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What Aggregate Royalty Do Manufacturers of Mobile Phones Pay to License Standard-Essential Patents?

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For a decade or more, proponents of the royalty-stacking conjecture have claimed that, when an end-user product (such as the smartphone) incorporates multiple standard-essential patents (SEPs), the aggregate SEP royalty might be so high as to make it infeasible for manufacturers to make a standard-compliant product.[1] A decade's worth of royalty-stacking claims in the academic literature and in patent-infringement litigation begs this question: what is the aggregate royalty actually paid for SEPs used in standard-compliant products—specifically, smartphones?

In 2015, Keith Mallinson, an engineering consultant in the mobile telecommunications industry, supplied an elegantly simple answer. He estimated the total monetary burden that royalties for mobile communications SEPs actually impose on manufacturers of mobile handsets and then compared that aggregate royalty to total global handset revenues for 2014.[2] Mallinson found that the aggregate royalty for 2G, 3G, and 4G SEPs was approximately 5 percent of global handset revenues.

I replicate Mallinson's important study. I am able to confirm his results with publicly available data and my own analysis of a dataset on mobile handset sales in 2013 and 2014. In this article, I first explain Mallinson's methodology. I then separately examine the revenues of major SEP owners, patent pools, large implementers of SEPs, and patent-assertion entities (PAEs). I show that, even using large assumed values for balancing payments

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1 Mark A. Lemley & Carl Shapiro, *Patent Holdup and Royalty Stacking*, 85 TEX. L. REV. 1991, 1993 (2007).

2 Keith Mallinson, *Cumulative Mobile-SEP Royalty Payments No More Than Around 5% of Mobile Handset Revenues*, WISEHARBOR (2015), http://www.wiseharbor.com/pdfs/Mallinson%200n%20cumulative%20mobile%20SEP%20royalties%20for%20IP%20Finance%202015Aug19.pdf.

in cross licenses, the aggregate SEP royalty that implementers paid in 2013 and 2014 was between 4 and 5 percent of global handset revenues for handsets practicing the 3G and 4G standards.

I. Mallinson's Methodology

To estimate the aggregate royalties that implementers paid for mobile communications SEPs, Mallinson divided SEP licensors into three groups: (1) major mobile communications SEP holders with licensing programs, (2) patent pools, and (3) other SEP holders. The first group consists of Alcatel-Lucent, Ericsson, Nokia, InterDigital, and Qualcomm.[3] The second group consists of patent pools SIPRO (for the 3G WCDMA standard), Via Licensing (for the 4G LTE standard), and Sisvel (for the 4G LTE standard).[4] The third group consists of SEP holders such as defensive cross licensors, PAEs, and other nonpracticing entities (NPEs).[5] The subcategory of defensive cross licensors includes SEP holders such as Samsung and Huawei.[6] Mallinson did not include companies with large SEPs portfolios like Samsung and Huawei in his first category of major mobile SEP holders with licensing programs because, in his view, those companies are standards implementers that are "inevitably unable to extract large total licensing fees because they have the overriding priority of protecting their downstream devices businesses—in product design, manufacture, and sales—from patent infringement challenges."[7] Consequently, he argues, those companies cross license their SEPs rather than maximize patent revenues from cash payments.[8] Mallinson also includes Apple in the third group of SEP holders because, being similarly situated to an implementer, Apple cannot easily extract large monetary payments in patent fees from its licensees.[9]

Mallinson's methodology is to determine the amount of royalties that each group of mobile communications SEP holders collects in a given year, and then to divide that number by total global handset revenues for that year. This fraction represents what Mallinson calls the "royalty yield" for a given group of SEP licensors.

However, it is difficult to calculate precisely the amount of royalties that the third group earns by licensing its SEPs.[10] Consequently, Mallinson says that he "logically and also conservatively estimate[s]" royalties for the third

[3] Mallinson, *supra* note 2, at 1.
[4] *Id.*
[5] *Id.* at 6–8.
[6] *Id.* at 1, 6.
[7] *Id.* at 6.
[8] *Id.*
[9] *Id.*
[10] *Id.* at 6–8.

group of SEP holders to be less than $6 billion per year.[11] In lieu of using Mallinson's estimate of less than $6 billion, I construct my own empirical model to estimate how much this third group receives in licensing revenues.

II. Major Mobile Communications SEP Holders with Licensing Programs

I begin by compiling the royalty amounts that Alcatel-Lucent, Ericsson, Nokia, InterDigital, and Qualcomm collected in licensing revenues for 2013 and 2014, which is the time frame that Mallinson used for his study.[12] I specifically rely on those five companies' annual reports to calculate the licensing revenues that they earned.[13] Next, I calculate the royalty yield for each company by dividing its licensing revenues by global handset revenues for a given year.[14] It bears emphasis that my estimates—as well as Mallinson's estimates—of licensing revenues for these five companies are conservative (that is, the companies' actual revenues from licensing their mobile communications SEPs are less than Mallinson's and my estimates), because the reported patent-licensing revenues for those five companies "also significantly include licensing for other patents including non-SEPs, SEPs for non-cellular standards including WiFi, video and audio compression, and even non-patent licensing with brands and technology transfer in the case of Nokia, for example."[15] Furthermore, the actual revenues from licensing SEPs (that are essential to mobile communications standards) for those five companies are less than the estimated licensing revenues, because their actual revenues include royalties collected from manufacturers' sales of tablets, PC dongles, and M2M devices in addition to licensing fees collected from manufacturers' sales of handsets.[16] However, to avoid undercounting revenues earned from licensing SEPs, Mallinson and I both divide the estimated licensing revenues by combined global revenues from handset sales, instead of dividing by the

[11] *Id.* at 8.

[12] *Id.* at 6.

