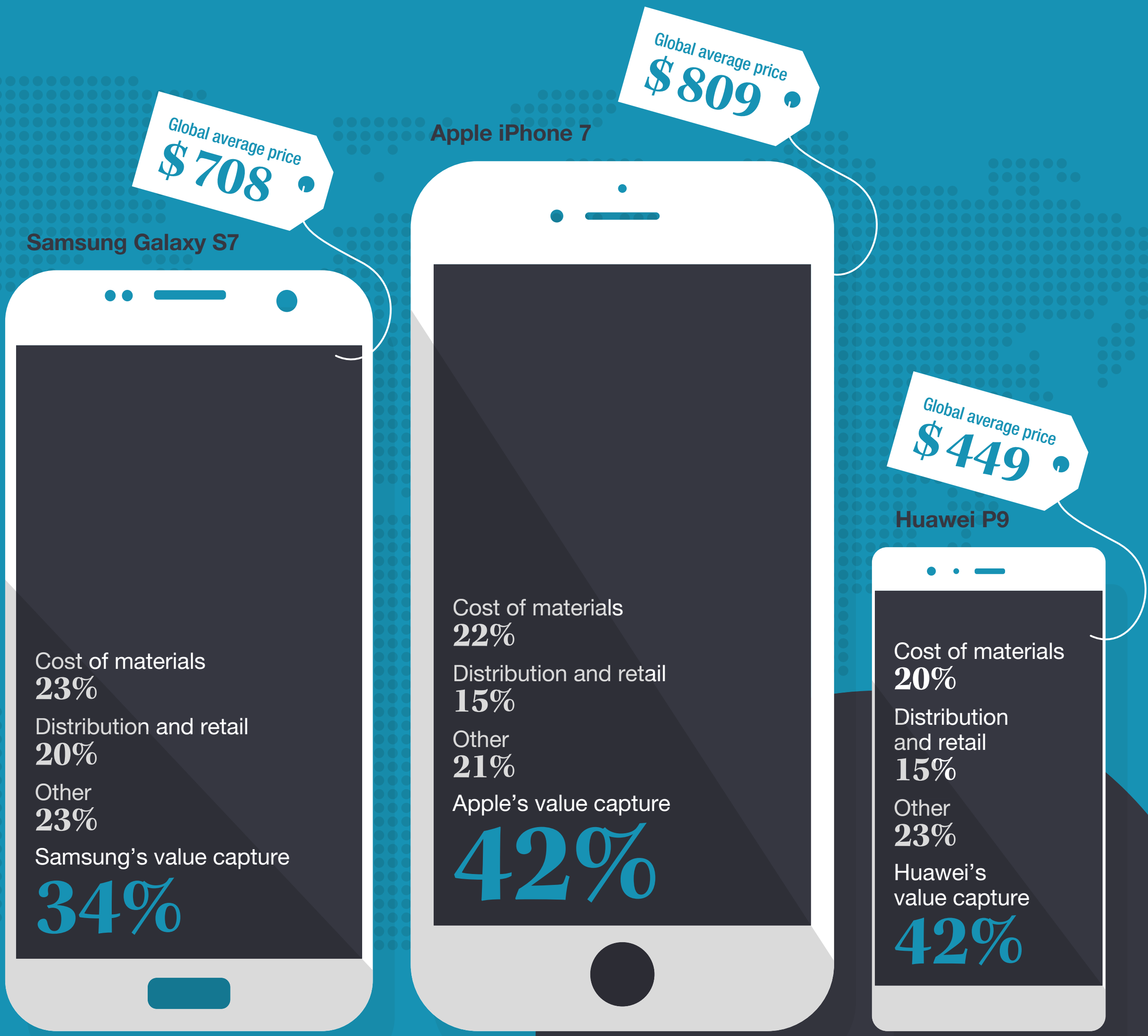
Success in the smartphone industry is based on intangibles



Leading firms use **technology, design and branding** to secure a huge share of market value.

35%

Up to 35% of all patents filed worldwide since 1990 may relate to smartphones.

Designs of user interfaces are also heavily protected.

Dimensions of mobile phone illustrations reflect their average global retail prices.

Source: World Intellectual Property Report 2017

Chapter 4
Smartphones: what's inside the box?

Smartphones are cellular telephones with an operating system that allows consumers to tap into increasingly rich mobile applications. They are produced by global value chains composed of a few handset manufacturers that draw on a large range of communications technology, component and software suppliers.

This chapter takes a look inside the smartphone global value chain. It quantifies the value capture for three recent top-end smartphones from market leaders Apple, Huawei and Samsung, with a focus on the creation and valorization of intangible assets.[1] Section 4.1 details the characteristics of the underlying global value chain; section 4.2 identifies who captures the value of smartphone sales; section 4.3 assesses the role of intangible assets and intellectual property in value capture; and section 4.4 discusses the process of technological learning.

4.1 – The smartphone global value chain

Despite the leadership of a few firms in terms of consumer market shares, a vast network of firms operating in the electronics and software industry is ultimately responsible for the conception and production of smartphones.

4.1.1 – The evolving nature of the smartphone market

Over the last 20 years, cellular communications have shifted from basic phones used for voice communications to smartphones used also for data-intensive content applications. The smartphone industry has grown from 124 million units sold in 2007 to 1.47 billion unit sales in 2016 with a total market value of USD 418 billion.[2] Globally, there are 3.8 billion users today, and that figure is expected to reach 5.8 billion by 2020, with growth mainly driven by uptake in developing countries.[3]

While growth in the smartphone market has been steady and strong, the handset providers leading the industry have changed over time. The brands initially dominating global smartphone sales were Nokia and BlackBerry, but Apple and Samsung have taken their place since 2011. The market continues to experience exit and entry (table 4.1). Huawei, which only entered in 2010, took third place in 2015.

Table 4.1

Global smartphone market shares, in percentage of units sold

Company	2007	2010	2013	2016
Samsung Electronics	1.8	7.5	31.1	21.1
Apple	3.0	15.6	15.1	14.6
Huawei	–	0.6	4.8	9.5
LG	–	–	4.7	3.7
Xiaomi	–	–	1.8	3.6
Lenovo	0.0	0.2	4.5	3.5
Motorola	6.1	4.6	1.2	*
HTC	2.4	7.2	2.2	1.0
Nokia	49.2	32.8	3.0	*
BlackBerry	9.9	16.0	1.9	.05

Note: *Nokia's smartphone business was bought by Microsoft, and Motorola's by Lenovo.

Source: IDC Worldwide Mobile Phone Tracker, 2017.

Apple (57 percent) and Samsung (25 percent) dominate the market for high-end phones – those costing more than USD 400.[4] The average selling price (ASP) of a smartphone has declined from USD 425 in the period 2007-2011 to USD 283 in 2016, and phones fitted with the Android mobile operating system are now significantly cheaper than Apple devices running iOS (see table 4.2). The proportion of high-end smartphones sold as a share of the entire smartphone market is also declining, due partly to competition in the high-end segment and partly to the rise of cheaper Chinese brands in the mid- to low-end segment.[5] While Chinese smartphone makers Xiaomi, Oppo and Vivo are still relatively unknown to the average consumer outside China, they are now among the top 10 in terms of global smartphone sales.[6]

Table 4.2

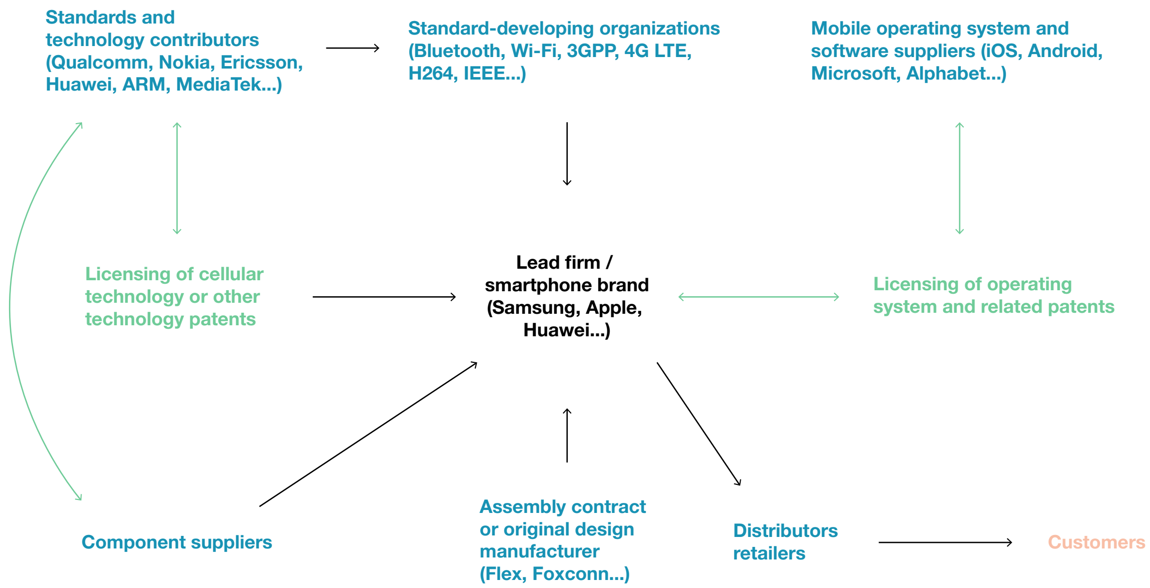
Average selling price of smartphones by mobile operating system, in USD

Operating system	2007	2010	2013	2014	2015	2016
iOS (Apple)	594	703	669	680	716	690
Android (Google)	–	441	272	237	217	214

Source: IDC Worldwide Mobile Phone Tracker, 2017.

Figure 4.1

The smartphone global value chain is shaped like a spider



Note: Black lines represent the flow of parts or components through the value chain, green lines the licensing of technology and IP.

4.1.2 – Innovation in and the shape of the global smartphone value chain

The smartphone global value chain involves the usual stages of research and development (R&D), design, manufacturing, assembly, marketing, distribution and sales. It is organized not as a linear value chain, but rather – to use concepts introduced in chapter 1 – in a producer-driven "spider" form (see figure 4.1).

In this set-up, the lead firm operates under a strong brand and is responsible for considerable R&D, product design and product specifications. But Apple, Huawei and Samsung source components and technology from third parties, who are sometimes equally innovative and active in producing intangible assets.

First, these lead firms require components and access to standards-related technology. Apple sources mainly from outside suppliers whereas Huawei and Samsung source mainly from within their firms. Certain inputs are commoditized, for example resistors and wiring, while other, high-value, components such as phone casings and chipsets are highly specialized.

All these components also have their own global supply chains. For example, a chip may be designed by a specialized U.S. company for a smartphone supplier; it is then manufactured in China and packaged in Malaysia to reach the end-consumer.

Second, smartphone producers require access to technology employed in interoperability and connectivity standards, such as the fourth-generation (4G) Long-Term Evolution (LTE) cellular standard or the 802.11 Wi-Fi standard. Large companies such as Nokia, Ericsson, Qualcomm, InterDigital, Huawei, Samsung, NTT DoCoMo and ZTE contribute patented technologies to the development of such standards, which are defined by standard-setting organizations. Typically, these technologies are licensed separately, entailing the payment of licensing fees.

Third, smartphone firms require software – not only a mobile operating system, but also other dedicated mobile software applications, often from third parties. Samsung, Huawei and others use Android, developed by Google; Apple produces its own system, iOS.

Table 4.3

R&D expenditures of smartphone technology firms and their ranking among top global R&D spenders

Rank among top company R&D spenders worldwide	Name	Economy or country	Industrial sector	R&D 2015/16 in EUR million	R&D three-year compound annual growth 2014-16 (%)	R&D intensity, 2015/16 (% of revenues)
2	SAMSUNG ELECTRONICS	Rep. of Korea	Electronic and electrical equipment	12,527.9	10.7	8.0
3	INTEL	U.S.	Technology hardware and equipment	11,139.9	5.1	6.1
4	ALPHABET	U.S.	Software and computer services	11,053.6	22.4	22.2
5	MICROSOFT	U.S.	Software and computer services	11,011.3	-0.5	4.8
8	HUAWEI INVESTMENT & HOLDING CO.	China	Technology hardware and equipment	8,357.9	26.3	15.0
11	APPLE	U.S.	Technology hardware and equipment	7,409.8	33.6	3.5
17	CISCO SYSTEMS	U.S.	Technology hardware and equipment	5,701.3	4.2	12.6
25	QUALCOMM	U.S.	Technology hardware and equipment	5,042.7	11.9	21.7
35	ERICSSON	Sweden	Technology hardware and equipment	3,805.6	2.7	14.2
54	NOKIA	Finland	Technology hardware and equipment	2,502.0	-15.6	18.4
57	ALCATEL-LUCENT	France	Technology hardware and equipment	2,409.0	-0.4	16.9
65	ZTE	China	Technology hardware and equipment	1,954.1	12.4	13.8
70	TAIWAN SEMICONDUCTOR	Taiwan (Province of China)	Technology hardware and equipment	1,826.7	17.5	7.8
85	SK HYNIX	Rep. of Korea	Technology hardware and equipment	1,543.0	21.2	10.5
90	HON HAI PRECISION INDUSTRY	Taiwan (Province of China)	Electronic and electrical equipment	1,462.9	4.8	1.2
95	MICRON TECHNOLOGY	U.S.	Technology hardware and equipment	1,414.5	18.8	9.5
98	MEDIATEK	Taiwan (Province of China)	Technology hardware and equipment	1,380.3	30.3	23.2
106	LENOVO	China	Technology hardware and equipment	1,284.7	31.3	3.1
112	NVIDIA	U.S.	Technology hardware and equipment	1,222.6	5.4	26.6
120	STMICROELECTRONICS	The Netherlands	Technology hardware and equipment	1,149.1	-18.7	18.1
141	MARVELL TECHNOLOGY	U.S.	Technology hardware and equipment	968.4	-0.1	38.7
142	BROADCOM	Singapore	Electronic and electrical equipment	963.5	46.3	15.4
162	INFINEON TECHNOLOGIES	Germany	Technology hardware and equipment	817.0	16.9	14.1
457	TCL COMMUNICATION TECHNOLOGY	China	Technology hardware and equipment	231.4	25.7	6.8

Source: WIPO based on the EU Industrial R&D Investment Scoreboard, European Commission, Joint Research Center.[7]

Fourth, the assembly of the final product is often undertaken by large original design or contract manufacturers such as Flextronics, Foxconn and Wistron. These assemblers compete for high-volume – but often low-margin – opportunities. Samsung, however, mostly internalizes the assembly in its own factories, whereas Huawei does both.

Finally, to distribute and retail its phones, Apple is vertically integrated with its own online and physical stores, whereas Samsung operates more through regular distributors. Huawei operates a growing number of exclusive retail outlets, not only in Asia. Other Chinese brands still lack international distribution channels.[8]

As shown in table 4.3, the global value chain is made up of some of the most R&D-intensive firms in the world. These firms also regularly top the rankings of innovative firms, including one of the newly emerging Chinese smartphone brands, Xiaomi.[9] Innovation occurs throughout the above smartphone value chains, including both product innovation (i.e., the introduction of new product features) and product differentiation (i.e., the extent to which existing products differ along a set of characteristics).[10] These innovations occur in all parts of the global value chain: (i) in cellular technology; (ii) in the various smartphone components, in particular in the field of semiconductors as well as in batteries and displays; (iii) in the design and functionality of smartphones, including graphical user interfaces (GUI); and (iv) in the area of software and applications. Even firms traditionally associated with simple assembly, such as Foxconn, spend considerable sums on R&D and own large patent portfolios (see table 4.3).

This highly innovative smartphone global value chain, composed of exclusive technology providers, is far from stable. As the experiences of BlackBerry and Nokia have shown, changing technology and consumer tastes can lead former top brands to drastically lose market share. And as evidenced in the daily press, change also occurs frequently within the supply chain. Lead firms often decide to shift away from established component suppliers; for example, Apple recently shifted its purchases from Qualcomm to Intel.[11] They often also attempt to build high-value components and IP internally, as seen in Huawei's and Xiaomi's quest to develop their own chipsets and Apple's efforts to build graphics processing units (GPUs), turning away from its former supplier, Imagination Technologies Group.[12]

Even the assembly of smartphones is shifting constantly, with lead firms often struggling to meet high demand, leading to experiments with new manufacturers or assembly locations such as India in the case of Apple and Viet Nam in the case of Samsung.

4.2 – Value capture along the smartphone value chain

Who captures most of the value from innovation along the smartphone value chain?

This section addresses this question at the level of specific phones and companies, for the Apple iPhone 7, Huawei P9 and Samsung Galaxy S7. For these phones, released in 2016, estimates are produced by subtracting the costs of purchased intermediate inputs and direct labor costs along the various stages of the global value chain from the wholesale price of each phone (see box 4.1). The residual balance – referred to as "value capture" or gross profits here – accrues to Apple, Huawei or Samsung as lead firms in the smartphone global value chain and as compensation for their intangible assets.

