, suggestions, and corrections with us so that they may be included in future versions. As we have done with the first version of this data set, we would like to improve upon these estimates by making corrections when we have erred and to obtain superior data sources when they exist. We will be the first to seek improvement in our third edition, and hope to benefit from the support of others. Perhaps with ongoing cooperation within the community over time we may all gain greater clarity as to the functioning of individual firms and the industry.

Table 1: Types of Licensors Classified by Type and the Quality of Their Data

	Confirmed	Documented	Approximated	Researched	Other identified firms
Public corporation	***Qualcomm (2.1)*** ***Ericsson (2.2)*** ***Nokia (2.3) (incl. Alcatel-Lucent, 2.3.1)***[1] ***Interdigital (2.4)*** **Parker Vision (3.9)** **Unwired Planet (3.10)**[2] **VirnetX (3.11)**	***Microsoft (2.5)***	**Philips (3.1)**[3] **Xperi (3.5)**[4] **Rambus (3.6)** **Acacia Technologies (3.7)** **Quarterhill (3.8)**[5] **Marathon Patent Group (3.12)** **IBM (3.13)**** **Tivo (3.14)**** **Technicolor (3.15)**** **Blackberry (3.16)****	**AT&T 802.11 (3.2)** **AT&T MPEG4 (3.3)** **Broadcom (3.4)**	Apple (6.0) Google (6.0) Infineon (6.0) Samsung Electronics (6.0) Siemens (6.0) Texas Instruments (6.0) Sony Corp (6.0) LG Electronics (6.0)
Private corporation			***Huawei (5.6)***	**SISVEL Wireless (5.1)** **IP Com (5.2)**[7] **PanOptis-Optis (5.3)**[2] **IP Bridge (5.4)** **Intellectual Ventures (5.5)** **Conversant (5.7)**[8]	Form Holdings(6.0)[11] France Brevets (6.0)[12] ETRI (6.0)[13] ITRI (6.0)[14] Longitude Licensing (6.0)[15] Mobile Media Ideas (6.0) Rockstar (6.0) VoiceAge (6.0) Round Rock (6.0)
Patent pool		**Via Licensing AAC (4.1)** **MPEGLA MPEG4 (4.3)** **MPEGLA AVC H.264 (4.4)** **MPEGLA HEVC (4.9)**** **HEVC Advance (4.10)****	**Via Licensing LTE (4.2)**[6]	**SISVEL LTE (4.5)** **SISVEL WiFi (4.6)** **Via Licensing WCDMA (4.7)**[9] **Vectis WiFi (4.8)**[10] **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.* ** Added in the 2017 update.

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

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 WiFi 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.

Table 2: Cumulative Royalty Yield Classified by the Quality of the Data (in 2016)

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

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

Table 3: Cumulative Royalty Yield Classified by Quality of Data (in 2015)

	Type 1 Public company	*Type 2 Private company*	*Type 3 Patent Pools*	*Total*
Confirmed	$11,280,132,214 (73.6%)	-	-	$11,280,132,214 (73.6%)
Documented	$1,134,500,000 (5.7%)	-	$311.408.407 (2.6%)	$1.445.908.407 (8.3%)
Approximated	$871,263,710 (7,1%)	$432,488,000 (4.5%)	-	$1,303,751,710 (11.7%)
Researched	$245,000,000 (2.6%)	$144,461,024 (1.0%)	$86,982,900 (0.6%)	$476,443,924 (4.2%)
Total	$13,530,895,924 (89.1%)	$576,949,024 (5.5%)	$392,183,807 (3.2%)	$14.506.236.255 (100%)

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

Table 4: 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	$1,000	$ 1,500	$ 2,000
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.

Figure 1: Patent Royalties as % of Value of Mobile (Smart and Feature) Phones Shipped, 2007-2016

Figure 2: Breakdown of the average selling wholesale price of a mobile phone (in 2016)

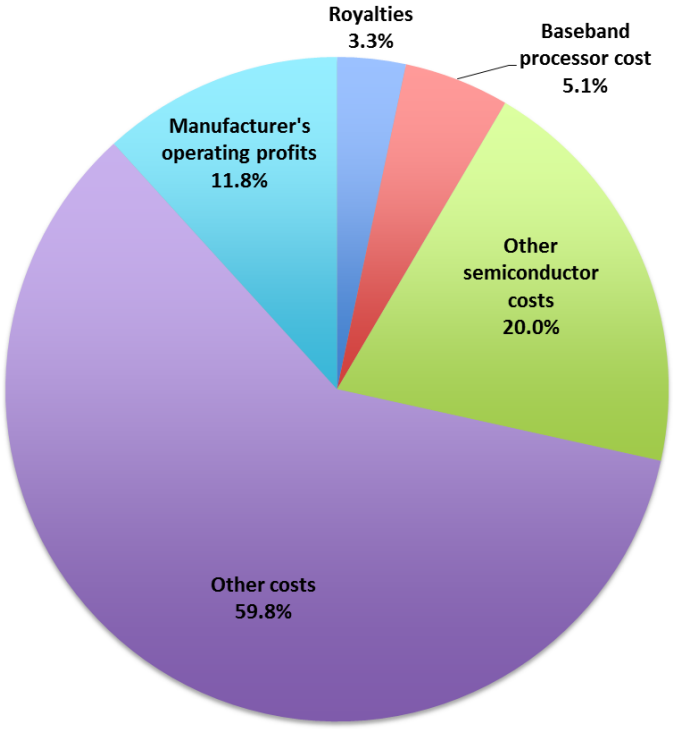

Figure 3: Breakdown of the average selling (wholesale) price of a mobile phone (in 2015)