[13] *See* Qualcomm, Inc., Annual Report for the Fiscal Year Ended September 27, 2015 (SEC Form 10-K), at 38 (filed Nov. 4, 2015), http://investor.qualcomm.com/secfiling.cfm?filingID=1234452-15-271&CIK=804328 [hereinafter 2015 Qualcomm 10-K]; Ericsson, Ericsson Annual Report 2015, at 63, 74 (2015), http://www.ericsson.com/res/investors/docs/2015/ericsson-annual-report-2015-en.pdf [hereinafter Ericsson Annual Report]; Nokia, Report for Quarter 4 and Full Year 2015, at 21 (2015), http://company.nokia.com/sites/default/files/download/investors/nokia_results_2015_q4.pdf [hereinafter Nokia Report 2015]; Nokia, Nokia in 2014, at 144 (2014), http://company.nokia.com/sites/default/files/download/investors/nokia_uk_ar14_full.pdf [hereinafter Nokia Report 2014]; InterDigital, Inc., Annual Report for the Fiscal Year Ended December 31, 2015 (SEC Form 10-K), at 50, 53 (filed Feb. 18, 2016), http://files.shareholder.com/downloads/IDCC/1801737891x0xS1405495-16-47/1405495/filing.pdf [hereinafter 2015 InterDigital 10-K]; Alcatel-Lucent, Alcatel-Lucent Consolidated Financial Statements at December 31, 2014, at 25 (2015) [hereinafter Alcatel-Lucent Report].

[14] I have obtained data on global handset revenues from International Data Corp., Worldwide Quarterly Mobile Phone Tracker 2014Q3 tab 7 (2014) [hereinafter International Data Corp.].

[15] Mallinson, *supra* note 2, at 4.

[16] *Id.*

combined global revenues from sales of handsets, tablets, PC dongles, and M2M devices.[17] Table 1 reports my estimated licensing revenues for the five major mobile communications SEP holders. I have converted all revenues from 2013 to 2014 dollars.[18]

Table 1. Sidak Estimate of Licensing Revenues for the Five Major Mobile Communications SEP Holders

	2013		2014	
	Licensing Revenues and Global Handset Revenues (Millions of 2014 Dollars)	Royalty Yield	Licensing Revenues and Global Handset Revenues (Millions of 2014 Dollars)	Royalty Yield
Qualcomm	$8,019	2.08%	$7,862	2.04%
Ericsson	$1,649	0.43%	$1,446	0.38%
Nokia	$405	0.11%	$435	0.11%
InterDigital	$269	0.07%	$403	0.10%
Alcatel-Lucent	$31	0.01%	$17	0.00%
Total	$10,374	2.70%	$10,163	2.64%
Global Handset Revenues	$384,659		$384,956	

Source: International Data Corp., *supra* note 14; 2015 Qualcomm 10-K, *supra* note 13, at 38; Ericsson Annual Report, *supra* note 13, at 63, 74; Nokia Report 2015, *supra* note 13, at 21; Nokia Report 2014, *supra* note 13, at 144; 2015 InterDigital 10-K, *supra* note 13, at 50, 53; Alcatel-Lucent Report, *supra* note 13, at 25; Bureau of Economic Analysis, *supra* note 18.

Thus, I estimate the aggregate royalty yield for the five major mobile communications SEP holders to be 2.70 percent in 2013 and 2.64 percent in 2014. For reference, Table 2 reports Mallinson's estimated licensing revenues for the five major mobile communications SEP holders.

[17] *Id.*

[18] *Table 1.1.9. Implicit Price Deflators for Gross Domestic Product*, Bureau of Economic Analysis, http://bea.gov/iTable/iTable.cfm?reqid=9&step=3&isuri=1&903=13#reqid=9&step=3&isuri=1&904=1929&903=13&906=a&905=2015&910=x&911=1.

Table 2. Mallinson Estimate of Licensing Revenues for the Five Major Mobile Communications SEP Holders

	2013		2014	
	Licensing Revenues and Global Handset Revenues (Millions)	Royalty Yield	Licensing Revenues and Global Handset Revenues (Millions)	Royalty Yield
Qualcomm	$7,878	2.09%	$7,862	1.92%
Ericsson	$1,583	0.42%	$1,480	0.36%
Nokia	$688	0.18%	$791	0.19%
InterDigital	$264	0.07%	$416	0.10%
Alcatel-Lucent	$100	0.03%	$75	0.02%
Total	$10,513	2.79%	$10,625	2.59%
Global Handset Revenues	$377,000		$410,000	

Source: Mallinson, *supra* note 2, at 4–5.
Note: Table 2 preserves Mallinson's estimates in nominal dollars.

III. Patent Pools

Mallinson writes that "[p]atent pools for mobile SEPs collect no more than the equivalent of around 1 percent of total global handset revenues and probably significantly less than this figure."[19] Furthermore, patent pools typically represent licensors who have relatively few mobile communications SEPs.[20] Nevertheless, to derive maximum possible royalty yields from the fees that patent pools publicly post, Mallinson "take[s] market-representative or mid-range tariffs, from the royalty 'rate cards' for the three mobile SEP patent pools."[21] He derives royalty yields from patent pool fees because data on licensing revenues for patent pools are not publicly available.[22] Consequently, Mallinson can rely only on patent pool prices to calculate royalty yields. Thus, he divides the patent pool price by the average selling price of a handset in a given year to calculate the patent pool's royalty yield. He also "applie[s] a market value weighting which reflects the proportion of mobile device market revenues for handset products including 3G WCDMA (the vast majority) and LTE (still in the minority)."[23] The three mobile commu-

[19] Mallinson, *supra* note 2, at 5.
[20] *Id.* (citing Keith Mallinson, *Absurd (F)RAND Licensing-Rate Determinations for SEPs*, IP Finance (Nov. 15, 2013), http://www.ip.finance/2013/11/absurd-frand-licensing-rate.html).
[21] *Id.*
[22] *Id.*
[23] *Id.*

nications SEP pools are SIPRO (for 3G WCDMA), Via Licensing (for LTE), and Sisvel (for LTE).[24] There are no significant patent pools for 2G, 3G CDMA2000, or 3G TD-SCDMA.[25]

To replicate Mallinson's study, I also derive maximum yields from publicly listed patent pool fees. Mallinson is unclear in describing how he takes the market-representative tariffs from the royalty rate cards for the three mobile communications SEP patent pools. Consequently, I use my own methodology, though I follow the same logic that I understand Mallinson to employ.