Value capture at the product and firm level is the closest one can get to the concepts of the global value chain residual calculation and "returns to intangible assets" developed in chapter 1. The underlying work in Chen et al. (2017) discussed in that chapter can be seen as the macro-equivalent of the calculations by Dedrick and Kraemer (2017) presented here.

According to this approach, smartphone lead firms and suppliers of high-end components capture a vast part of the value generated from the sale of these three top-of-the-line phones.

4.2.1 – A look inside a smartphone

Smartphones consist of anywhere between 1,500 and 2,000 physical parts. The most expensive input – up to 20 percent of the total cost – is the touchscreen module (see table 4.4). In decreasing order, the other most expensive items are processors, memory and storage, casing, camera, battery, printed circuits, sensors, and assembly.

The location of core activities is depicted in table 4.5. R&D and design usually occurs near the company's headquarters. Development is done jointly by the lead firm and engineers from contract manufacturers.

Table 4.4

Cost of intermediate inputs as a percentage of total material costs

Function	Apple iPhone 7	Samsung Galaxy S7	Huawei P9
Display/touchscreen	15.9	20.5	16.8
App processors/baseband	10.2	18.1	14.3
Storage	4.5	5.2	4.2
Memory	6.1	10.1	7.3
Casing	8.2	8.6	7.8
Subtotal for key components	72.7	71.3	63.6
Hundreds of other components	13.0	18.2	21.8
Assembly	2.2	1.6	2.4
Total factory cost	88	88.9	88
Software	iOS	Android	Android
IP licenses for standard-essential patents (SEPs)	12.0	11.1	12.0
Cost of goods sold	100	100	100

Sources: Dedrick and Kraemer (2017) based on IHS Markit teardown report.

Table 4.5

Location of activities in the global value chain of the smartphone industry

Activity	Standard setting	R&D, design, sourcing	Development and engineering	Manufacture of key components	Production/ final assembly
Apple	International standard-setting organizations	U.S.	U.S./Taiwan (Province of China)	U.S./Japan/Republic of Korea/Taiwan (Province of China)/China	China, India (as of 2017)
Samsung	International standard-setting organizations	Republic of Korea	Republic of Korea	Republic of Korea/ Japan/U.S./China	Republic of Korea, Viet Nam, China, India, Brazil, Indonesia
Huawei	International standard-setting organizations	China	China	China/Republic of Korea	China, India

Suppliers of electronic components, whether low or high end, are mostly located in the United States, Japan, the Republic of Korea, Taiwan (Province of China) and China.

Specifically, the role of U.S.-based suppliers ranges from 29 percent to 45 percent of value capture for handsets from the U.S. and the Republic of Korea, but only 9 percent for Huawei's P9 phone. Republic of Korea-based suppliers account for 31 percent of the value capture of suppliers for Samsung, while Chinese-based suppliers make up 34 percent of all suppliers for Huawei.The leaders are in the U.S. (Apple, Google, Qualcomm, Intel and a number of other component makers), the Republic of Korea (Samsung, LG and SK Hynix), Singapore (Broadcom), Taiwan (Province of China) (Taiwan Semiconductor Manufacturing Company, TSMC and some smaller chip and component makers), Japan (Japan Display, Sony, Murata) and China (Foxconn, Huawei and its subsidiary HI Silicon, plus Xiaomi, Oppo, Vivo and Lenovo).

Assembly is left to turnkey suppliers, mostly in China, Japan and East Asia, and with little activity in other world regions except incipient activity in Brazil and India.

4.2.2 – Value capture for high-end smartphone models

Only a few country locations, mostly the United States and a few Asian countries, capture the vast majority of value in smartphone production. Besides the cost of materials, a significant share goes to retailing, to IP, and directly as value capture to the lead firm. Indeed, the "lead firm advantage" – associated in earlier studies only with Apple – also extends to other high-end smartphone manufacturers.

The breakdown of smartphone retail prices shows that the value capture of the lead firm is far more than the combined value captured by, or gross profits of, all the suppliers; USD 283 for Apple as compared to USD 71 for suppliers; USD 228 for Samsung as compared to USD 76 for suppliers; and USD 188 for Huawei as compared to USD 47 for suppliers (see box 4.1).

Applying the above methodology, figure 4.4 shows the value captured in USD terms as a percentage of the smartphone retail price. The results underline the advantageous position of the lead firms in general, and Apple in particular. At the macro-level, the electronics sector saw an increase in the share of intangible asset income as a percentage of total value over the period 2000-2014 (see chapter 1). It also confirms that in producer-driven global value chains, the returns do indeed rest with activities before the final production stage.

As a proxy for value capture, Apple keeps 42 percent of the retail price of each iPhone sold (or USD 270), Huawei 42 percent (USD 203) and Samsung 33 percent (USD 221.76). Huawei's selling price is lower, thanks to its reliance on low-cost components in part produced internally by its subsidiary Hi-Silicon, and reflecting its pricing strategy as it competes with a large number of other Android phone makers. Samsung's value capture is hurt by its greater reliance on retailers and carriers to sell its products. The figures for value capture include wages and salaries for R&D, design, management, marketing and whatever these lead firms do to generate a competitive advantage.

Figure 4.2

How to arrive at the value capture estimate

Smartphone retail price

- Cost of materials
  in decreasing order of cost: touchscreen display, application processor, enclosure, camera and baseband processor...

- Assembly and other labor costs

- Distribution costs

= Value capture or gross profits

Box 4.1

The smartphone value capture model – analytical approach and limitations

Value capture at each stage of the global value chain is calculated by subtracting the costs of purchased intermediate inputs and direct labor costs along the various stages of the global value chain and the distribution costs from the selling price of the specific phone (see figure 4.2 and figure 4.3). This amount includes the direct cost of materials used in creating the product along with the direct labor costs used to produce it – including assembly and testing – defined as "cost of goods sold" (COGS).[13] Teardown reports from IHS Markit are used to estimate these costs to arrive at the residual value capture.[14]

The value capture pays for selling, general and administrative expenses (SG&A), R&D and other indirect costs, with the rest being the return to the firm or ultimately the shareholders, which also ultimately constitutes the lead firm's return on its tangible and intangible capital. Figure 4.3 compares the concept of value capture to value added. Five limitations are noteworthy.

First, the supplier and component lists in teardown reports are incomplete, and prices – so-called "rack rates" – may be overestimates when firms are able to negotiate bulk discounts or they produce these components internally. For example, the display in the Samsung S7 – the most expensive component – is sourced from Samsung Display by Samsung Electronics. In the teardown reports the market value of USD 55 is applied, whereas the actual cost may be lower.[15]

Second, independently of the country in question, firm-level information about pure value added is not readily available because publicly listed companies do not generally reveal the amount of their wages for "direct labor." Instead, the wage bill for assembly by third parties is hidden within "cost of goods sold" or "cost of sales." As a result, the difference between "net sales" and "cost of goods sold" is used as a proxy for value capture.

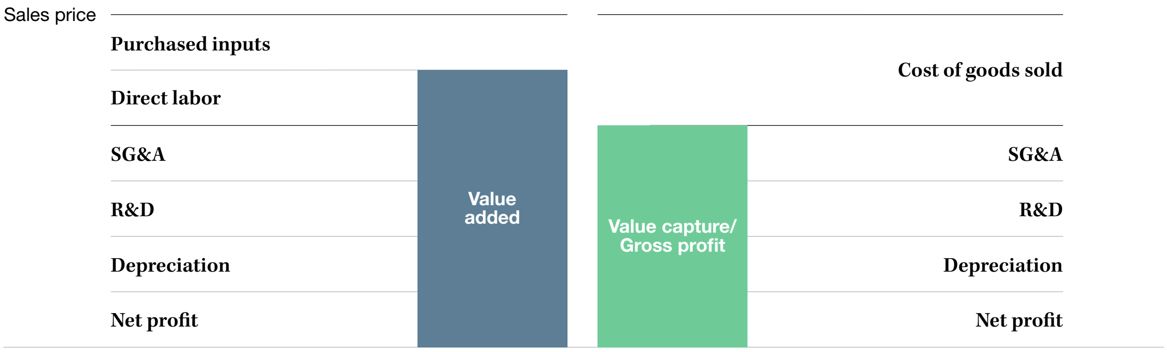
Third, it is assumed that R&D and other intangible asset-related value capture originates and accrues to the company headquarters, including in the form of R&D staff wages. Today, these multinational companies arguably conduct a share of such functions abroad. The "stickiness" of value or profits to the headquarters location that is assumed in such accounting-based studies – and thus the assumption that all value captured by Apple, for example, is generated and kept in its main location, the U.S. – may thus be exaggerated. Indeed, Apple's 2017 Annual Report shows that the U.S. has less than one-half of its global operating income, and less than two-thirds of its long-lived assets. Furthermore, since Apple's public stock is owned by global investors, its profits distributed as dividends or capital gains are widely distributed globally. So more information is needed to better measure key metrics for affiliated entities within a global value chain of a multinational corporation, and more data to test or specifically analyse the geographic location of economic activity, including profits from IP, across jurisdictions.

Fourth, teardown reports focus on physical components; they do not cover intangibles, including payments for IP. To get a sense of the total return to intangible assets, obtaining estimates for IP-related value is necessary. This is challenging as IP-related transactions are often undisclosed and sometimes indirect.[16] As a proxy, in this exercise the licensing royalties for SEPs are calculated as 5 percent of the phone's cost on average (section 4.2.2). Other IP-related value or payments are even harder to trace, notably those related to internally developed or externally sourced software. For example, the actual cost of using third-party software is unknown. This may well inflate the value capture of the lead firm, though without reducing the estimate for overall returns to intangible capital. In addition, some IP-based transactions such as cross-licensing do not leave a monetary trace, but are still very valuable.[17]

Finally, this methodology abstracts from the large interconnected revenues of the telecommunications operators, and the increasing share of lead-firm revenues driven by accessories, content and services.[18]

Figure 4.3

The difference between value capture and value added



Source: Dedrick et al. (2010) and Dedrick and Kraemer (2017) for more details.

Figure 4.4

Smartphone lead firms capture a large chunk of the value in the chain

Value captured at each stage of the chain as a percentage of smartphone sale price

42%
Apple

22%
Cost of materials

15%
Distribution and retail

5%
IP licenses

5%
Unidentified material

3%
Other U.S.

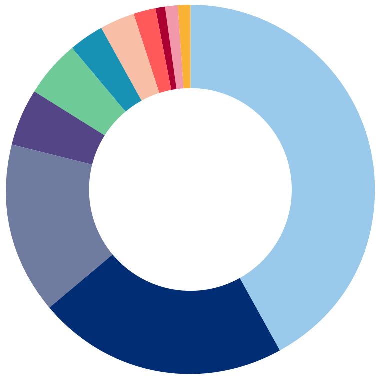
3%
Taiwan (Province of China)

2%
Unidentified labor

1%
Labor (China)

1%
Rep. of Korea

1%
Japan



Apple iPhone 7

34%
Samsung Electronics

23%
Cost of materials

20%
Distribution and retail

7%
Unidentified material

5%
IP licenses

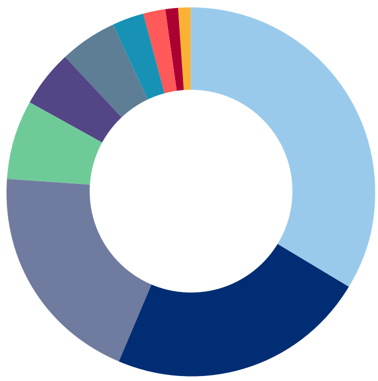
5%
U.S.

3%
Other Rep. of Korea

2%
Unidentified labor

1%
Labor (China)

1%
Japan



Samsung Galaxy S7

42%
Huawei

20%
Cost of materials

15%
Distribution and retail

9%
Unidentified material

5%
IP licenses

3%
Other China

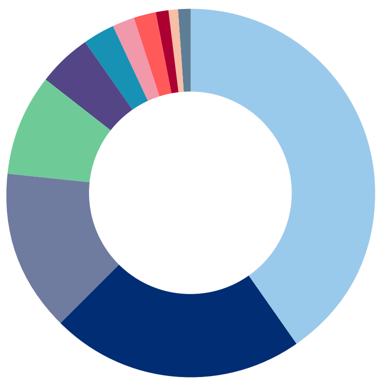
2%
Rep. of Korea

2%
Unidentified labor

1%
Labor (China)

1%
Taiwan (Province of China)

1%
U.S.



Huawei P9

Sources: Dedrick and Kraemer (2017).

Note: The numbers in some charts do not add up to exactly 100% because some numbers have been rounded up.

Figure 4.4 also shows the value captured by other firms in selected countries. For example, other U.S. firms capture 3 percent of the retail price of an iPhone.

As outlined in box 4.1, it is important to remember that the full value capture may not accrue to the headquarters location; subsidiaries in other countries may share in the benefit.[19] Apple is a multinational company with entities spread throughout the world (e.g., Ireland). To enable more detailed, country-specific breakdowns, more information would be needed to better measure key metrics for affiliated entities within a global value chain of a multinational corporation, and more data to analyze the geographic location of economic activity, including profits from IP, across jurisdictions.

Finally, figure 4.4 shows that the amount paid for IP to third parties varies from USD 34 per phone for Samsung to USD 32 for Apple to USD 24 for Huawei. In the following discussion, these costs are subtracted to ultimately yield the value capture of the lead firm, but for our broader analysis these sums constitute an important part of the return to intangible assets across the global value chain, earned here by the owners of cellular technology. Firms such as Qualcomm and others which do not generate revenues from the sale of smartphones spend considerable amounts on communication-technology-related R&D, thereby enabling the functionality of smartphones. These payments help to finance these high R&D costs, and allow for specialization in the marketplace.

4.2.3 – Who reaps most of the value of high-end smartphone sales?

For all three phones, capture of value added is largely detached from the flow of physical goods.[20]

While the value capture shares of the three firms are comparable at the level of the product (the individual phone), at the firm level Apple accounts for a large chunk of overall profits in the industry. By selling only high-end phones, Apple is able to capture a whopping 90 percent of the profits of all smartphone makers, according to third-party estimates, even though it only accounts for 12 percent of all smartphones sold.[21]

Apple captures most of the industry profits thanks to its high prices, large profit margins and the volume of iPhone sales worldwide (see table 4.6).

Its value capture in U.S. dollars is much larger than Samsung or Huawei's, as Apple sells significantly more high-end phones (over 215 million units, compared to 88 million for Samsung and 25 million for Huawei; see table 4.6). When the three companies' high-end phone sales for 2016 are compared, Apple walks away with 83 percent of the combined profits generated by the Apple iPhone 6, Huawei P8 and Samsung Galaxy 6 (see table 4.6). These exceptionally large benefits for Apple are a function of its investments in R&D, design and other intangible assets. They also allow it to spread its significant marketing and overhead costs over a higher volume of sales.

Samsung and Huawei capture high value on their most expensive phones, but their overall margins are reduced by the large number of low-cost products they sell.

Furthermore, this calculation abstracts from the smartphone content and services revenues generated on the basis of the handheld device after its sale. Apple's strategy to integrate everything from the supply of the phone to the delivery of content and services and related standards plays a significant role in its value capture outside, driven by platform lock-in, network externalities and the ability to bundle products efficiently.[22] And, although omitted here, these revenues are on the rise in absolute terms and as a share of Apple's revenues.[23] Other lead firms, however, see these added value and profits accrue to other providers as they do not partake in the added revenues generated in the sale of digital items, online content and services.

Yet Apple is not alone in capturing high profits and value. Component suppliers reap significant revenues and margins too, in particular when linked to proprietary technologies. As opposed to volume effects, smartphone suppliers experience significant variance in their margins. Qualcomm, for example, stands out for its significant value capture, a result of the performance of its baseband chipsets.[24] Qualcomm's value capture is far higher than that of MediaTek, reflecting the fact that it sells to premium-tier phone makers whereas MediaTek sells to low-price phone makers. In markets such as displays and memory, too, the dominant player, Samsung, earns 60 percent margins, while memory maker Micron Technologies settles for 20 percent.[25]

This high variance continues to the level of the contract manufacturers. Most earn low margins while still benefiting from high-volume activity and an important opportunity for technological learning (discussed further in section 4.4).

Table 4.6

Comparison of value capture for premium phone models in 2016

Smartphone model	Global average sales price (USD)	Value capture/ margin (%)	Value capture/ gross profit (USD per phone)	Worldwide shipments (units shipped in 2016)	Total 2016 value capture/gross profits (USD bn)
Apple iPhone 6	748	42	314	199,614,814	62.4
Apple iPhone 7	809	42	339	15,871,584	5.4
Apple total					67.8
Samsung Galaxy 6	732	34	248	52,892,898	13.1
Samsung Galaxy S7	708	34	240	35,701,806	8.6
Samsung total					21.7
Huawei P8	298	42	125	15,418,859	1.9
Huawei P9	449	42	188	9,986,811	1.9
Huawei total					3.8

Sources: Dedrick and Kraemer (2017) based on IHS Markit teardown report.