SIPRO, Via Licensing, and Sisvel charge rates for their patent pools on the basis of how many practicing devices each SEP implementer is producing. For example, Table 3 shows Via Licensing's licensing schedule.

Table 3. Via Licensing's LTE License Fees for General Terminal Products Sold or Otherwise Supplied

Volume (Per Unit/Year)	Per-Unit Fee for Each Licensed Product
For the first 1 to 500,000 units	$3.00
For units 500,001 to 2,500,000	$2.55
For units 2,500,001 to 5,000,000	$2.40
For units 5,000,001 to 10,000,000	$2.25
For units 10,000,001 and higher	$2.10

Source: *LTE License Fees*, Via Licensing, http://www.via-corp.com/licensecontent.aspx?id=1516.

For example, if an implementer produced 10,000,001 licensed LTE products in a calendar year, that implementer would pay to Via $3.00 per product for the first 500,000 products, $2.55 per product for the next 2,000,000 products (2,500,000 – 500,000 = 2,000,000), $2.40 per product for the next 2,500,000 products (5,000,000 – 2,500,000 = 2,500,000), $2.25 per product for the next 5,000,000 products (10,000,000 – 5,000,000 = 5,000,000), and $2.10 per product for the last product (10,000,001 – 10,000,000 = 1). The total royalty for that implementer would be calculated as follows:

($3.00 × 500,000) + ($2.55 × 2,000,000) + ($2.40 × 2,500,000) + ($2.24 ×5,000,000) + ($2.10 × 1) = $23,800,002.10.

Thus, the implementer would pay $23,800,002.10 in total royalties to Via Licensing that year. One can calculate the average patent fee that that imple-

[24] *New Licensing Terms!*, Sipro Lab Telecom, http://www.sipro.com/Licensing-Terms-W-CDMA.html; *LTE License Fees*, Via Licensing, http://www.via-corp.com/licensecontent.aspx?id=1516; *LTE/LTEA License Terms*, Sisvel, http://www.sisvel.com/lte-ltea/license-terms.

[25] Mallinson, *supra* note 2, at 5.

menter pays to Via by dividing that total royalty figure by the number of practicing devices that the implementer produced that year: $23,800,002.10 ÷ 10,000,001 = $2.38. Thus, on average, this hypothetical implementer pays Via a royalty of $2.38 per practicing device.

Suppose that this value of $2.38 is also the average royalty that all implementers pay to Via per practicing device. If there are 500 million units of 4G LTE devices made in a year, then Via would collect $1.19 billion in royalties for that year ($2.38 × 500 million = $1.19 billion). Suppose further that total global handset revenues are $400 billion in that year. Then, Via Licensing's royalty yield would be 0.30 percent ($1.19 billion ÷ $400 billion = 0.30 percent).

Using data from International Data Corporation (IDC),[26] which documents sales and shipments of handsets by company, I repeat those calculations for all three mobile communications SEP pools. IDC lists how many 3G- or 4G-compliant mobile phones each vendor shipped to all distribution channels or directly to end users in a given year (2013 or 2014), which I use as a proxy for the number of 3G- or 4G- compliant products that each manufacturer produced in 2013 and 2014. I calculate the royalty that each manufacturer pays on average to a given patent pool per practicing device, and I then take the average of those royalties, weighted by the number of 3G- or 4G-compliant devices that each vendor is shipping. Next I multiply that average by the total number of 3G- or 4G-compliant practicing devices made in that year to get the total royalty revenues that the patent pool received in that year. I divide those total royalty revenues by the total global handset revenues for that year to derive the patent pool's royalty yield.

However, the IDC database that I have ends with the third quarter of 2014 (that is, although the number of practicing units that each vendor shipped in 2014 is available, that number represents the number of practicing units that each vendor shipped from the first quarter to the third quarter of 2014). Consequently, the data that I have for 2014 are incomplete. To account for this deficiency in the data, I multiply the quantities of mobile devices shipped in 2014 by 4/3, thereby annualizing the 2014 data.

Table 4 reports my results for estimated per-unit royalties charged by patent pools and the implied royalty yield. I have converted all 2013 dollar amounts to 2014 dollars.

[26] International Data Corp., *supra* note 14.

Table 4. Sidak Estimates of Typical Licensing Prices and Royalty Yields for Patent Pools with Fully Compliant Implementers

		2013					2014				
		[A]	[B]	[C] = [A] × [B]	[D]	[E] = [C] ÷ [D]	[A]	[B]	[C] = [A] × [B]	[D]	[E] = [C] ÷ [D]
	Standard	Patent Pool Fee per Device (2014 Dollars)	Total Number of 3G or 4G Compliant Mobile Phones Shipped (Millions)	Total Revenues Received (Millions of 2014 Dollars)	Global Handset Revenues (Millions of 2014 Dollars)	Royalty Yield	Patent Pool Fee per Device (2014 Dollars)	Total Number of 3G or 4G Compliant Mobile Phones Shipped (Millions)	Total Revenues Received (Millions of 2014 Dollars)	Global Handset Revenues (Millions of 2014 Dollars)	Royalty Yield
SIPRO	WCDMA	$1.14	788 (3G)	$896	$384,659	0.23%	$1.00	803 (3G)	$799	$384,956	0.21%
Via Licensing	LTE	$2.25	278 (4G)	$627	$384,659	0.16%	$2.23	445 (4G)	$991	$384,956	0.26%
Sisvel	LTE	$0.73	278 (4G)	$204	$384,659	0.05%	$0.73	445 (4G)	$324	$384,956	0.08%
Total				$1,727	$384,659	0.45%			$2,114	$384,956	0.55%

Source: International Data Corp., *supra* note 14; *New Licensing Terms!*, Sipro Lab Telecom, http://www.sipro.com/Licensing-Terms-W-CDMA.html; *LTE License Fees*, Via Licensing, http://www.via-corp.com/licensecontent.aspx?id=1516; *LTE/LTEA License Terms*, Sisvel, http://www.sisvel.com/lte-ltea/license-terms; Bureau of Economic Analysis, *supra* note 18.

Note: I use the number of 3G- or 4G-compliant mobile phones shipped as a proxy for the number of 3G- or 4G-compliant mobile phones produced. In 2013 dollars, the patent pool fee per device in 2013 was $1.12 for SIPRO, $2.22 for Via Licensing, and $0.72 for Sisvel.

Thus, I estimate the total royalty yield for patent pools to be 0.45 percent in 2013 and 0.55 percent in 2014. These estimated yields, if anything, overestimate the royalty yield for patent pools, because the assumption underlying my estimations (and also Mallinson's) is that all SEP implementers are paying the listed rate-card prices, which is an assumption that Mallinson calls "highly optimistic."[27] Furthermore, Mallinson says that "the WCDMA patent pool is commonly known to have been a very weak performer over many years," and that it is unlikely that the LTE patent pools collect "half of what the royalty yields imply because they have not been in business long enough to assert themselves."[28] For these reasons, the true royalty yield is likely to be lower than what Mallinson and I each estimate. In other words, my results in Table 4, and Mallinson's results (reproduced for comparison in Table 5), assume that all SEP implementers pay the listed rate-card prices.

Table 5. Mallinson Estimates of Typical Licensing Prices and Royalty Yields for Patent Pools with Fully Compliant Implementers

		2013			2014		
	Standard	Patent Pool Fee Per Device	Market Value Weighting	Royalty Yield	Patent Pool Fee per Device	Market Value Weighting	Royalty Yield
SIPRO	WCDMA	$1.00	85%	0.42%	$1.00	90%	0.43%
Via Licensing	LTE	$2.50	25%	0.31%	$2.50	45%	0.54%
Sisvel	LTE	$0.45	25%	0.05%	$0.45	45%	0.10%
Total		$3.95		0.78%	$3.95		1.07%

Source: Mallinson, *supra* note 2, at 6.

Note: Table 5 preserves Mallinson's estimates in nominal dollars. I understand Mallinson's term "market value weighting" to mean the proportion of the market for mobile devices that reads on a given standard. For example, Mallinson estimates that in 2013, 85 percent of products in the market for mobile devices read on the 3G WCDMA standard. Mallinson uses the handset average selling price to calculate each patent pool's royalty yield. He calculates the average selling price to be $204 in 2013 and $209 in 2014. For SIPRO's royalty yield in 2013, for example, Mallinson arrives at his royalty yield of 0.42% by calculating: (85% × 1.00) ÷ $204 = 0.42%. Using Mallinson's reported values, I find that the calculated royalty yield for Sisvel in 2013 is halfway in between 0.05% and 0.06%. However, Mallinson reports that Sisvel's royalty yield in 2013 is 0.05%. Mallinson's reported royalty yield for Sisvel in 2013 could be due to a more precise measurement of market value weighting, average selling price, or patent pool fee per device.

[27] Mallinson, *supra* note 2, at 6.
[28] *Id.*

IV. Deriving the Amount That Defensive Cross Licensors and PAEs Collect in Licensing Revenues

So far, I have estimated the parts of the aggregate SEP royalty collected as licensing revenues by two groups, major SEP holders with licensing programs and patent pools. However, it is difficult to calculate precisely the amount that Mallinson's third group of SEP holders—which includes defensive cross licensors, PAEs, and NPEs—collects in licensing revenues.[29] Consequently, Mallinson writes that he "logically and also conservatively estimate[s]" royalties for that third group to be less than $6 billion per year.[30]

Here, I generate my own econometric estimate of the royalties for large implementers on the basis of publicly available information. To this estimate, I add RPX Corporation's estimate of the licensing revenues that publicly traded PAEs collect per year so as to derive the total estimated royalties that Mallinson's third group of SEP holders receives. I first use an ordinary least squares (OLS) regression to estimate the amount that defensive cross licensors—a group in which Mallinson includes Apple, Huawei, RIM, Samsung, and LG[31]—collect in licensing revenues. I do so by exploiting the correlation between SEP holders' shares of patents declared essential to the 4G LTE standard and the share of 4G revenues that holders of patents essential to the 4G LTE standard collect in licensing revenues. That is, I regress the share of 4G revenues that SEP holders collect in licensing revenues on SEP holders' individual shares of all the patents declared essential to the 4G LTE standard. This technique enables me to find the average amount of additional revenue that a company would expect to receive as its share of patents declared essential to the 4G LTE standard increases. I use the results from this regression to predict how much one would expect a cross-licensor to collect in implicit licensing revenues.[32] I use the share of 4G revenues that SEP holders collect in licensing revenues (in 2013 or 2014) as the dependent variable and SEP holders' shares of patents declared essential to the 4G LTE standard as the independent or predictor variable. Each observation in my regression is a separate SEP holder (in 2013 or 2014). I estimate the share of 4G revenues (but not the share of 3G revenues) that SEP holders collect because data on SEP holders' shares of patents declared essential to the 3G standard are unavailable.