4.3 – The role of intangible assets in value capture

How do intangible assets, and IP in particular, relate to the value capture discussed above?

The ability to sell a smartphone at a profit depends largely on its performance, features, brand name, design and applications. In this chapter, value capture is a measure of the return to the firm's intangible assets. To protect their intangible assets and reap some related dividends, the actors in the smartphone industry which benefit from high value capture – as set out in section 4.2 – make extensive use of the full spectrum of IP rights.[26]

But is IP the main cause of value capture?

A leading study on the Apple iPhone calculates the value of patentable technologies in the iPhone as a part of Apple's total stock market value.[27] Estimates of brand value, smartphone design and their value as driver of a firm's market value also exist (discussed further below in sections 4.3.2 and 4.3.3).

But these studies rest on a number of strong assumptions. Despite a high correlation between value capture and the use of IP, a direct causal relationship between these two factors is hard to estimate, as is the specific value captured by selected IP assets. IP is usually only a source of competitive advantage when combined with complementary assets such as organizational expertise and human capital plus management skills and effective firm strategies.[28] When enforceable without excessive costs, the value of IP is both direct (i.e., with revenue impacts) and indirect (i.e., it produces defensive or strategic value). In light of these complexities, even smartphone makers themselves are unlikely to have full evidence of the specific value of their different IP assets.

The next sections shed light on the role of intangible assets and IP in value capture. Less formal appropriation schemes such as trade secrets play an important role, but are not included in the analysis as they are even harder to measure.

4.3.1 – Smartphone inventions drive a significant number of patent filings

Most industry experts and academics agree that a vast number of patents are part and parcel of modern smartphones.

One widely used source states that 27 percent of patents granted in the U.S. were related to mobile phones, up from 20 percent in 2012 and 10 percent in 2002.[29] The following calculations show that this is potentially an underestimate, if a broad definition of smartphone-related patents is used (see figure 4.5).

Another frequently cited source dating back to 2012 claims that one in every six patents in force – or about 16 percent of all active patents filed at the United States Patent and Trademark Office (USPTO) – are smartphone-related; other estimates argue that the number of active patents relevant to today's smartphones has increased from 70,000 in the year 2000 to 250,000 now, mainly due to the expanded set of features and functionalities.[30] The methodologies by which these sources arrive at these figures are mostly undisclosed and unverifiable.

Mapping the exact number of smartphone-related patents is a ferociously complex task (see box 4.2 on the approaches taken in this chapter). No simple technology field in international or national patent classifications easily corresponds to the smartphone product, and several issues further complicate the smartphone patent mapping.

First, a smartphone consists of many different technological components, some of which might not be unique to smartphones alone. Instead the components identified in section 4.2 range from semiconductors to memory, to other types of computer or communication technologies. While these items are integral to smartphones, they are also core to most other information and communication technology (ICT) products, and increasingly also to other product types which have connectivity as a built-in component, e.g., cars, fridges and medical technology. Assigning them to smartphones uniquely would be wrong.

Second, a number of inventions are core to the smartphone but are not found in the technology fields most strictly related to modern smartphone technology, for example patent classifications which relate directly to "portable communication terminals" or "telephone sets." Some are inventions in traditional sectors, outside the ICT industry, such as glass-related patents providing for more durable smartphone casing. Others are inventions in high-technology fields such as navigation displays, sensors and fingerprint technology. If one opens the door to software and other mobile applications which relate to e-commerce, social networks, payment, fitness, or health, the number of potentially relevant patents is even higher. Consequently, it is challenging to identify all relevant patents by traditional search methods which rely on patent classifications or keywords such as "smartphone"; in any case, the related inventions are also typically not unique to smartphones alone.

In the patent-mapping exercise conducted for this report, both a "narrow" and a "broad" smartphone grouping were calculated (see box 4.2). Invariably, the approaches chosen in smartphone patent-mapping exercises will be too constricted in the narrow category or too comprehensive in the broad category. The gap between the two estimates does, however, give a good sense of the sheer number of potential smartphone patents involved.

That said, by any account, smartphone-related patents have increased steadily in recent years, including as a share of total patents.

In the aggregate data, in 2016 patent applications under the Patent Cooperation Treaty (PCT) at WIPO related to digital communication accounted for the largest share of total PCT applications, followed by computer technology (17,155).[31] In fact, digital communication overtook computer technology – which held the top position in 2014 and 2015 – to become the top technological field in 2016. It has been experiencing some of the fastest growth in terms of new PCT filings. In 2014, the latest year for which national patent filing data are available, the field of digital communication also saw its fastest annual growth of any year since 2005.[32]

The patent mapping performed for this chapter shows that between 1990 and 2013 the number of smartphone first patent filings worldwide grew from about 100 patents in the early 1990s to about 2,700 patents in the narrow category in 2013, and from about 230,000 first filings (or about 350,000 patents overall) in the early 1990s to more than 650,000 first filings (or about 1.2 million patents overall) in the broad category. In the broad category – and bearing in mind that many of these patents are not exclusive to smartphones – this represents about 30-35 percent of patents filed worldwide between 1990 and 2013.

Box 4.2

Mapping smartphone patents

To mitigate the complexity of identifying smartphone patents, two approaches were chosen for the patent-mapping analysis discussed in this chapter. One uses a narrow choice of applied patent classifications as relevant to smartphones, the other a broader combination of more comprehensive lists of pertinent patent classifications plus company names and keywords.

1. The narrow approach

A list of restricted Cooperative Patent Classification (CPC) codes was used – mainly H04M 1/72519 ("Portable communication terminals with improved user interface to control a main telephone operation mode or to indicate the communication status") and H04M 1/247 ("Configurable and interactive telephone terminals with subscriber controlled features modifications"), plus a number of related sub-codes.[33] As the figures in this chapter show, these narrow choices necessarily lead to a gross underestimate of smartphone patents.

2. The broad approach

This involved the application of a broad list of International Patent Classification (IPC) codes generated by the identification of the most pertinent IPC categories in:

Section F: mechanical engineering, including lighting or cooling technologies;

Section G: physics, including measuring and navigation, optics, camera, controlling technologies, computing such as data and image processing, communication-related categories, cryptography, digital speech and information storage; and

Section H: electricity, including in telecommunications and digital communication processes, semiconductors and printed circuits and, for example, batteries.[34]

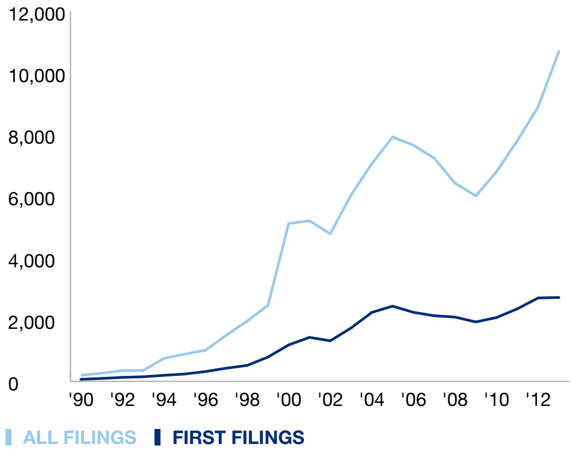
Some of these IPC classes are strictly related to smartphones and mobile communication in general. Others were generated by conducting keyword searches within the IPC classes and in patent databases – mostly Espacenet and the database of the German patent office – with the help of patent examiners.[35] A list of companies involved in the smartphone global value chain was compiled for further checks of the data. The objective was to single out IPC codes which might cover smartphone-related technologies, going beyond a narrow subset, but also covering the multiple technology areas highlighted later in figure 4.10, for example. This search strategy yielded patents in fields such as vehicles, cameras and some of the fields mentioned above, but the problem with this approach is that it yields a large number of patents, and some IPC classes such as semiconductors or cameras are essential but not exclusive to smartphones.

Figure 4.5

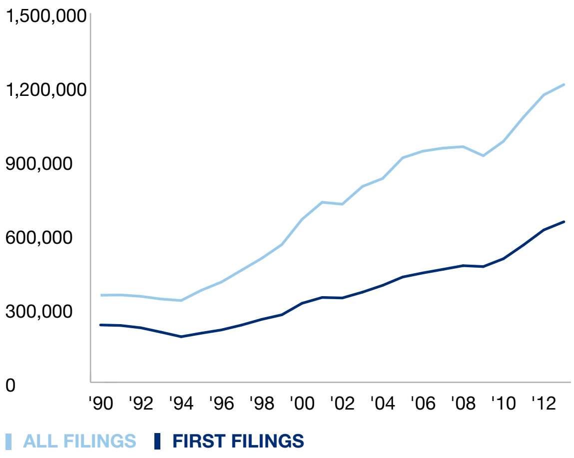
The number of smartphone patent filings is large and growing

First filings and all filings worldwide for smartphone-related patents (narrow and broad definitions), 1990-2013

Narrow



Broad



Notes: For the narrow and broad approaches to mapping smartphone patents, see box 4.2. "First filings" represent unique inventions protected by a unique patent. The same invention can then be patented in additional jurisdictions through secondary filings, leading to multiple patents on the same underlying invention ("all filings").

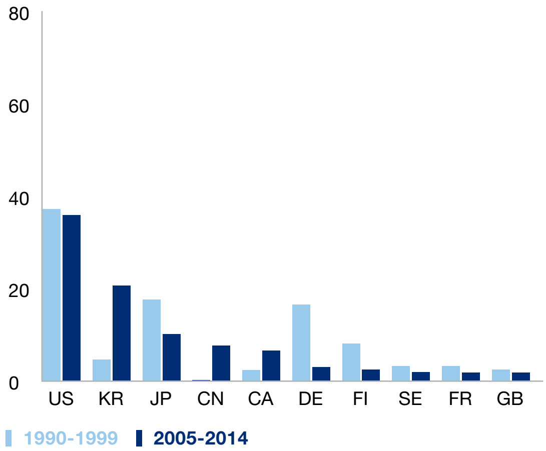
Source: WIPO based on PATSTAT database.

Figure 4.6

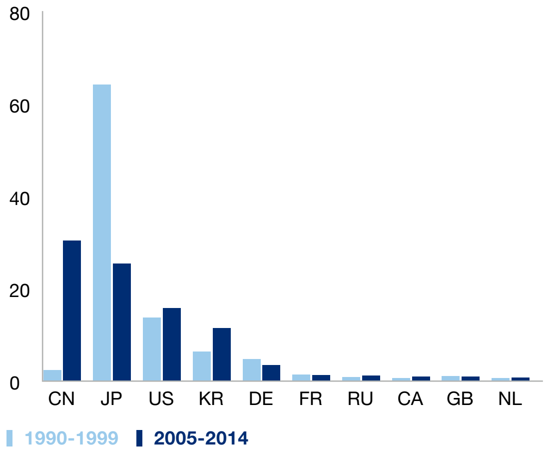
The top origins of smartphone patent filings have changed over the past decade

First filings worldwide by origin for smartphone-related patents (narrow and broad definitions), 1990-1999 versus 2005-2014

Narrow

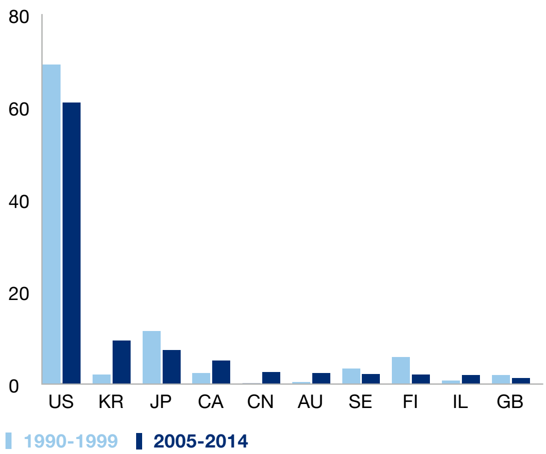


Broad

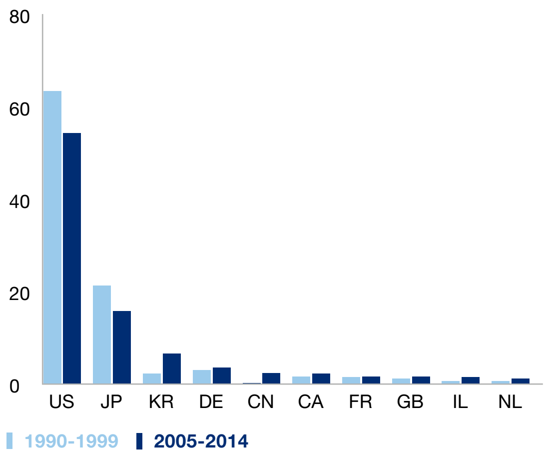


First filings at the USPTO by origin for smartphone-related patents (narrow and broad definitions), 1990-1999 versus 2005-2014

Narrow



Broad



Notes: The use of origin data at the USPTO in the bottom graph introduces a "home bias" at the expense of non-U.S. patent applicants, who tend to file fewer applications abroad or at the USPTO than in their own jurisdiction. Country codes as follows: AU = Australia, CA = Canada, CN = China, DE = Germany, FI = Finland, FR = France, GB = United Kingdom, IL = Israel, JP = Japan, KR = Republic of Korea, NL = Netherlands, RU = Russian Federation, SE = Sweden, US = United States.

Sources: WIPO based on PATSTAT and the USPTO database.

On both the narrow and broad definitions, the U.S., China, Japan and the Republic of Korea are the leading origins of smartphone patents worldwide, followed by patent filers based in Canada, Germany and Finland in the narrow category, and Germany, France, the Russian Federation and Canada in the broad category. Across both definitions, two trends stand out: (i) the shares of Japan and Germany (and in the narrow category, Germany and Finland) declined between 1990-1999 and 2005-2014; and (ii) the shares of China and the Republic of Korea rose markedly – mostly at the expense of Japan but not the U.S., whose share is increasing in the broad category. These trends correspond with the finding that IP capacity in relation to smartphones has built up significantly in these two economies (see figure 4.6). The U.S., Japan and the Republic of Korea are the leading origins of smartphone patents at the USPTO.

Where are smartphone patents filed worldwide, including by firms such as Apple, Huawei and Samsung? Although the lead firms involved in producing smartphones are heavily concentrated in a few countries such as the U.S., the Republic of Korea and China, smartphone inventors seek protection in multiple destinations; see figure 4.7, depicting smartphone patent families.[36] The U.S. is the most sought-after destination, followed by Europe, Japan and China, the Republic of Korea and, to a significant but lesser extent, Canada and Australia. Additional jurisdictions across the world also receive smartphone patent applications, including many economies in Latin America, the Russia Federation and Central Asia, other parts of Asia including Indonesia, but also South Africa, other parts of Africa and Australia.

The strong growth in smartphone-related patenting is first and foremost a reflection of the desire of inventors to appropriate the returns to their considerable innovation investments.[37]

In addition, the use of IP goes beyond the appropriation of innovation rents alone. In the smartphone industry, IP is also an important enabler of collaboration.[38] A smartphone would not see the light of day without extensive vertical and horizontal partnerships, and these are often enabled by IP. In the case of certain technologies, hundreds or sometimes thousands of patent holders, both firms and universities, supply inventions to form a new technology.

In the case of Bluetooth 3.0, which enables short range connectivity between the smartphone and other devices, more than 30,000 patent holders have contributed, including 200 universities.[39]

The use of IP also allows specialization. While most smartphone-related patents are held by large firms, including for defensive purposes, smaller and/or specialized component suppliers make extensive use of the IP system, affording scope for market entry.[40] For example, Corning, the producer of the Gorilla glass in Apple iPhones and a leading glass maker, files a significant number of patents.

In addition, major technologies relevant for smartphones are published via the patent system years, or sometimes decades, before actual commercialization of the knowledge, leading to effective knowledge transfer and possible technological learning.[41]

At the same time, the smartphone industry has experienced quite a patent build-up and related high-profile disputes in recent years. In the U.S., for example, the Apple-Samsung case produced one of the five largest initial adjudicated damages sums in the period 1997-2016, attracting considerable media attention.[42] In this context one may ask: do the increasingly strategic use of IP and the increase in legal disputes harm the smartphone industry?

In truth, the exact litigation costs to firms and the system-wide costs are unknown.