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[29] *Id.* at 6.

[30] *Id.* at 8.

[31] *Id.* at 6–7.

[32] For similar regression analysis used to analyze the relationship between LTE patent share and requested royalty rates per patent, see Peter Quies, Valuing Standard Essential Patents: An Examination of Announced FRAND Royalty Rates for LTE (Dec. 2012), http://www.americanbar.org/content/dam/aba/publications/litigation_committees/intellectual/012413-valuing-standard-essential-patents-memo.authcheckdam.pdf. Quies' analysis, like mine, uses the share of patents contributed to the LTE standard as a proxy for how much SEP holders are receiving in licensing royalties.

A. Estimating the Implicit Revenues of Large Implementers

In 2013, the Cyber Creative Institute detailed the number of patents (on a patent-family basis) declared essential to the 4G LTE standard by each patent holder.[33] Although I use the Cyber Creative Institute's dataset on declared essential patents by patent holder, this dataset is imperfect in the sense that not every declared essential patent (even on a patent-family basis) is likely to be actually essential to the 4G LTE standard.[34] For my analysis, I assume that the proportions of SEPs contributed to the 4G LTE standard by patent holder would remain the same in 2014—that is, if a report issued in 2013 listed patent holder *A* as contributing 5 percent of SEPs to the 4G LTE standard, I assume that a report issued in 2014 would still list patent holder *A* as contributing 5 percent of SEPs to the 4G LTE standard. Put differently, I assume that the shares of SEPs contributed to the 4G LTE standard remain constant from 2013 to 2014. This assumption is justified because the composition of the universe of patents essential to practice a given standard does not change drastically from one year to the next.

I find that the shares of 4G revenues that SEP holders received in 2013 and 2014 are not normally distributed. Consequently, I find that a log-log regression best fits the data, relative to other regression models. Figure 1 plots the linear relationship between the log of the shares of 4G revenues received in 2013 and 2014 and the log of the shares of patents contributed to the 4G LTE standard. I use the log of the shares of 4G revenues received by the five major SEP holders with licensing programs whose licensing revenues I derived in Part I. I derive the share of 4G revenues that those five companies receive by dividing my estimated licensing revenues for those five companies by global 4G revenues, which I estimate to be $175.3 billion in 2013 and $224.0 billion in 2014.[35] If these licensors are better able to exploit the value of their patent portfolio than other licensees, the relationship between portfolio share and revenues that I estimate will tend to overestimate the revenues earned by other patent holders. I have converted all 2013 dollar amounts to 2014 dollars.[36]

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33 Cyber Creative Institute Co. Ltd., Evaluation of LTE Essential Patents Declared to ETSI 6 fig.1 (3d ed. 2013) [hereinafter Cyber Creative Institute], http://www.cybersoken.com/file/lte03EN.pdf.

34 *See, e.g.*, *id.* at 16 ("Because patent declarations to ETSI are done voluntarily by each company, no indications are made whether they are really essential and conforming to standards or they are supplementary in the sense that they simply facilitate implementations. Furthermore, the criteria to decide whether a particular patent is essential or not are up to each company, and the decision is made based on the company's own IPR strategy, to make the most of its IPR assets. In addition, ETSI does not evaluate the relevance of the declared patents to the standards."); *see also* J. Gregory Sidak, *The Meaning of FRAND, Part I: Royalties*, 9 J. Competition L. & Econ. 931, 958–59 (2013) (explaining why patent holders might have incentives to overdeclare patents as essential to a standard).

35 International Data Corp., *supra* note 14.

36 Bureau of Economic Analysis, *supra* note 18.

Figure 1. Linear Relationship Between the Log of the Share of 4G Revenues Received and the Log of the Share of Patents Contributed to the 4G LTE Standard, 2013 and 2014

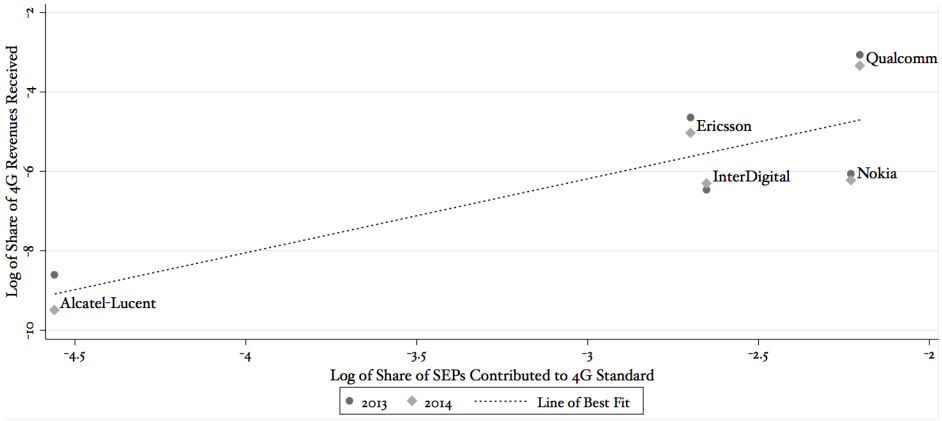

Figure 1 shows a clear positive relationship between the log of a firm's share of 4G revenues received and the log of that firm's share of patents contributed to the 4G standard.

Table 6 reports the results from an OLS regression of the natural log of a firm's share of 4G revenues that patent holders received on the natural log of that firm's share of patents contributed to the 4G LTE standard. To account for systematic differences in revenues between the two years, I include a dummy variable indicating whether the observation is from 2014—that is, when the year of the observation is 2013, that indicator variable is equal to zero, whereas it is equal to one when the year of the observation is 2014.