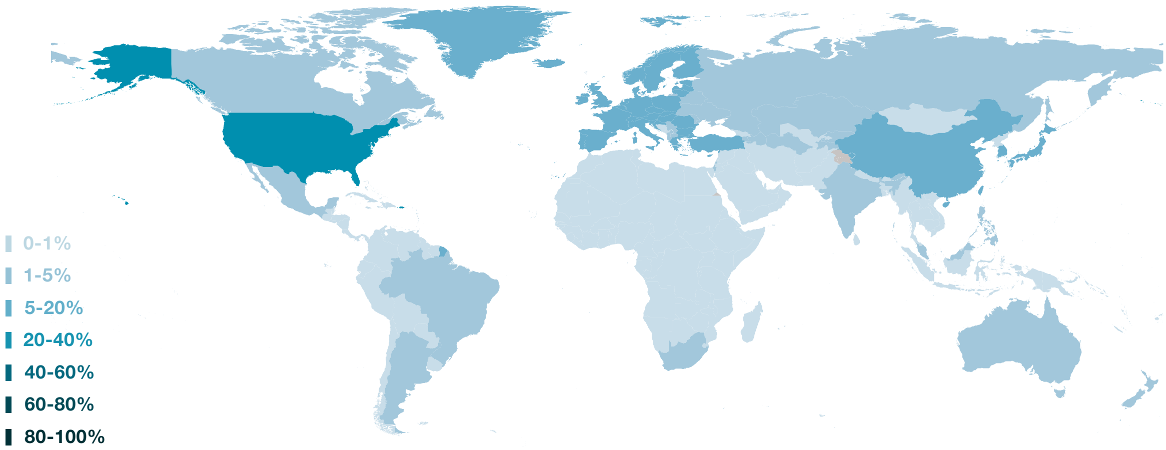
On the one hand, such disputes and their eventual resolution are a means for firms to attempt to appropriate the returns to their intangible assets. They are a reflection and byproduct of competition in a highly innovative marketplace with high stakes.[43] They are also a reflection of the substantial use of IP in this industry. And the smartphone industry is by no means special. Based on U.S. IP litigation data, other industries such as consumer products, biotech and pharma, computer hardware and software are considerably more litigation intensive.[44]

On the other hand, litigation may well impose considerable costs on firms without necessarily creating legal certainty. The Apple-Samsung case provides a prominent example – ongoing in multiple jurisdictions, and with heterogonous and fluctuating outcomes. In this respect, a related source of concern is the amount of litigation and the possible deadweight losses in legal expenditures.

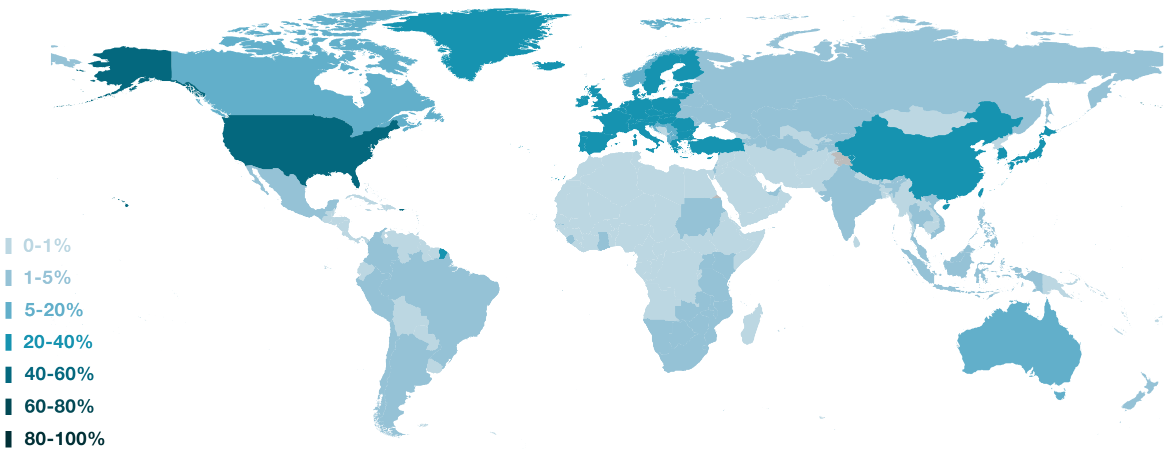
Figure 4.7

The United States is the biggest destination for smartphone patent filings

Total foreign-oriented smartphone patent families filed, 1995-2014 (narrow definition)



Total foreign-oriented smartphone patent families filed, 1995-2014 (broad definition)



Note: For the narrow and broad approaches to mapping smartphone patents, see box 4.2.

Source: WIPO based on PATSTAT.

An important question arises from an economic point of view: does the large number of smartphone patents truly incentivize investment in discovery and innovation? Or do these patents instead facilitate anti-competitive behavior by allowing incumbent firms to block key technologies, thereby reducing competition rather than rewarding continued innovation? In other words, the effects of large volumes of smartphone patents on follow-on innovation or market entry are of considerable interest.

Again, the definitive verdict on this issue is not out yet, but recent history testifies to continued smartphone innovation on both the hardware and application sides, and by both smartphone lead companies and an ever-changing array of component and service suppliers. And the rapid changes in the market shares of key firms in recent years would also seem to indicate solid competition among both large and smaller firms.

Moreover, firms have increasingly used market-based strategies to overcome scattered IP rights and solve disputes. Firms engage in collaborative IP strategies involving technology cross-licensing, patent pools, patent clearing houses and other collaboration. IP disputes have often been the effective trigger for amicable solutions – a recent example being the patent licensing deal signed by Nokia and Apple in the first half of 2017, ending all IP-related litigation between the two companies and triggering other forms of collaboration.

Standard-essential patents

The identification of standard-essential patents (SEPs) related to smartphones is simpler than mapping all smartphone-related patents. The IPlytics database was used; this combines IPC/CPC clusters with industry concordances focusing on SEPs in the ICT field.

A relatively high share of smartphone patenting relates to SEPs in the field of communication technologies (see figure 4.1).[45] These IP-enabled standards expand the potential licensing markets, encouraging investment in R&D.[46]

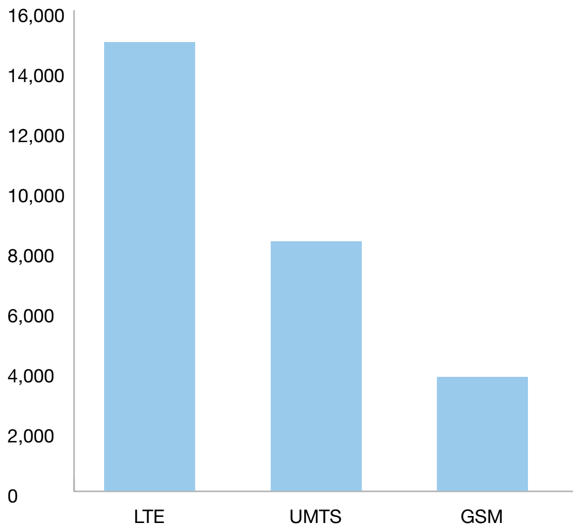
Over time, and as faster cellular and more complex technologies are developed, SEPs associated with these technologies have increased.

As illustrated in figure 4.8, the fourth-generation LTE cellular standard is associated with almost four times as many declared SEPs than the earlier, less complex, second-generation Global System for Mobile Communications (GSM) standard, and almost double the number for the third-generation Universal Mobile Telecommunications System (UMTS).

Figure 4.8

Smartphone standard-essential patents are on the rise in fourth-generation mobile technologies

SEPs for second-, third- and fourth-generation mobile technologies in number of unique patent family counts



Note: A patent family is a set of interrelated patent applications filed in one or more countries or jurisdictions to protect the same invention. See the glossary in WIPO (2016).

Source: WIPO based on IPlytics database, downloaded in June 2017.

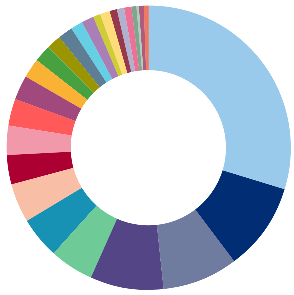
Figure 4.9 shows the breakdown for the GSM (top) and the more recent, fourth-generation, LTE standard (bottom). Over time, European and U.S. telecommunication companies' share of SEPs has declined whereas new entrants in the U.S. (mostly Internet firms such as Google) and new smartphone brands in the Republic of Korea (Samsung) and China (ZTE, Huawei) have seen their share grow – in part to utilize cross-licensing, reduce payments and fend off litigation. In addition to highlighting the fact that Asian players have become very active in contributing to the development of standards, these figures also demonstrate that firms such as Apple contribute less to their development.

Figure 4.9

The Republic of Korea, China and Internet-based firms are claiming a growing share of SEPs

Applicant company shares of worldwide SEPs for the GSM standard based on patent family count

- 33.16% Nokia Corporation
- 11.20% Ericsson
- 9.53% Nokia Siemens Networks SA
- 9.45% QUALCOMM Incorporated
- 5.56% Huawei Technologies Co., Ltd.
- 5.03% Siemens Aktiengesellschaft
- 5.03% Microsoft Corporation
- 3.73% Motorola Mobility
- 3.73% NTT DOCOMO, Inc.
- 3.28% InterDigital, Inc.
- 3.05% Panasonic Corporation
- 2.52% BlackBerry Limited
- 2.21% NEC Corporation
- 2.06% Core Wireless
- 1.75% Kyocera Corp.
- 1.52% Apple Inc.
- 1.37% Alcatel-Lucent
- 1.14% Sony Corporation
- 1.14% Sharp Corporation
- 0.91% LG Electronics Inc.
- 0.91% Intel Corporation
- 0.91% Rockstar Consortium Inc.
- 0.61% Samsung Electronics Co. Ltd.
- 0.53% Koninklijke Philips N.V.
- 0.46% Infineon Technologies AG
- 0.50% Others



Latest assignee company shares of worldwide SEPs for the LTE standard based on patent family count

- 13.49% Samsung Electronics Co. Ltd.
- 9.88% Huawei Technologies Co., Ltd.
- 9.41% QUALCOMM Incorporated
- 8.74% Nokia Corporation
- 6.58% Ericsson
- 6.13% LG Electronics Inc.
- 4.79% Google Inc.
- 4.52% InterDigital, Inc.
- 4.28% NTT DOCOMO, Inc.
- 2.14% Sharp Corporation
- 2.08% Panasonic Corporation
- 2.05% BlackBerry Limited
- 1.74% Apple Inc.
- 1.61% Institute of Telecommunication Science And Technology
- 1.56% NEC Corporation
- 1.47% China Academy of Telecommunications Technology
- 1.40% ZTE Corp.
- 1.26% Texas Instruments Inc.
- 1.20% Siemens Aktiengesellschaft
- 1.20% Electronics and Telecommunication Research Institute
- 1.12% Sony Corporation
- 1.12% Alcatel-Lucent
- 0.91% Nokia Siemens Networks SA
- 0.88% Kyocera Corp.
- 0.70% Microsoft Corporation
- 8.15% Others

Source: WIPO based on IPlytics database.

Note: SEP declarations exceed the number of patents which are actually standard essential. See Audenrode et al. (2017) for details.

Some of these SEPs were developed internally whereas others were acquired as part of patent portfolios, with, for example, Apple, Microsoft and others buying the Nortel patent portfolio, Google buying the Motorola portfolio and Lenovo buying an SEP portfolio from Unwired Planet that Unwired Planet had originally acquired from Ericsson. Lenovo also later acquired parts of the Motorola portfolio from Google.[47] Moreover, patent assertion entities (PAEs) such as Intellectual Ventures and Rockstar have been increasing their ownership share.[48]

While the share of litigated SEPs in total declared SEPs has been increasing over time up to 2015, the broader ownership of patent portfolios seems to have encouraged cross-licensing deals and patent pools, potentially reducing litigation in years to come. A drop in related litigation has been observable since 2012.[49]

Looking forward, firms are currently working on obtaining a stake in fifth-generation mobile technology, with a lead role for Huawei, Samsung and selected Japanese firms, but also for European and U.S. companies such as Nokia, Qualcomm, Ericsson and Orange. Other Internet firms are also claiming their stake; Google, for example, has made related acquisitions.[50]

For the purposes of this study, sensible estimates for the value of SEP-related licensing payments are required so as to better approximate total returns to intangible assets.

Unfortunately, most suppliers do not report licensing data, and for those who do, it is challenging to single out the income which is indeed driven by smartphone SEPs. Fortunately, a number of reports exist in the field, with some – often from the camp of licensees – suggesting that so-called “royalty stacks” are excessive while others – often from licensors – argue that they are reasonable.[51] Based on these studies, it is assumed here that SEP licensing costs range from 3 to 5 percent of the retail price of a phone (see box 4.1 and table 4.7).[52]

At the level of individual firms the related incomes are significant. Annual reports show that Nokia, for example, generated about USD 1 billion in licensing revenues in 2016 (and a predicted EUR 800 million in 2017), while Ericsson earned around USD 1.2 billion in 2016.[53] Two-thirds of Qualcomm’s revenues in 2016 came from chip sales (USD 15.4 billion), and one-third from licensing its technology (USD 7.6 billion).

Table 4.7

Mobile SEP licensing fee revenues and royalty yields in the global handset market, 2014

	Revenues (USD bn)	Yield*
Major SEP owners with licensing programs: Alcatel-Lucent, Ericsson, Nokia, InterDigital, Qualcomm	10.6	2.6
Patent pools: SIPRO (WCDMA), Via Licensing and Sisvel (LTE)	< 4	<1
Others: including Apple, Huawei, RIM, Samsung, LG	< 6	<1.5
Cumulative maximum: fees and yield for mobile SEPs	~ 20	~5

Note: Yields are total licensing fee revenues including lump sums and running royalties as a percentage of USD 410 billion in total global handset revenues.

Source: Dedrick and Kraemer (2017) based on Mallinson (2014) and Galetovic et al. (2016).

The percentages used here – and also to derive value capture in section 4.2 – are conservative estimates. Moreover, they exclude IP revenues generated via technologies covered by implementation patents.

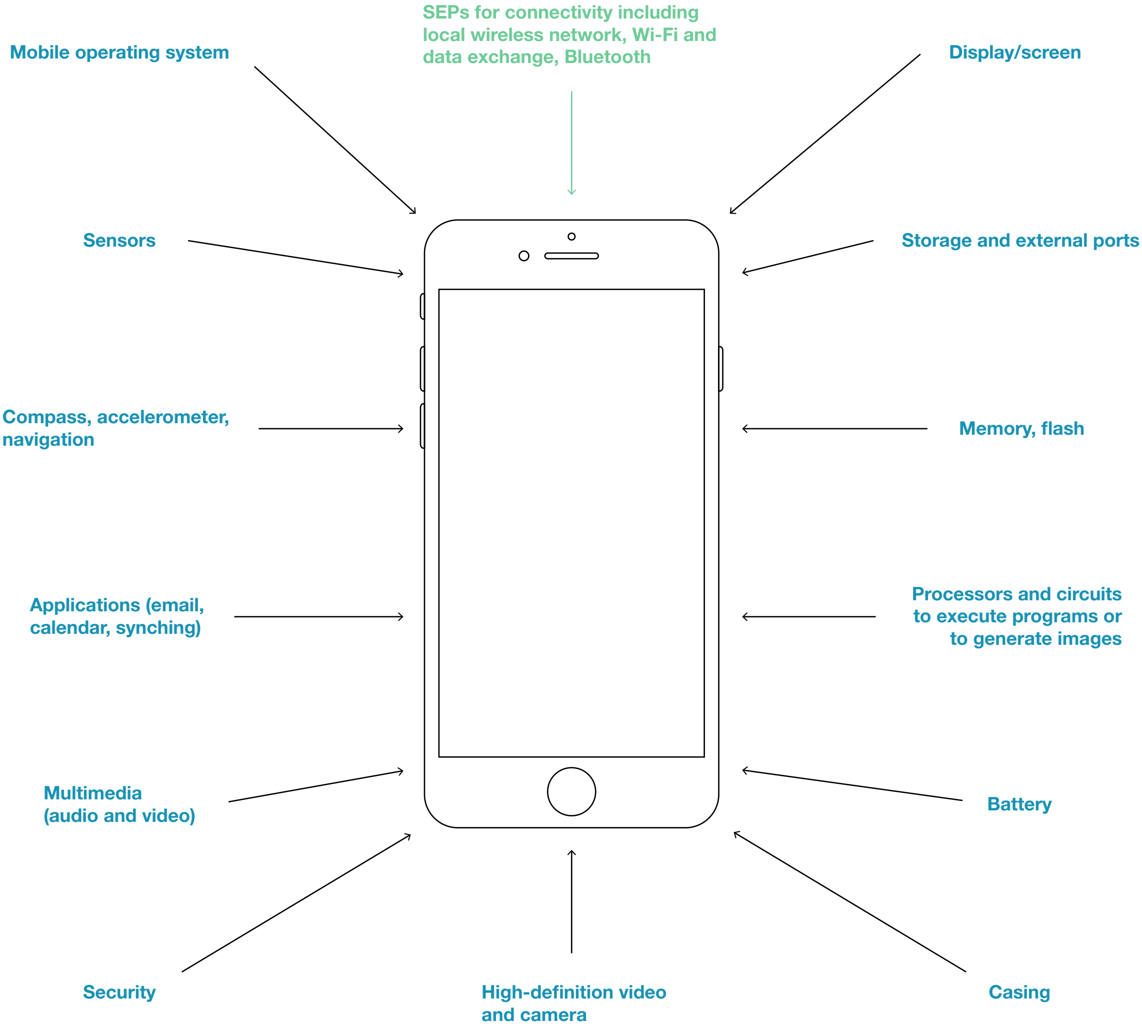
Implementation patents

Implementation patents involve technologies that can provide differentiation for specific products for individual manufacturers. Both lead firms and component suppliers patent and license such technology. The former, for example, might acquire a license to use a microprocessor from companies such as ARM.[54] For some firms, including Microsoft and BlackBerry, licensing their patents to third parties is at the core of their operations, whereas firms such as Apple do not license their patents.