Table 6. Regression of the Log of the Share of 4G Revenues Received by SEP Holders on the Log of the Share of SEPs Contributed to the 4G LTE Standard, 2013 and 2014

Dependent Variable: Natural Log of the Share of 4G Revenues Received by SEP Holders in 2013 and 2014	
Natural Log of the Share of SEPs Contributed to the 4G LTE Standard	1.861*** (0.462)
Indicator Variable For Year 2014	−0.309 (0.804)
Constant	−0.449 (1.442)
R^2	0.701
F	8.19**
Observations	10

Notes: * indicates statistical significance at the 90-percent confidence level, ** indicates statistical significance at the 95-percent confidence level, and *** indicates statistical significance at the 99-percent confidence level. Standard errors are in parentheses.

In Table 6, the coefficient on the share of 4G SEPs indicates a positive relationship, which means that an increase in the share of SEPs that a firm contributed to the 4G LTE standard is associated with an increase in that firm's share of 4G revenues received by SEP holders in 2013. That positive relationship is statistically significant at the 99-percent confidence level. Although the five companies reported similar revenue shares in 2013 and 2014, the negative value of the coefficient for the year dummy—which is not statistically significant at the 90-percent confidence level—indicates that average revenues were lower in 2014. Including both years in the regression allows one to measure more accurately the average revenues that a company could expect to earn if it owns a given share of patents essential to the standard. I find similar results if I estimate separate regressions for each year.

The R^2 for the regression in Table 6 is 0.701, which indicates that the share of SEPs contributed to the 4G LTE standard explains more than two-thirds of the variation of the share of 4G revenues that the SEP holders received. Furthermore, the F statistic is significant at the 95-percent confidence level, which implies that the regression model predicts the share of 4G revenues that SEP holders received more accurately than the average share of 4G revenues that SEP holders received would predict on its own.

Given the small sample size, one should interpret Table 6's estimates with caution. However, the small sample size should not be a reason to

discount the regression results. Although only five companies' revenues and patent shares are included in the regression, those five companies contributed 36.7 percent of all patents contributed to the 4G LTE standard.[37] To the extent that the publicly available information on the revenue shares of these companies allows me to estimate an upper bound on the revenue of all SEP holders, I am able to test the size of the aggregate royalty that publicly available information can support. That is, although I predict a point estimate for the implied revenues of each SEP holder, the chief goal of this analysis is to determine whether it is possible for publicly available data to support a finding of a burdensome amount of aggregate royalties, using assumptions favorable to finding the existence of a royalty burden that would thwart implementation of the standard by manufacturers of handsets.

Because both my dependent variables and independent variables are natural logs, the regression coefficient for the share of SEPs contributed to the 4G LTE standard should be interpreted as an elasticity, or the percentage change in the share of revenues as the share of contributed patents increases by one percent.[38] For example, if the share of SEPs that an SEP holder contributes to the 4G LTE standard increases by 1 percent, my regression results predict that the share of 4G revenues that that SEP holder receives in licensing revenues would increase by 1.861 percent in 2013, and by 1.552 percent in 2014 (that is, 1.861 – 0.309 = 1.552). That my regression results from Table 6 have a high R^2 and a high F statistic suggests that using the share of SEPs contributed to the 4G LTE standard to predict the portion of 4G revenues that SEP holders are collecting in 2013 and 2014 will provide more accurate results than simply using the average share of revenues.

Thus, I use the regression coefficients to estimate the predicted implicit revenues that defensive cross licensors could expect to receive in 2013 and 2014. I multiply the natural log of a given patent holder's share of patents contributed to the 4G LTE standard by 1.861, and then add –0.449 (the constant term) to derive the predicted log of the share of 4G revenues received in 2013. For 2014, I do the same calculation, but I also add –0.309 (the regression coefficient for the 2014 dummy variable) to my predicted log of the share of 4G revenues. From the predicted share of 4G revenues received, I can then derive the predicted revenues received and the predicted royalty yield.

Table 7 reports my process for calculating the predicted implicit revenues received in 2013 and 2014 by large implementers, as well as the predicted royalty yields.

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[37] Cyber Creative Institute, *supra* note 33, at 6 fig.1.

[38] *See, e.g.*, James H. Stock & Mark W. Watson, Introduction to Econometrics 270 (Addison Wesley 3d ed. 2011) (explaining the interpretation of the regression coefficient in a log-log model).

Table 7. Predicted Implicit Revenues for Large Implementers in 2013 and 2014

	2013				2014			
		[A]	[A] × Global 4G Revenues in 2013 = [B]	[B] ÷ Global Handset Revenues in 2013 = [C]		[A]	[A] × Global 4G Revenues in 2014 = [B]	[B] ÷ Global Handset Revenues in 2014 = [C]
Patent Holder	Share of Patents Contributed to 4G LTE Standard	Predicted Share of 4G Revenues Received in 2013	Predicted Revenues Received (2014 Dollars)	Predicted Royalty Yield	Share of Patents Contributed to 4G LTE Standard	Predicted Share of 4G Revenues Received in 2014	Predicted Revenues Received (2014 Dollars)	Predicted Royalty Yield
Apple	1.32%	0.02%	$35,422,740	0.01%	1.32%	0.01%	$33,243,452	0.01%
Huawei	10.19%	0.91%	$1,594,079,616	0.41%	10.19%	0.67%	$1,496,008,320	0.39%
RIM	0.52%	0.00%	$6,359,281	0.00%	0.52%	0.00%	$5,968,044	0.00%
Samsung	11.02%	1.05%	$1,843,587,328	0.48%	11.02%	0.77%	$1,730,165,632	0.45%
LG	5.36%	0.27%	$481,652,320	0.13%	5.36%	0.20%	$452,019,968	0.12%
Total	28.40%	2.26%	$3,961,101,285	1.03%	28.40%	1.66%	$3,717,405,416	0.97%

Note: I calculate global 4G revenues to be $175,254,828,440 in 2013 and $224,122,858,176 in 2014. I calculate global handset revenues to be $384,659,251,261 in 2013 and $384,956,220,857 in 2014.