Figure 4.10 illustrates the technology areas with the majority of implementation patents beyond the SEPs discussed earlier.[55] In terms of technology fields, the most important ones are in the areas of image display and screen (and more recently organic light-emitting diode screens), battery, antenna and more software-related ones like mapping, calendar management, voice recognition and other features in the field of artificial intelligence.[56]

Figure 4.10

Smartphones draw on an increasing number of technology fields



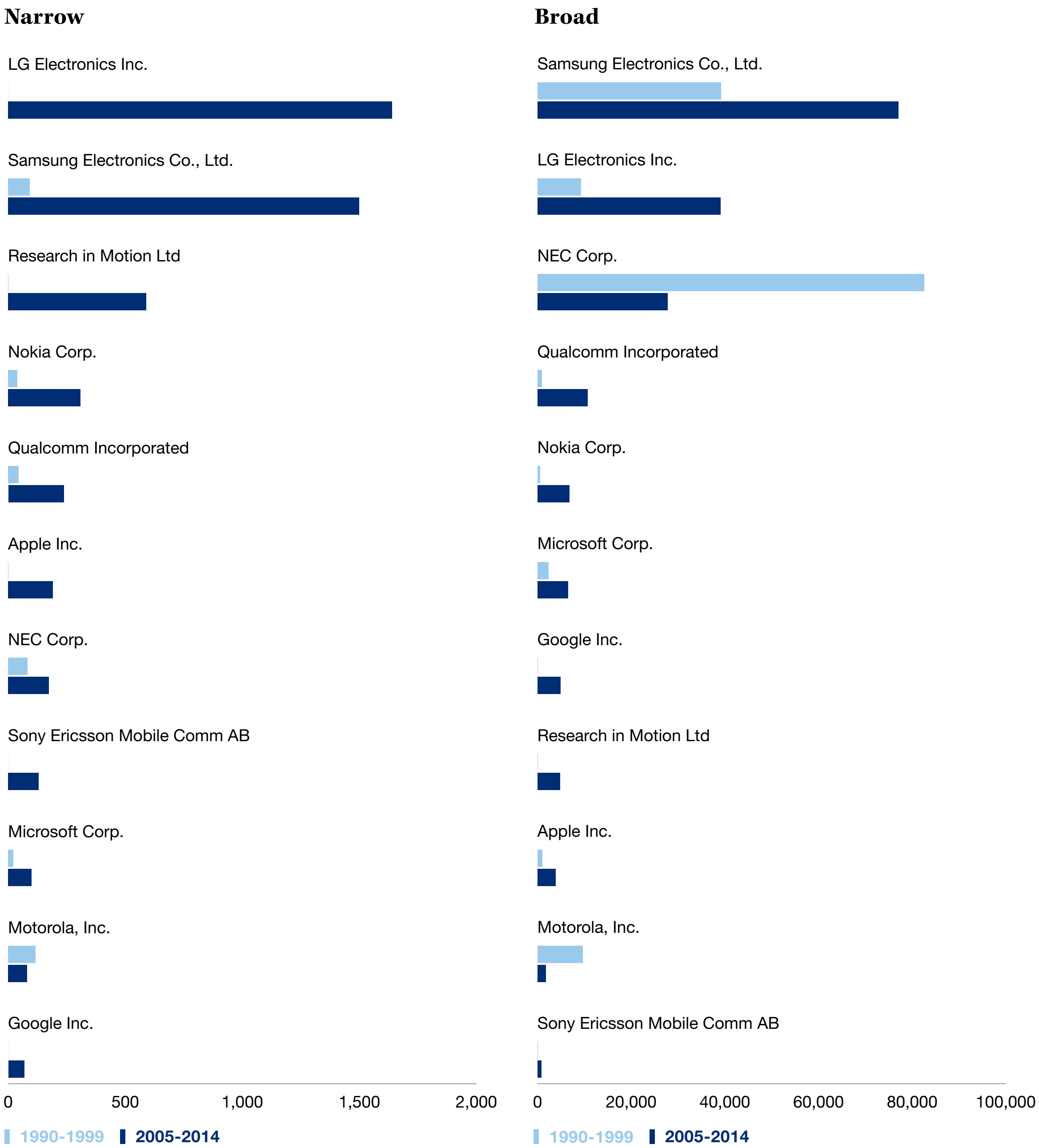
Smartphone patents worldwide are led by Samsung Electronics, LG Electronics, NEC Corporation – a Japanese IT services and product firm – and Qualcomm in the broad category, and LG Electronics, Samsung Electronics, Research in Motion and Nokia in the narrow category. Over time, NEC and Motorola have become less important players while others such as Apple, Microsoft and Google have joined the fray (see figure 4.11). As expected – see also table 4.8 – Apple's share of patent filings is more significant in the narrow smartphone category than if one considers broad fields of related technologies in which other firms excel.

Smartphone patents at the USTPO during the period 2000-15 were led by Samsung Electronics and Apple when the narrow definition is applied, and by IBM and Samsung under the broad definition (table 4.8). Thanks to its recent strong wave of patent filings, Huawei now ranks among the top 40 smartphone patent filers at the USPTO. In the broad category, however, Honghai Precision files more USPTO patents than Huawei, echoing a trend signaled earlier in this chapter. Table 4.8 also features some non-practicing entities such as ELWHA, a holding company of Intellectual Ventures, as well as universities such as the University of California.

Figure 4.11

Samsung Electronics, LG Electronics, NEC and Qualcomm are the global leaders in smartphone-related patents (broadly defined)

First global filings of smartphone-related patents (broad and narrow definitions), 1990-1999 versus 2005-2014



Note: For the narrow and broad approaches to mapping smartphone patents, see box 4.2.

Source: WIPO based on PATSTAT database.

Table 4.8

Smartphone-related patents at the USPTO are led by Samsung and Apple (narrow definition) and IBM and Samsung (broad definition)

First filings of smartphone-related patents (narrow and broad definitions) at the USPTO, 2000-2015

Narrow

Company name	USPTO patents	Percentage of USPTO smartphone patents
Samsung Electronics	1,239	3.2
Apple	810	2.1
Qualcomm	522	1.4
LG Electronics	502	1.3
Motorola	663	1.3
Intel	832	1.2
Digimarc	450	1.2
Nokia	443	1.1
Microsoft	556	1.1
Silverbrook Research, Australia	393	1.0
Sony Ericsson Mobile	303	0.8
NEC	293	0.8
Google	262	0.7
Research in Motion	256	0.7
Sony	230	0.6
IBM	201	0.5
Panasonic	163	0.4
BlackBerry	158	0.4
Broadcom	140	0.4
Fitbit	140	0.4
Fujitsu	137	0.4
Palm	134	0.3
Headwater Partners, U.S.	134	0.3
AT&T IP	133	0.3
Kyocera	131	0.3
Flextronics	113	0.3
Energous	107	0.3
Citrix Systems	103	0.3
Nokia Mobile Phones	100	0.3
FLIR Systems	90	0.2
Ericsson	85	0.2
Honda Motor	84	0.2
AT&T Mobility	83	0.2
Tencent Technology	82	0.2
Nant Holdings IP	72	0.2
Hewlett Packard	68	0.2
Huawei	65	0.2
Sharp	63	0.2
Elwha LLC	63	0.2
NTT DoCoMo	62	0.2

Broad

Company name	USPTO patents	Percentage of USPTO smartphone patents
IBM	57,414	1.8
Samsung Electronics	41,421	1.3
Qualcomm	29,572	0.9
Intel	26,150	0.8
Microsoft	22,844	0.7
Canon	18,983	0.6
Fujitsu	18,038	0.6
Sony	18,036	0.6
Panasonic	17,515	0.5
Hewlett Packard	16,881	0.5
Honda Motor	14,859	0.5
Hitachi	11,985	0.4
Google	11,243	0.3
Philips Electronics	10,818	0.3
Seiko Epson	10,645	0.3
Apple	10,598	0.3
Motorola	10,489	0.3
LG Electronics	10,369	0.3
Texas Instruments	10,213	0.3
Taiwan Semiconductor Mfg	9,399	0.3
NEC	9,093	0.3
Infineon Technologies	8,221	0.3
Cisco Tech	8,033	0.2
General Electric	7,764	0.2
Honghai Precision	7,613	0.2
3M	7,391	0.2
Honeywell	7,284	0.2
Samsung Display	7,212	0.2
Mitsubishi Electric	6,956	0.2
Toshiba	6,693	0.2
Nokia	6,567	0.2
Sharp	6,526	0.2
Ericsson	6,469	0.2
Broadcom	6,254	0.2
Advanced Micro Devices	6,027	0.2
Siemens	5,892	0.2
Huawei	5,845	0.2
Semiconductor Energy Lab	5,810	0.2
University of California	5,477	0.2
Sun Microsystems	5,341	0.2

Note: For the narrow and broad approaches to mapping smartphone patents, see box 4.2. Source: WIPO based on USPTO database.

The patents and other rights related to software and applications are important intangible assets, possibly determining a large share of future value capture. By using its own mobile operating system, Apple gains greater control of the downstream market for applications and content, such as on the App Store, typically asking 30 percent of in-app purchases from application developers, dropping to 15 percent under special conditions later.[57] According to information produced in IP-related litigation and unconfirmed reports in the press, firms such as Google paid Apple USD 1 billion in 2013 and possibly three times that amount in 2017 to be the default search engine in mobile Safari, the pre-installed web browser on iPhones and other iOS devices.[58]

Android is monetized in a different way, not through charging a direct usage fee. If phone makers want to run Android on their phones, they need to install the Google ecosystem (Search, Play Store, Maps) on their phone. Google makes money from Android in two ways: it takes a proportion of the sales of apps and media on the Google Play Store, and it shows display advertising to Android users. Google excludes phone makers from any revenue from the Play Store, reducing their ability to generate revenues from downstream content and services markets.

Firms such as Samsung using the Android system have also decided to pay significant patent royalties to Microsoft to settle claims by Microsoft that Google's Android violates Microsoft patents. Samsung made a royalty payment of over USD 1 billion to Microsoft in 2013, according to court filings and news articles.[59]

4.3.2 – Smartphone design is critical to consumers

The literature, consumer surveys and court decisions find that smartphone design – both physical and software-related – is one of the most critical factors driving consumer purchase decisions, technology acceptance and later brand loyalty.[60] This is particularly the case when technical features are the same across phones.

Understandably, then, all three handset lead firms in question invest considerable sums in new designs and related partnerships, and in recruiting a large number of designers.

Industrial designs are held mostly by large lead firms rather than component suppliers and smaller entities.[61] An econometric study suggests that in the case of Apple, filing industrial designs – referred to as design patents in the U.S. – is actually more important to the evolution of the firm's stock market value than patents.[62] In the well-known Apple-Samsung case, industrial design infringement and the copying of the look of Apple's smartphones – including elements of GUIs, especially icons – were the subject of legal dispute in U.S. and other courts.[63] Since the Apple -Samsung jury award in 2012 in the U.S., industrial design filings have also been increasing at the USPTO – potentially in part due to the high damages initially awarded to Apple (see also figure 4.12).[64] At time of writing, this case is not fully closed in the U.S.: the Supreme Court reversed the first trial decision in December 2016. Furthermore, related litigation is still pending or has produced different outcomes in other jurisdictions. All of this illustrates the inherent legal uncertainty associated with enforcing industrial designs. Still, the court cases and ensuing design filing activity reflect a broader movement toward using industrial designs as a tool for appropriating innovation rents in conjunction with other IP forms.

A look at the leading industrial design filers illustrates the point: Samsung, Sony, Microsoft, LG, Hon Hai Precision/Foxconn and Apple were among the top holders of design patents at the USPTO in 2015.[65] Identifying industrial designs which relate to the specific smartphones used in section 4.2, or to smartphones in general, is complicated by various factors.[66] For a start, there is no specific classification for smartphones in the International Classification for Industrial Designs under the Locarno Agreement, or in the United States Patent Classification System (USPC). Industrial designs for smartphones do not just concern the device itself, but also GUIs, icons, display screens, and so on. Moreover, some of the GUIs and icons are used across different product groups. For example, an industrial design for an Apple icon or GUI is likely to be used across all Apple family products (iPhone, iPad, iPod, etc.), and is thus not exclusively a smartphone design. Some Samsung GUIs may apply to washing machines, fridges, photo cameras or video cameras.

Figures 4.11 and 4.12 present the industrial designs protected by Apple, Samsung Electronics and Huawei using data from the USPTO and the European Union Intellectual Property Office (EUIPO). In the case of the USPTO, USPC class D14 (Recording, Communication, or Information Retrieval Equipment) was used as a starting point to then filter further using patent titles. The same approach was used for the EUIPO, with the difference that the initial dataset included all applications for classes 14-03 (Communications Equipment, Wireless Remote Controls and Radio Amplifiers) and 14-04 (Screen Displays and Icons) of the International Locarno classification for Industrial Designs.

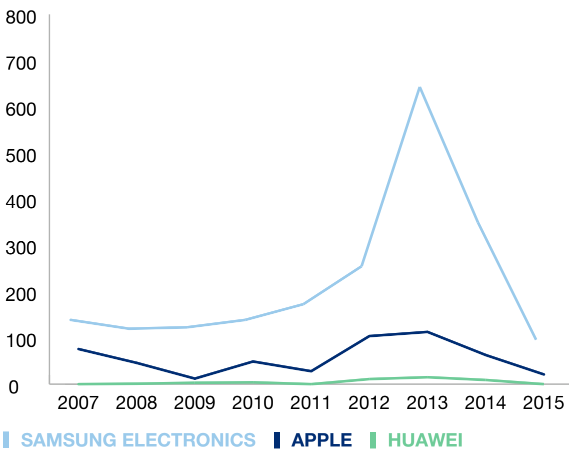
The design portfolios of Apple and Samsung at the USPTO and the EUIPO are large and have been growing, with a particularly big spike in 2012 or 2013 (see figure 4.12). As noted above, Apple's initial success in enforcing a GUI design against Samsung in the U.S. courts may have contributed to this GUI filing growth. The number of registrations by Samsung Electronics far outstrips those of Apple, but this most likely also reflects potential measurement issues as Samsung is a more diversified electronics conglomerate than Apple. While Huawei has started registering industrial designs in recent years, Apple and Samsung still own considerably more extensive design portfolios.

The portfolios of designs protected by the three companies are also distinct. A large proportion of Huawei designs protected at the USPTO (41.9 percent, or 18) in the period 2007-2015 were designs of phones themselves. In contrast, most of Apple's designs in the same period were for GUIs (75.2 percent). Samsung Electronics designs were also mainly GUIs (43.7 percent of total), but followed in absolute number of registrations by designs for phones themselves (30.9 percent). Apple's design registrations at the EUIPO were largely for GUIs (70.1 percent of total), while all of Huawei's were for phones. There was a major peak in design registrations around 2012-2013, following the Apple-Samsung legal dispute. Industrial designs in these two years alone represent 42.4 percent of all Apple's designs at the USPTO in the period 2007-2015, and 22.2 percent at the EUIPO. For Samsung they represent 44.1 percent of total designs in the period 2007-2015 at the USPTO and 44.3 percent at the EUIPO.

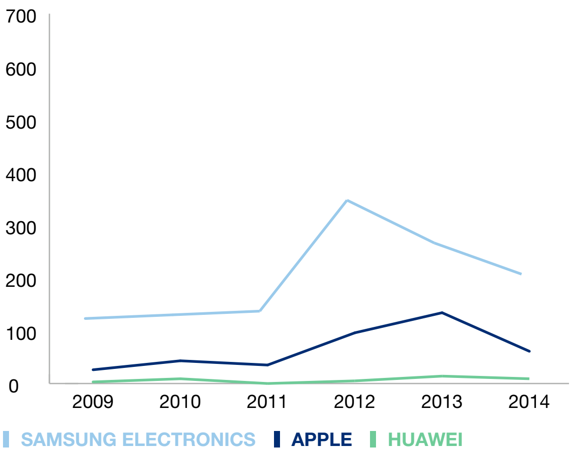
Figure 4.12

Industrial designs by smartphone firms increased in 2012 and 2013

Number of industrial designs registered at the USPTO, 2009-2014



Number of industrial designs registered at the EUIPO, 2009-2014



Notes: Data correspond to industrial designs that are registered and published. EUIPO data show the total number of individual designs published and registered in all applications filed. Only data for Samsung Electronics are presented. However, it is common practice that designs can be filed through subsidiaries. For example, Samsung Display Co. Ltd., a Samsung subsidiary, registered 22 industrial designs at the EUIPO in the period 2013-2015.