As Table 7 reports, my estimate of the total implicit licensing revenues collected in 2013 by large implementers that cross license—Apple, Huawei, RIM, Samsung, and LG—is $3.96 billion, which amounts to 1.03 percent of global licensing revenues in 2013. Table 7 also reports that my estimate of the total implicit licensing revenues collected in 2014 by Apple, Huawei, RIM, Samsung, and LG is $3.72 billion, which amounts to 0.97 percent of global licensing revenues in 2014.

B. Estimating the Aggregate Royalty for Mallinson's Third Group of SEP Holders

Mallinson's estimate of less than $6 billion collected in licensing revenues per year for his third group of SEP holders included revenues from PAEs and NPEs as well as large implementers. To estimate the amount that PAEs collect in licensing revenues, I rely on a 2014 report by RPX Corporation on publicly traded PAEs.[39] RPX reported that publicly traded PAEs collected $969 million in royalty revenues in 2013 and $1,197 million in 2014.[40]

Table 8 reports my estimate of the royalties for Mallinson's third group of SEP holders, which includes large implementers and PAEs. I also show the upper and lower bounds for the predicted implicit revenues of large implementers at the 95-percent confidence level. The estimate for the amount that PAEs collect in licensing revenues is the same for the lower bound, average, and upper bounds. Although the upper bound leads to a high royalty yield for large implementers and PAEs, it bears emphasis that the upper bound represents an extreme value and that the actual value is likely to be closer to the mean estimate, which is 1.46 percent in 2014. I report the upper and lower bounds to show that even the highest reasonable estimate of the royalty yield for Mallinson's third group of SEP holders was only 3.83 percent in 2013 and 3.66 percent in 2014. It is highly unlikely that large implementers would have a higher royalty yield from cross-licenses than large SEP holders (such as Qualcomm or Ericsson) collect.[41]

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[39] RPX Corporation, Q4 2014 Public PAE Report 13 (2015), https://www.rpxcorp.com/wp-content/uploads/sites/2/2015/04/RPX-Q4-2014-Public-PAE-Report.pdf.

[40] *Id.* The RPX study identifies InterDigital as a PAE. To avoid double counting, I subtract the licensing revenues that I estimated InterDigital to receive from RPX's estimation of the licensing revenues that publicly traded PAEs had received in 2013 and 2014. I convert all 2013 dollar amounts to 2014 dollars. Bureau of Economic Analysis, *supra* note 18.

[41] In this analysis, I have made a number of reasoned assumptions. First, I assume that relationship between the share of patents contributed to the 4G LTE standards and the share of licensing revenues received is linear. If, instead, the share of revenues increases more quickly as the number of patents increases for SEP holders with few SEPs than for SEP holders with many SEPs, then my regression model would underestimate the amounts that small implementers are receiving. In other words, it might be argued that the relationship between patents contributed and revenues received is stronger (that is, more positive) for companies with smaller portfolios than it is for companies with larger portfolios.

Second, I assume that it is reasonable to exclude implementers with small numbers of declared essential patents (like Airbiquity, which has contributed five patents to the 4G LTE standard) in my estimated royalties for Mallinson's third group of SEP holders. Cyber Creative Institute, *supra* note 33, at 6 fig.1. This exclusion could bias my estimate towards a lower value. I do not include those implement-

Table 8. Predicted Aggregate Royalty Collected by Large Implementers and PAEs

	2013 (Millions of 2014 Dollars)			2014 (Millions of 2014 Dollars)		
	Lower Bound	Average	Upper Bound	Lower Bound	Average	Upper Bound
Large Implementers	$1,149	$3,961	$13,751	$1,078	$3,717	$12,905
PAEs	$969	$969	$969	$1,197	$1,197	$1,197
Total	$2,118	$4,930	$14,720	$2,275	$4,914	$14,102
Royalty Yield	0.55%	1.28%	3.83%	0.59%	1.28%	3.66%

Note: I calculate global handset revenues to be $384,659,251,261 in 2013 and $384,956,220,857 in 2014.

Mallinson's estimate for the licensing revenues collected by large implementers, PAEs, and NPEs was less than $6 billion (for presumably either 2013 or 2014), which led to this group of SEP holders collecting a royalty yield of greater than 1.5 percent in 2014.[42] Mallinson does not separately report large implementers' royalty yields for 2013. However, given that Mallinson estimates global handset revenues to be $377 billion in 2013,[43] his estimated royalty yield for large implementers in 2013 would equal 1.6 percent, using the same $6 billion number.[44]

It bears emphasis that Mallinson's estimate of less than $6 billion also includes the licensing revenues that large implementers received for the use of their 3G SEPs (in addition to their 4G LTE SEPs). In contrast, my estimates of $3.96 billion in 2013 and $3.72 billion in 2014 for large implementers

ers with small SEP portfolios in my replication of Mallinson's analysis of the aggregate royalty because Mallinson does not include implementers with small numbers of declared SEPs like Airbiquity in his third group of SEP holders; rather, he includes only implementers with large numbers of declared SEPs (specifically, Apple, Samsung, Huawei, RIM, and LG). Mallinson, *supra* note 2, at 1 fig.1, 6. However, if I were to use my regression model to predict the licensing revenues for all implementers—including those with small numbers of declared essential patents—my regression model would predict an upper bound at the 95-percent confidence level of $21,627,805,696 in licensing revenues for 2013 (implying a royalty yield of 5.62 percent) and an upper bound of $20,297,213,952 in licensing revenues for 2014 (implying a royalty yield of 5.27 percent).That is, excluding small implementers reduces my estimated upper bound on the royalty yield of large implementers by 2.05 percentage points in 2013 and 1.92 percentage points in 2014. However, licensing revenues for some of these patent holders are already included in the payments to patent pools.