Sources: WIPO based on the USPTO and EUIPO databases.

Over time, the design portfolios of the three companies have also changed. Apple was an early mover in the industry. It filed a total of 370 designs at the EUIPO in 2007 and 2008 – 35.7 percent of its total in the period 2007-2015 – coinciding with the release of the first iPhone. None of these registrations related to the smartphone design itself, but rather to GUIs (69.2 percent) and icons (30.8 percent). This is not surprising given that most of Apple's designs are not iPhone specific, but are used across Apple products. Since then, Apple has been registering industrial design registrations (or design patents in the U.S.) at the USPTO and the EUIPO less frequently. It is hard to know the exact reasons for this trend, but one possible explanation is that Apple's design ecosystem and identity have now been set up and are relatively mature.

In contrast, Samsung's portfolio has been more volatile. Its registrations of designs of GUIs and icons have increased over time, while those for smartphones themselves have decreased. Samsung could be following Apple's strategy and adapting to the market, particularly after 2012 and the GUI legal dispute.

Finally, Huawei is an emerging player in the industry, with a low absolute number of design registrations relative to Apple and Samsung. All its registrations at the EUIPO are for the smartphone itself, although it has patented designs for GUIs at the USPTO.

Protection of designs for smartphones and related GUIs and icons seems to be increasingly important. In many jurisdictions, these types of designs are among the fastest growing and represent the types of designs for which industrial design protection is most frequently sought, by both local designers and those based abroad.[67] Often, GUIs impact not only appearance but also functionality – not covered by industrial design rights – and ease of use. Different IP rights offer different protection and have different eligibility requirements, and there may be significant variations in both protection and eligibility criteria across jurisdictions. Patent, design and copyright protection are the most likely options for legal protection.[68] In the U.S. a special form of trademark, trade dress, which covers the appearance of a product, its box, shape or otherwise, may also be relevant, for example to protect the distinctive design of Apple's iPhone boxes.

Figure 4.13 sets out filings (or registrations) by Apple and Samsung with respect to GUIs and icons. The number of GUI industrial designs filed by Apple and Samsung Electronics has grown considerably since 2012 at both the USPTO and the EUIPO. At the EUIPO, Apple filed 222 designs on GUIs between 2009 and 2014, while Samsung filed 379. In 2007, the same year the first iPhone was released, half (38) the industrial designs filed by Apple at the USPTO were for GUIs, and the other half were icon designs. In 2008, GUI industrial designs accounted for 89 percent (41) of Apple's filings at the USPTO. About 66 percent (189) of Apple's filings at the EUIPO in 2008 were for GUIs, and 34 percent (98) were icon designs. Icon designs have also grown, particularly for Samsung, which more than tripled its number of icon design applications at the USPTO between 2012 and 2013. Remarkably, Huawei filed only 17 designs for display screens with GUIs between 2012 and 2015 at the USPTO, and has so far filed no GUI designs at all at the EUIPO.

Comparing the absolute number of industrial designs filed by these firms is challenging, however. First, the methodology used to identify smartphone industrial designs is not exact. Second, Samsung Electronics is a conglomerate filing for a large product range of smartphones and other electronics products, whereas Apple has released 15 iPhone models onto the market since 2007.[69] Finally, Apple's designs for GUIs and icons are used across all Apple products and in many cases across iPhone models, which can result in even fewer absolute filings.

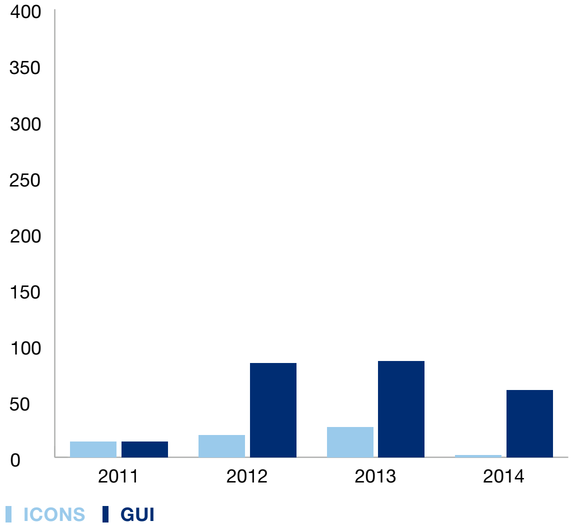
Lastly, in some cases an overlap between trademark and design protection arises, if and when firms later trademark a design, claiming distinctiveness. An industrial design and a trademark may be obtained covering the same subject matter:[70] the former grants a limited period of protection for a design, while the latter may in effect provide perpetual protection for the same design as a mark.

Figure 4.13

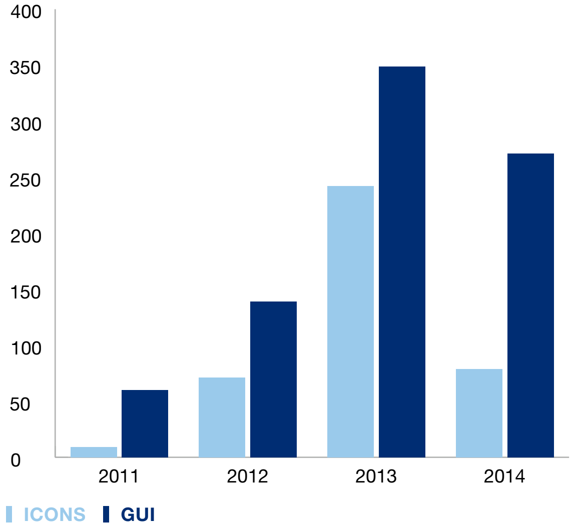
GUIs and icons represent the largest share of smartphone industrial designs

Number of industrial designs registered at the USPTO by company and type

Apple

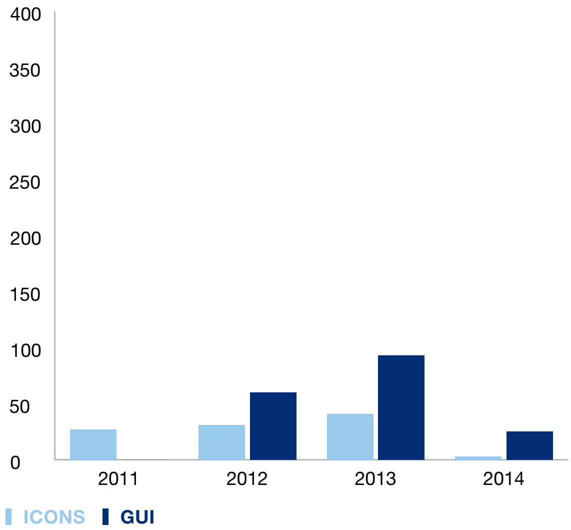


Samsung Electronics

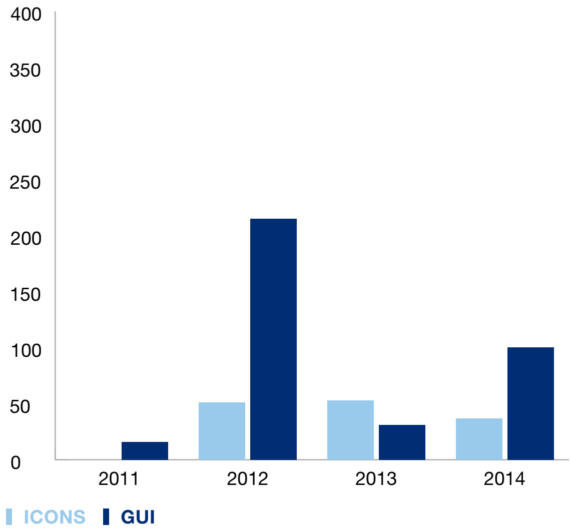


Number of industrial designs registered at the EUIPO by company and type

Apple



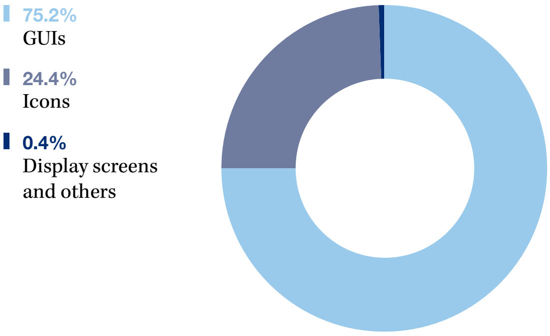
Samsung Electronics



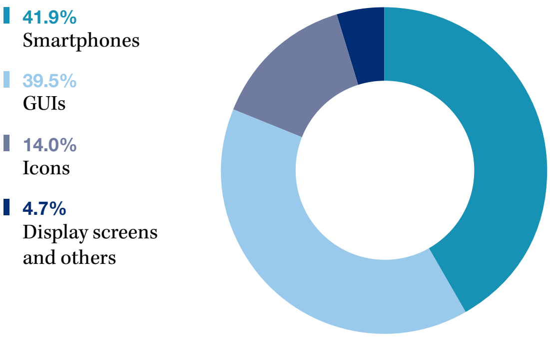
Source: WIPO based on USPTO and EUIPO databases; see technical notes.

Figure 4.13 (cont.)

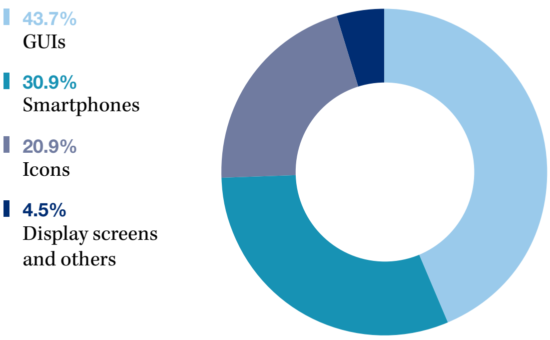
Share of industrial designs (“design patents”) registered at the USPTO by selected companies for different smartphone elements, 2007-2015



Apple

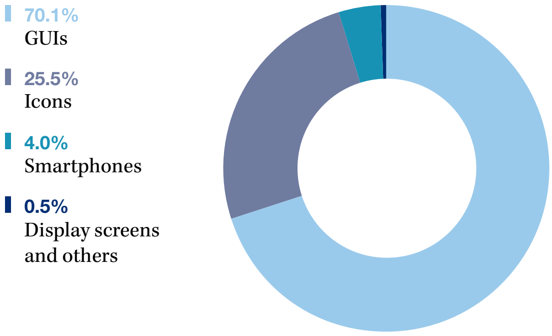


Huawei

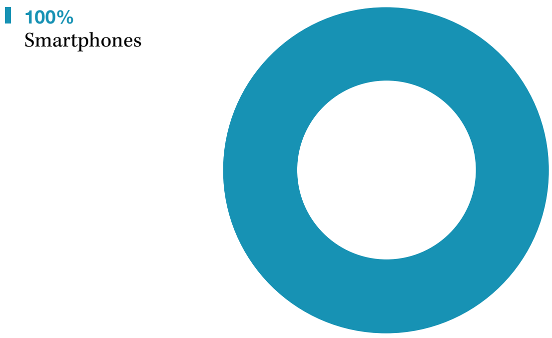


Samsung Electronics

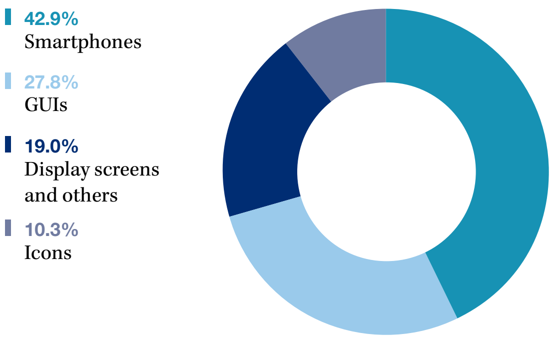
Share of industrial designs registered at the EUIPO by selected companies for different smartphone elements, 2007-2015



Apple



Huawei



Samsung Electronics

Source: WIPO based on USPTO and EUIPO databases; see technical notes.

4.3.3 – The high value of the brands behind the leading smartphones

The *World Intellectual Property Report 2013* outlined the importance of brands – and trademarks – as intangible assets, and as a driver of the ability to command higher prices, including in the smartphone sector.[71] Brands were also shown to play an important role in explaining why lead firms capture a majority of profits along the way.

Apple, Samsung and more recently Huawei spend heavily on advertising (see figure 4.14). Echoing the interrelationship between branding and innovation, all three firms put marketing on par with R&D for the development of innovative products. Apple increased spending to USD 1.8 billion in 2015 (with 2016 figures unavailable), while Samsung spent USD 3.8 billion in 2016 – rivalling companies with the largest advertising budgets worldwide such as Coca-Cola, after a sustained decision as of 2012 to vastly increase its yearly advertising spend, mainly to promote its Galaxy brand.[72] Official advertising data for Huawei are not available, but the ever-more global marketing campaigns around the company and its P-series smartphones demonstrate its intent to move out of the low-margin segment by building a premium brand.[73]

Identifying the value of brands for the smartphone business in general, or for specific smartphone models in particular, is challenging. Much of a brand's value rests with the reputation and image of the lead firm, such as Apple, Samsung or Huawei, and this brand value is particularly high, with Apple and Samsung at the top of brand rankings, and Apple in the number one spot for two out of the three rankings (see table 4.9 of this report plus table 1.1 and box 1.6 in WIPO, 2013 for a technical critique of these brand values). Huawei is worth less as a brand, but is catching up. Newer Chinese smartphone firms are still distant.

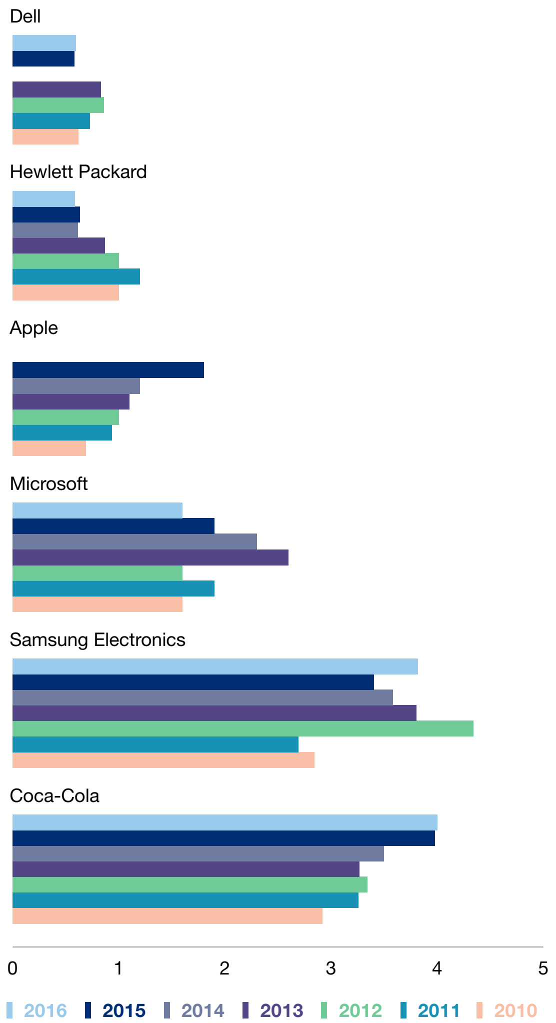
The three companies follow similar branding and trademark strategies. According to estimates produced for this report, Apple started registering trademarks related to its iPhone at the USPTO in 2006, including a trademark for the name "iPhone."[74] Sustaining its lead-time advantage, the company then registered a total of 15 trademarks in 2007, the year it introduced the iPhone. Samsung and Huawei started registering smartphone-related trademarks only in 2009 and 2011, with Samsung seemingly filing a relatively high number of trademarks without necessarily using them in the marketplace subsequently.

While Huawei registered few trademarks – just 10 in all over the entire period – Samsung immediately began to register a large number of trademarks; it has registered a total of 300 over this period. Samsung's spike in trademark registrations in 2012 coincided with the previously mentioned increased advertising that year (see figure 4.15).

Figure 4.14

Samsung and other smartphone makers are among the world's top advertisers

Global advertising expenditure (USD bn)



Notes: Data for Dell not available for 2014. Data for Apple not available for 2016. Data for Microsoft and Apple correspond to fiscal years.

Source: WIPO based on company annual reports.

Table 4.9

Brand values of leading smartphone makers, 2016

Company	Interbrand Rank and value	As a percentage of market cap	BrandZ Rank and value	As a percentage of market cap	Forbes Rank and value	As a percentage of market cap
Apple	Rank 1 USD 178 bn	23	Rank 2 USD 22 bn	30	Rank 1 USD 154 bn	20
Samsung	Rank 7 USD 52 bn	20	Rank 48 USD 19 bn	7.2	Rank 11 USD 36 bn	13
Huawei	Rank 72 USD 6 bn	0.4	Rank 50 USD 19 bn	1.3	–	n.a.