Third, I assume that there is a constant level of patent quality across the SEP portfolios of not only the five companies in my regression, but also the other companies for which I predict implicit licensing revenues. If the average patent quality is higher for smaller companies than larger companies, then my analysis would underestimate the aggregate royalty payment (however, if the average patent quality is lower for smaller companies than larger companies, then my analysis would overestimate the aggregate royalty payment). Even if smaller companies have higher-quality patents on average or earn a higher share of revenues for a given number of patents, it is unlikely that all implementers would collect an aggregate royalty yield of 5.62 percent in 2013 and 5.27 percent in 2014 from cross licenses, which is higher than the royalty yield that large SEP holders collect (because I estimate that large SEP holders collected a royalty yield of 2.70 percent in 2013 and 2.64 percent in 2014). Furthermore, even if implementers were indeed collecting an aggregate royalty yield of 5.27 to 5.62 percent, such a royalty yield would surely not be substantial enough to make it infeasible to manufacture standard-compliant smartphones.

42 Mallinson, *supra* note 2, at 1.

43 *Id.*

44 $6 billion ÷ $377 billion = 1.6%.

include *only* licensing revenues for 4G LTE SEPs. Mallinson's estimate of less than $6 billion for his third group of SEP holders fits within my estimated lower and upper bounds for how much that third group collected in licensing revenues. Thus, in light of Mallinson's estimate of less than $6 billion in licensing revenues for large implementers (of both 3G and 4G SEPs), PAEs, and NPEs, my estimates of approximately $4.9 billion in both 2013 and 2014 for licensing revenues for large implementers of 4G SEPs and PAEs are reasonable.[45]

V. The Aggregate Royalty for Mobile Communications SEPs

Table 9 reports my estimates of the aggregate royalty yield for holders of mobile communication SEPs.

Table 9. Sidak Estimates of Aggregate Mobile Communications SEP Licensing Revenues and Royalty Yields on Global Handset Revenues

	2013		2014	
	Revenues (Billions of 2014 Dollars)	Yield	Revenues (Billions of 2014 Dollars)	Yield
Major SEP Holders with Licensing Programs	$10.4	2.70%	$10.2	2.64%
Patent Pools	$1.7	0.45%	$2.1	0.55%
Other	$4.9	1.28%	$4.9	1.28%
Cumulative	$17.0	4.43%	$17.2	4.47%
Global Handset Revenues	$385		$385	

Source: International Data Corp., *supra* note 14; 2015 Qualcomm 10-K, *supra* note 13, at 38; Ericsson Annual Report, *supra* note 13, at 63, 74; Nokia Report 2015, *supra* note 13, at 21; Nokia Report 2014, *supra* note 13, at 144; 2015 InterDigital 10-K, *supra* note 13, at 50, 53; Alcatel-Lucent Report, *supra* note 13, at 25; *New Licensing Terms!*, Sipro Lab Telecom, http://www.sipro.com/Licensing-Terms-W-CD-MA.html; *LTE License Fees*, Via Licensing, http://www.via-corp.com/licensecontent.aspx?id=1516; *LTE/LTEA License Terms*, Sisvel, http://www.sisvel.com/lte-ltea/license-terms; Bureau of Economic Analysis, *supra* note 18.

For comparison, Table 10 reports Mallinson's estimates of aggregate mobile communications SEP licensing revenues and royalty yields on global handset revenues.

[45] Even if one assumes that large implementers can license their 3G portfolios for the same amount as their 4G portfolios, their combined licensing revenues would still be below my estimated 95-percent confidence level upper bound.

Table 10. Mallinson Estimates of Aggregate Mobile Communications SEP Licensing Revenues and Royalty Yields on Global Handset Revenues

	2013		2014	
	Revenues (Billions of Dollars)	Yield	Revenues (Billions of Dollars)	Yield
Major SEP Owners with Licensing Programs	$10.5	2.8%	$10.6	2.6%
Patent Pools	$2.94	0.78%	<$4	<1%
Others	<$6	1.6%	<$6	<1.5%
Cumulative Maximum	~$19.4	~5.1%	~$20	~5%
Global Handset Revenues	$377		$410	

Source: Mallinson, *supra* note 2, at 1–6.
Note: Table 10 preserves Mallinson's estimates in nominal dollars.

My findings in Table 9 are similar to Mallinson's in Table 10. My findings for the first two groups differ slightly in size from Mallinson's, although not in a meaningful way. These differences likely arise because of assumptions made in the application of quantity discounts, or differences in the underlying production and sales data. For the third group, I applied a different method than Mallinson but again find that his results are reasonable. My analysis—and Mallinson's analysis in Table 10—shows that the aggregate royalty collected by SEP holders is approximately 4 to 5 percent of global handset revenues.

VI. Conclusion

It has taken a decade for the royalty-stacking conjecture to be subjected to a simple test of its factual plausibility: if SEP holders have indeed been imposing excessive aggregate royalties on SEP implementers, one should be able to observe those excessive royalties in the SEP holders' publicly reported licensing revenues relative to global handset revenues. Keith Mallinson had this insight in 2015 and found no evidence to support the existence of an excessive aggregate royalty. My replication of Mallinson's analysis confirms his conclusion. Using publicly available information, I find that SEP holders collected aggregate royalties in 2013 and 2014 that were between 4 and 5 percent of global handset revenues.