Sources: Dedrick and Kraemer (2017) based on WIPO (2013) and data from Interbrand (2016), Millward Brown (2016) and Forbes (2016).

Few trademarks seem to relate specifically to a particular smartphone model, reinforcing the conclusion that the brand value draws mainly on the generic company trademark. For example, Apple has not protected the term “iPhone 7” via a trademark. Samsung filed a trademark for “S7” or “S7Edge” but abandoned it at the USPTO, though it is protected at the EUIPO. Huawei is the only company that pursues a trademark strategy that protects the brand name displayed on the device, the name of the product series and the specific product name, for example “Huawei P9” at the USPTO. All three market leaders have, however, sought to protect the product series such as “iPhone”, “Galaxy” and “Huawei P.”

In addition, trademarks are registered on underlying hardware or software innovations which become distinctive product features. Examples are “retina display” (Apple) and “Infinity display” (Samsung) and – in Apple’s repertoire – “assistive touch”, “AirPort Time Capsule” and “A10 fusion chips.”

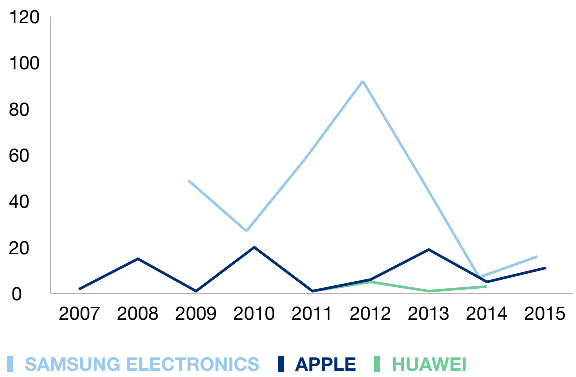
Figure 4.16 shows the smartphone trademarks of Apple, Huawei and Samsung Electronics by Nice class – the international classification of goods and services applied for the registration of trademarks – over time.[75] The relevant class for smartphones is class 9, and all three companies submit their greatest number of filings in this class, with Apple filing 68 in the period 2007-2016, Samsung close to 300 and Huawei around 10. The most interesting aspect of this graph is the distribution across classes, precisely because the companies do not file only in class 9, but spread their trademarks across classes, especially services.

This is important for two reasons: (i) it helps them to build brand value and use their brand for a larger range of product and service categories than just “traditional” electronic products and (ii) occupying as much space across classes as reasonably possible means they are better placed to avoid the appropriation of brand value by competitors and other firms (and squatters), but bearing in mind that a mark must be used for the relevant class in order to be protected. The graph also shows that Huawei is starting to change its approach by filing in more classes.

Figure 4.15

Apple was the first to file smartphone trademarks

Number of smartphone-related trademarks registered annually at the USPTO by Apple, Huawei and Samsung, 2007-2015



Source: WIPO based on USPTO database; see technical notes.

Figure 4.16

Smartphone trademarks are increasingly filed in service-related classes

Smartphone-related trademark registrations filed annually at the USPTO by Apple, Huawei and Samsung, by Nice class, 2006-2016

Note: The size of the bubble indicates the number of trademark filings for the relevant Nice class.

Source: WIPO based on USPTO database; see technical notes.

Huawei filed exclusively in class 9, but Apple and Samsung also filed smartphone-related trademarks in a number of other classes, including those related to services. For example, the first iPhone trademark in 2006 was also filed in class 28, which comprises games and toys, as a "hand-held unit for playing electronic games." The most common service class is class 38, which covers telecommunication services, but there are also a number of filings in class 42, which covers design and development of computer software, among other things.

As suggested earlier, Apple holds three trademarks on the design (trade dress) of its iPhone. Samsung also attempted to get such IP protection at both the USPTO and the EUIPO but failed. Rights in relation to packaging are interesting too. Apple has a trademark as well as a design right on the shape of the iPhone box.

In addition, some component suppliers also own trademarks which handset brands use when marketing their phones, such as Corning's Gorilla Glass trademark or Huawei's use of the Leica trademark to market its new smartphone camera.

Handset makers and component suppliers also refer to and license trademarks on standards and third-party technologies essential to the networking capacity of the phone, such as "LTE", "Wi-Fi" and "Bluetooth." Such marks are usually owned by standard-setting organizations or industry alliances, not individual component suppliers.[76]

Finally, elements which relate to smartphone software, content and services such as "Siri" for Apple and "Bixby" for Samsung, "iTunes" or "Apple Pay" are also protected by trademarks.[77] Some are owned by third-party providers such as "Android."

Trademarks are also filed on GUIs and icons related to smartphone applications and accessories. Apple and Samsung are particularly keen on filing for trademark and industrial design protection on GUIs, underling the notion that GUIs distinctively identify products.

4.4 – Perspectives on technological learning and intangibles

How has technological learning occurred in the smartphone global value chain? Is value capture shifting? And what role might IP play in this process?

Once more, a simple answer is impossible; the factors at work are too manifold. But it is useful to recall the timetable for smartphone innovation, and the small number of firms and locations involved.

In terms of the inventions required for smartphones, the development of mobile phones and underlying technologies dates back several decades. The first handset was launched by Motorola in 1973.[78] Cell phones also depend on a vast set of other technologies, including processors, which have their own long history.[79] The first critical patent for wireless communication, for example, can be traced back to 1974.

In terms of market penetration, NTT DoCoMo – a Japanese firm – reached relatively high penetration in Japan with its first smartphones, introduced in 1999. Still, it was in 2007 that Apple's iPhone made an important breakthrough. Apple was followed by Samsung in 2009, and only somewhat later by Huawei.[80] Apple defined the dominant design for a smartphone. In the innovation literature, establishment of dominant design is an important milestone, as the ensuing competition happens within these design parameters.

To this day, also, technological learning remains relatively concentrated among a few core firms and countries. There has been a shift in capacity, from Europe, Japan and the United States initially to selected firms in the Republic of Korea (Samsung and LG), Taiwan (Province of China) and China (Huawei and ZTE). As with other advanced technologies, participation in these technologies does not reflect a divide between developed and developing countries; Europe, for example, is no longer a serious contender, whereas China has become an important one.

There are important differences between the newcomer countries. The Republic of Korea built its capacity largely internally, supported by government policies and the strength of its domestic conglomerate enterprises. China's technological learning was shaped by extensive involvement with foreign entities, in particular through providing assembly services for foreign entities and foreign direct investment in China.

There were really two or three learning pathways in China. One involved companies from Taiwan (Province of China) setting up production facilities for multinationals in China (e.g., Foxconn assembling products for Apple and others). Another involved Chinese companies such as Huawei, ZTE and Lenovo that had established product lines (networking equipment and personal computers) subsequently moving into the smartphone market. A potential third pathway is the set of new Chinese firms selling cheap phones for China's home market without initially relying on strong internally generated technological inventions. As a result, China has a major role in the smartphone industry, but without necessarily having a large presence of mainland China firms in the global value chains of multinationals like Apple and Samsung.

Apart from these firms and countries, each with its own distinctive features, there has been little transfer of intangibles or creation of either new competitors or new participants in the smartphone global value chain. The only newer geographic shifts in global value chain participation can be seen in some limited transfer of assembly activities to countries outside East Asia.

Among the leaders, what do Apple, Samsung and Huawei have in common in terms of the development of their innovation capacity and the role of intangible assets?

First, before entering the smartphone market all three firms had backgrounds and innovative capacity in related fields of technology.

- Apple's history is well known. It started in the late 1970s with a focus on computer technology, and also developed core know-how in the field of drives, printers, input devices, displays and networking technologies over the course of the following four decades. It took some time for Apple to move from its audio player, the iPod, introduced in 2001, via software-related innovation such as iTunes to the simultaneous introduction of the iPhone and the iPad. Its capacity in internal component development is weaker than Huawei's or Samsung's – with the exception of the most expensive and strategic components such as processors and, more recently, graphics processing units.[81] In addition, Apple has substantial capacity in product design, integration and software.

- Samsung Electronics was always part of a larger conglomerate, entering initially as a supplier of components (specifically telecommunications hardware and phones) to other firms, beginning in the 1980s. Samsung Electronics initially manufactured inexpensive, imitative electronics for other companies. Samsung also produced a lot of its own-brand products for the Republic of Korea. Already back then, many of its plants were set up abroad, arguably benefiting from access to foreign-trained skills and labor. However, in 1996 it made a major shift towards developing internal design capabilities and building its own brand.[82] Today, Samsung remains unique in its reliance on internal transfer of technology, and production and product design capacities.

- Huawei started much later and with fewer integral capabilities, but had become the global leader in telecommunications networks by 2012.[83] Unlike other firms in China or Taiwan (Province of China), Huawei did not act as a contract manufacturer for Western entities. Instead, it focused consistently on telecom-related innovation and building its extensive relationships with operators worldwide. In 2003, Huawei started producing phones, mostly low-end types for Chinese telecom carriers. Since 2011, however, it has developed high-end devices. Rather than relying on joint ventures to secure technology transfer from foreign companies, Huawei focused on local R&D and on learning by reverse-engineering of foreign technologies (Chong, 2013). Today, Huawei is actually more R&D-intensive than Apple or Samsung (see table 4.3) and is maintaining this high R&D investment despite falling revenues and margins.[84] Academic studies show that this rapid catch-up by Huawei was due to its technological capabilities rather than cost advantages alone – by creating its own technological path rather than remaining a technological follower. Huawei grew rapidly by developing technologies that are different from those of Ericsson, a main competitor, with Huawei relying on recent scientific knowledge in its innovation strategies.[85] More recently, Huawei has looked to upgrade, setting up a number of partnerships or joint ventures with firms such as IBM, Siemens, 3Com and Symantec plus R&D partnerships with Motorola and other telecommunication operators, and it has also learned management practices from Western firms.

While each company has followed a different development path, all three have been heavily involved in the creation of innovation capacity and related intangibles, including brands. All three are highly R&D-intensive with an express goal of increasing their in-house production of technologically sophisticated, high-margin components such as chips. All three have also learned to use IP intensively, and now operate large IP portfolios and have significant IP litigation experience. Moreover, Samsung and Huawei are involved in related standard-setting technologies and IP.

Second, all three firms operate in extensive value networks and with component suppliers (sections 4.1 and 4.2). Learning and upgrading does not occur just within these smartphone lead firms, but also in related technology fields. These interactions lead to two-way flows of knowledge in the process of co-designing and manufacturing. At the component level, the “fabless” chip model adopted by major chip makers such as Qualcomm, Broadcom and Apple involves close collaboration with foundries such as Taiwan Semiconductor Manufacturing Corporation (TSMC) to design chips to meet specific manufacturing processes.[86] Partnerships between Qualcomm and Huawei to create next-generation mobile chipsets also involve significant knowledge exchange.

Involvement in the smartphone global value chain entails learning and upgrading right down to the level of contracted manufacturing. When Apple works with Foxconn on processes such as plastic molding, machine tooling and quality control, learning is involved. Firms such as Foxconn started by making simpler contributions but nowadays add value to the iPhone through their own intangible assets (machine tooling, rapid prototyping, high volume ramp-up, supply chain management), some of which may soon take place at Foxconn’s plant in the United States.[87]

When Huawei assembles outside Asia, for example in Brazil, knowledge transfer ensues.[88] In the same vein, knowledge transfer also occurs within multinational corporations. Samsung, for example, manufactures half its mobile phones in its own plants in Viet Nam. Apple has software developed in various countries. These activities lead to knowledge spillovers to domestic research institutes, suppliers and competitors, including business understanding as well as technological knowledge. In general, a great deal of the knowledge in these set-ups is tacit – never codified but flowing within and across organizations – whereas other knowledge gets codified to facilitate collaborations.

Third, acquisitions have helped these companies to progress. For example, Samsung purchased firms in areas as diverse as mobile music services, speech recognition technologies and nanotechnology firms delivering display solutions in 2016 and 2017 alone. This is also true of upcoming firms such as Foxconn, which bought Sharp in 2016 and is bidding for Toshiba's chip business.[89]

Fourth, labor mobility plays a large role. Firms such as Samsung benefited from labor mobility by learning from Japanese engineers in the 1990s, and by having access to Korean engineers trained in the United States. Huawei is known to have hired Western professionals in the area of marketing and public affairs, and key design experts from Apple or Samsung, and has set up design centers in London.[90] Apple also regularly hires from top U.S. firms such as Qualcomm or from U.S. universities.

Fifth, insourcing of technology and IP-based exchanges have been an important source of knowledge exchange and of firms' ability to operate. All three firms are engaged with SEPs, including through cross-licensing or licensing (e.g., licensing deals with Nokia).

Finally, another important factor in this story is the role of government policy and the broader environment for doing business and innovation. All three companies operate in countries with a pronounced emphasis on innovation-driven growth, a strong private and public commitment to science and R&D, excellent (or rapidly improving) research infrastructures, an abundance of engineering and science skills and a recognition of the value of technological and non-technological innovation. All three countries had a strong commitment to the borderless operation of global value chains, and their participation within them. They also had frameworks and policies in place to encourage IP filings and foster telecom standards; historically, China jumped on this bandwagon last, but it has made considerable progress in a short time.

From the perspective of international trade, all three firms benefited from very open international markets in the field of information technology products – markets secured through the Information Technology Agreement concluded in 1996 at the World Trade Organization, among others.[91]

All in all, government policy – and sometimes also the absence of explicit policy intervention – has played a role in fostering the smartphone industry.

Notes

1. This chapter draws on Dedrick and Kraemer (2017) and Stitzing (2017).
2. IDC (2017).
3. Credit Suisse (2017).
4. IDC (2017).
5. Credit Suisse (2016, 2017).
6. IDC (2017).
7. iri.jrc.ec.europa.eu/scoreboard.html.
8. Credit Suisse (2017).
9. BCG (2017).
10. Koski and Kretschmer (2007).
11. "Qualcomm calls for iPhone ban as Apple patent case intensifies," *Financial Times* (FT), July 6, 2017.
12. "China smartphone maker Xiaomi designs its first chip," FT, February 28, 2017; "China's Xiaomi to take on top tier with smartphone chip of its own," *Wall Street Journal* (WSJ), February 9, 2017; "Apple's building its own graphics processor for the iPhone, dropping Imagination GPUs," *PC World*, April 3, 2017.
13. See Dedrick et al. (2010) and Dedrick and Kraemer (2017) for more details.
14. IHS Markit (2016).
15. IHS Markit (2016), Samsung Galaxy S7.
16. It is not always the lead firm that pays the bill; sometimes component suppliers may pay. This is the case for Apple, which does not hold a license for Qualcomm's IP but instead relies on agreements between its contract manufacturers and Qualcomm.
17. See Neubig and Wunsch-Vincent (2017), a study produced for this report, which notes how taxation issues lead to distortions in the measurement of IP transactions.
18. Dedrick et al. (2011) found that the carriers capture most value, ahead of handset makers.
19. See Neubig and Wunsch (2017), which also discusses how companies shift their R&D and IP portfolios, including for tax reasons (e.g., Apple and other high-technology companies in Ireland).
20. See Ali-Yrkkö et al. (2011) for similar findings in this sector.
21. For the 90 percent estimate, which is widely echoed in other business stories, see S. Ovide and D. Wakabayashi, "Apple's share of smartphone industry's profits soars to 92%," WSJ, July 12, 2015: www.wsj.com/articles/apples-share-of-smartphone-industrys-profits-soars-to-92-1436727458.
22. Shapiro and Varian (1998), OECD (2005), Garcia-Swartz and Garcia-Vicente (2015). Korkeamäki and Takalo (2013) similarly demonstrate that – relative to its competitors – Apple captures most value from smartphone sales in terms of its positive stock price evolution.
23. Apple Annual Report, 2016.
24. See Dedrick and Kramer (2017).
25. Dedrick and Kramer (2017) based on FT Markets Data: markets.ft.com/data.
26. OECD (2011), Blind et al. (2014), and Cecere et al. (2015).
27. Korkeamäki and Takalo (2013).
28. Teece (1986).
29. Sharma (2016) and WIPO (2011, 2013 and 2015).
30. "Apple-Samsung case shows smartphone as legal magnet," *New York Times*, August 25, 2012: www.nytimes.com/2012/08/26/technology/apple-samsung-case-shows-smartphone-as-lawsuit-magnet.html; "There are 250,000 active patents that impact smartphones; representing one in six active patents today," *Techdirt*, October 18, 2012: www.techdirt.com/articles/20121017/10480520734/there-are-250000-active-patents-that-impact-smartphones-representing-one-six-active-patents-today.shtml. The original source for the 250,000 patent figure stems from an SEC filing by RPX Corporation, a "defensive patent aggregator", www.sec.gov/Archives/edgar/data/1509432/000119312511240287/ds1.htm, and is largely unverified.
31. WIPO (2017).
32. WIPO (2016).
33. The CPC is available at: www.cooperativepatentclassification.org. Experts at Clarivate, previously Thomson Reuters, provided advice on this choice, also based on Derwent World Patents Index's manual code for smartphones.
34. The IPC is available at: www.wipo.int/classifications/ipc.
35. worldwide.espacenet.com and Datenbankrecherche, Deutsche Patent- und Markenamt (DPMA), www.dpma.de/patent/recherche/index.html.
36. A patent family is a set of interrelated patent applications filed in one or more countries or jurisdictions to protect the same invention. See the glossary in WIPO (2016).
37. See OECD (2008) for a discussion of the role of IP in the ICT industry.
38. See WIPO (2011) on the economics of patents, and Blind et al. (2014) for an application to the ICT industry.
39. Engstrom (2017).
40. Reidenberg et al. (2012, 2014).
41. Gurry (2013).
42. PwC (2017).
43. Gurry (2013).
44. PwC (2017).
45. Reidenberg et al. (2012) show that the majority of patents relate to communications technology, followed by hardware and software patents.
46. Audenrode et al. (2017) and Baron et al. (2016).
47. Kumar and Bhasin (2017).
48. See Fan (2006) on Huawei and ZTE; and see IPlytics (2016) and Thumm and Gabison (2016) on the increasing role of PAEs and the increased SEP-related litigation.
49. Pohlmann and Blind (2016) and Reidenberg et al. (2014).
50. For example, Google purchased Alpental Technologies in 2014.

51. Sullivan and Cromwell (2013), Armstrong et al. (2014) and Mallinson (2015).

52. Galetovic et al. (2016) identify royalties for smartphone SEPs of USD 14.3 billion, equivalent to 3.4 percent of the value of smartphones. Sidak (2016) estimates that SEP royalty payments were between 4 and 5 percent of revenues using 3G and 4G standards in 2013 and 2014.

53. Nokia 2016 annual report: www.nokia.com/en_int/investors; Nokia News release, February 2, 2017: www.nokia.com/en_int/news/releases/2017/02/02/nokia-corporation-report-for-q4-2016-and-full-year-2016; Ericsson 2016 annual report: www.ericsson.com/assets/local/investors/documents/2016/ericsson-annual-report-2016-en.pdf; Ericsson press release, January 26, 2017: www.ericsson.com/en/press-releases/2017/1/ericsson-reports-fourth-quarter-and-full-year-results-2016, and "Top licensors Ericsson, Microsoft and Nokia all see drop in year-on-year patent revenues," *IAM Market*, February 9 2017

54. Shimpi (2013).

55. See Engstrom (2017), Kumar and Bhasin (2017) and "Royalty fees could reach $120 on a $400 smartphone," ZDNet, May 31, 2014: www.zdnet.com/article/patent-insanity-royalty-fees-could-reach-120-on-a-400-smartphone/for similar exercises.

56. Thomson Reuters (2012).

57. "iOS versus Android. Apple App Store versus Google Play," ZDNet, January 16, 2015; "App Store 2.0," *The Verge*, June 8, 2016; and see Campbell-Kelly et al. (2015) for a review of Google's and Apple's mobile platforms and the related business models at play.

58. "Google is paying Apple billions per year to remain on the iPhone, Bernstein says," CNBC, August 14, 2017. Estimate based on court documents and Apple's financial conference call in the first half of 2017 demonstrating that Apple's services revenues will equal USD 7.3 billion in the first quarter of 2017, with 22 percent growth on the previous year.

59. See unsealed filing on October 3, 2014 in the *Microsoft v. Samsung* U.S. District Court patent-royalty case filed in early August 2014. "Document sheds light on Samsung's payments to Microsoft over Android," CNET, October 4, 2014; "Samsung paid Microsoft $1 billion last year for Android royalty, filing says," WJS, October 3, 2014; and "Microsoft and Samsung end Android royalties dispute," *The Verge*, February 9, 2015.

60. See Liu and Yu (2017), Liu and Liang (2014) and related surveys by agencies and firms such as KISA (2014) and Samsung, "The most important feature in a mobile device", September 29, 2015: www.samsung.com/ae/discover/your-feed/the-most-important-feature-in-a-mobile-device; and *Apple v. Samsung*, C-11-01846-LHK (N.D. Cal. 2012).

61. Reidenberg et al. (2012).

62. Johnson and Scowcroft (2016).

63. *Apple v. Samsung*, C-11-01846-LHK (N.D. Cal. 2012).

64. See also Golinveaux and Hughes (2015) and PwC (2017) for a reference to this trend and/or effect.

65. USPTO Design Patent Report, January 1, 1991-December 31, 2015, published in March 2016: www.uspto.gov/web/offices/ac/ido/oeip/taf/design.pdf; and Reidenberg et al. (2014).

66. The discussion here draws on a collaboration between the WIPO Economics and Statistics Division and contributions by Christian Helmers, notably "Smartphone Trademark and Design Mapping", unpublished background report to the *World Intellectual Property Report 2017*, June 16, 2017.

67. WIPO Standing Committee on the Law of Trademarks, Industrial Designs and Geographical Indications (SCT), Proposal by the Delegations of Israel, Japan and the United States of America, "Industrial Design and Emerging Technologies: Similarities and Differences in the Protection of New Technological Designs", September 12, 2016, SCT/35/6 Rev. 2.

68. WIPO SCT, "Compilation of the Replies to the Questionnaire on Graphical User Interface (GUI), Icon and Typeface/Type Font Designs," October 17-19. 2016, SCT/36/2 Rev. 2; and WIPO SCT, "Analysis of the Returns to the Questionnaire on Graphical User Interface (GUI), Icon and Typeface/Type Font Designs," March 27-30, 2017, SCT/37/2 Rev.

69. iPhone (2007), iPhone 3G (2008), iPhone 3GS (2009), iPhone 4 (2010), iPhone 4S (2011), iPhone 5 (2012), iPhone 5C (2013), iPhone 5S (2013), iPhone 6 (2014), iPhone 6 Plus (2014), iPhone 6S (2015), iPhone SE (2016), iPhone 7 (2016), iPhone 7S (2017), iPhone 8 (2017).

70. See www.uspto.gov/web/offices/pac/mpep/s1512.html.

71. WIPO (2013).

72. Note, however, that the Samsung Electronics portfolio is vastly larger than that of Apple. These figures are thus not directly related to smartphone advertising alone and are not easily comparable. On the 2012-2015 estimates, see "The cost of selling Galaxies," *Asymco*, November 29, 2012; Adbrands Global Advertising Expenditure Ranking, December 2015: www.adbrands.net/top_global_advertisers.htm.

73. Huawei 2016 Annual Report: www.huawei.com/en/about-huawei/annual-report/2016.

74. See note 66 and technical notes.

75. See www.wipo.int/classifications/nice.

76. See, by way of example, www.wi-fi.org/who-we-are/our-brands, www.3gpp.org/about-3gpp/19-lte-logo-use and www.bluetooth.com/membership-working-groups/membership-types-levels.

77. www.apple.com/legal/intellectual-property/trademark/appletmlist.html.

78. Theodore Paraskevakos, U.S. Patent #3,812,296/5-21-1974.

79. See WIPO (2015) for the historical case of semiconductors and the underlying work of Professor Thomas Hoeren.

80. Samsung had experimented with earlier smartphone models, such as the SPH-I300 as early as October 2001 and the SGH-i607 in 2006.

81. "Apple looks long term with development of GPUs," FT, April 4, 2017; "Apple's building its own graphics processor for the iPhone, dropping Imagination GPUs," *PC World*, April 3, 2017.

82. Yoo and Kim (2015) and Song et al. (2016).

83. Boutellier et al. (2000), Zhang and Zhou (2015) and Kang (2015).

84. Huawei 2016 annual report. "Huawei 2016 numbers reveal the extent of Ericsson, Nokia and ZTE's challenge," *Telecoms.com*, March 31, 2017.

85. Joo et al. (2016).

86. Brown and Linden (2009). Fabless chip manufacturing is the design and sale of semiconductor chips while outsourcing the production of the chips to a specialized semiconductor foundry.

87. See Wunsch-Vincent et al. (2015) for a correspondingly growing patent portfolio of the Foxconn holding company.

88. Huawei and Xiaomi already have assembly facilities in places such as China, Viet Nam, India, Brazil and Indonesia in response to such forces. Apple's recent decision to set up production in India was in response to market demand and government incentives (Phadnis, 2016).

89. "Fight at Toshiba: Some board members want deal with Foxconn," WSJ, September 6, 2017.

90. "Huawei hires a former Apple creative director as a design chief," WSJ, October 29, 2015.

91. For more details, see www.wto.org/english/tratop_e/inftec_e/inftec_e.htm.

References

Ali-Yrkkö, J., P. Rouvinen, T. Seppälä and P. Ylä-Anttila (2011). Who captures value in global supply chains? Case Nokia N95 smartphone. *Journal of Industry, Competition and Trade*, 11(3), 263-278.

Armstrong, A.K., J.J. Mueller and T. Syrett (2014). The Smartphone Royalty Stack: Surveying Royalty Demands for the Components Within Modern Smartphones. SSRN, May 29, 2014: ssrn.com/abstract=2443848.

Audenrode, M.V., J. Royer, R. Stitzing and P. Sääskilahti (2017). Over-Declaration of Standard-Essential Patents and Determinants of Essentiality. SSRN, April 12, 2017. papers.ssrn.com/sol3/papers.cfm?abstract_id=2951617.

Baron, J., K. Gupta and B. Roberts (2016). Unpacking 3GPP Standards. Unpublished working paper, available at: pdfs.semanticscholar.org/bb7a/902cdedbc5fb97b039372d0c7541c696e539.pdf.

Blind, K., T. Pohlmann, F. Ramel and S. Wunsch-Vincent (2014). The Egyptian IT Sector and the Role of IP. *WIPO Economic Research Working Paper No. 18*. Geneva: WIPO.

Boston Consulting Group (BCG) (2017). *The Most Innovative Companies 2016*. Boston, MA: Boston Consulting Group.

Boutellier, R., O. Gassmann and M. von Zedtwitz (2000). Huawei: Globalizing through innovation – case study, Part IV.7. In *Managing Global Innovation – Uncovering the Secrets of Future Competitiveness*. Berlin: Springer Verlag, 507-523.

Brown, C. and G. Linden (2009). *Chips and Change: How Crisis Reshapes the Semiconductor Industry*. Cambridge, MA: MIT Press.

Campbell-Kelly, M., D. Garcia-Swartz, R. Lam and Y. Yang (2015). Economic and business perspectives on smartphones as multi-sided platforms. *Telecommunications Policy*, 39(8), 717-734.

Cecere, G., N. Corrocher and R.D. Battaglia (2015). Innovation and competition in the smartphone industry: is there a dominant design? *Telecommunications Policy*, 39(3), 162-175.

Chen, W., R. Gouma, B. Los and M. Timmer (2017). Measuring the Income to Intangibles in Goods Production: A Global Value Chain Approach. *WIPO Economic Research Working Paper No. 36*. Geneva: WIPO.

Chong, G. (2013). *Chinese Telecommunications Giant Huawei: Strategies to Success*. Singapore: Nanyang Technopreneurship Center, Nanyang Technological University.

Credit Suisse (2016). *The Wireless View 2016: Smartphones – The Wireless Slowdown*. Global (Americas, Europe and Taiwan) Equity Research.

Credit Suisse (2017). *The Wireless View 2017: Smartphones – A Slight Pickup in Growth Ahead*. Global (Americas & Europe) Equity Research.

Dedrick, J. and K.L. Kraemer (2008). Globalization of innovation: the personal computing industry. In Macher, J.T. and D.C. Mowrey (eds), *Running Faster to Stay Ahead? Globalization of Innovation in High-Technology Industries*. Washington DC: National Academies Press, 21-57.

Dedrick, J. and K.L. Kraemer (2017). Intangible Assets and Value Capture in Global Value Chains: The Smartphone Industry. *WIPO Economic Research Working Paper No. 41*. Geneva: WIPO.

Dedrick, J., K.L. Kraemer and G. Linden (2010). Who profits from innovation in global value chains? A study of the iPod and notebook PCs. *Industrial and Corporate Change*, 19(1), 81-116.

Dedrick, J., K.L. Kraemer and G. Linden (2011). The distribution of value in the mobile phone supply chain. *Telecommunications Policy*, 35(6), 505-521.

Engstrom, E. (2017). So how many patents are in a smartphone? Blog, January 19, 2017. San Francisco: Engine. www.engine.is/news/category/so-how-many-patents-are-in-a-smartphone.

Fan, P. (2006). Catching up through developing innovation capability: evidence from China's telecom-equipment industry. *Technovation*, 26(3), 359-368.

Forbes (2016). The World's Most Valuable Brands. www.forbes.com/powerful-brands/list/3/#tab:rank.

Galetovic. A., S.H. Haber and L. Zaretzki (2016). A New Dataset on Mobile Phone Patent License Royalties. *Working Paper Series No. 16011*. Stanford, CA: Hoover Institution, Stanford University.

Garcia-Swartz, D.D. and F. Garcia-Vicente (2015). Network effects on the iPhone platform: an empirical examination. *Telecommunications Policy*, 39(10), 877-895.

Golinveaux, J.A. and D.L. Hughes (2015). Developing trends in design patent enforcement. *World Trademark Review*, issue 54.

Graham, S.J.H., G. Hancock, A.C. Marco and A.F. Myers (2013). The USPTO trademark case files dataset: descriptions, lessons, and insights. *Journal of Economics & Management Strategy*, 22, 669–705.

Graham, S.J.H., G. Hancock, A.C. Marco and A.F. Myers (2015) Monetizing Marks: Insights from the USPTO Trademark Assignment Dataset. SSRN, April 1, 2015: ssrn.com/abstract=2430962 or dx.doi.org/10.2139/ssrn.2430962.

Gurry, F. (2013). Rethinking the role of intellectual property: a speech at Melbourne Law School: law.unimelb.edu.au/alumni/mls-news/issue-10-december-2013/rethinking-the-role-of-intellectual-property.

IHS Markit (2016). Teardown reports and spreadsheets for the Apple iPhone 7. Samsung Galaxy S7 and Huawei P9. Englewood, U.S.A.: technology.ihs.com/Categories/450461/teardowns-cost-benchmarking.

Interbrand (2016). Best Global Brands 2016 Rankings. interbrand.com/best-brands/best-global-brands/2016/ranking/#?sortBy=rank&sortAscending=desc.

International Data Corporation (IDC) (2017). Data Tracker Database on the Smartphone Industry, 2005-2017. Boston. MA: International Data Corporation.

Johnson, D.K.N. and S. Scowcroft (2016). The Importance of Being Steve: an econometric analysis of the contribution of Steve Jobs's patents to Apple's market valuation. *International Journal of Financial Research*, 7(2), 2016.

Joo, S.H., C. Oh and K. Lee (2016). Catch-up strategy of an emerging firm in an emerging country: analysing the case of Huawei vs. Ericsson with patent data. *International Journal of Technology Management*, 72(1-3), 19-42.

Kang, B. (2015). The innovation process of Huawei and ZTE: patent data analysis. *China Economic Review*, 36, 378-393.

Korea Internet and Security Agency (KISA) (2014). Final Report of Research on Actual Status of Mobile Internet Usage. 24 February, 2014.

Korkeamäki, T. and T. Takalo (2013). Valuation of innovation and intellectual property: the case of iPhone. *European Management Review*, 10(4), 197-210.

Koski, H. and T. Kretschmer (2007). Innovation and dominant design in mobile telephony. *Industry and Innovation*, 14(3), 305-324.

Kumar. A. and B.S. Bhasin (2017). Innovation and survival: lessons from the smartphone wars. In *Intellectual Asset Management Yearbook 2017.*

Liu, C.-J. and H.-Y. Liang (2014). The deep impression of smartphone brand on the customers' decision making. *Procedia – Social and Behavioral Sciences*, 109, 338-343.

Liu, N. and R. Yu (2017). Identifying design feature factors critical to acceptance and usage behavior of smartphones. *Computers in Human Behavior*, 70, 131-142.

Mallinson, K. (2014). Smartphone royalty stack. *IP Finance*, September 19, 2014: www.wiseharbor.com/pdfs/Mallinson%20on%20Intel's%20Smartphone%20Royalty%20Stack%2019Sept2014.pdf.

Mallinson, K. (2015). Busting smartphone patent licensing myths. Policy Brief, September 2015. Arlington, VA: Center for the Protection of Intellectual Property, George Mason School of Law. sls.gmu.edu/cpip/wp-content/uploads/sites/31/2015/10/Mallinson-Busting-Smartphone-Patent-Licensing-Myths.pdf.

Millward Brown (2016). *BrandZ Top 100 Global Brands*: www.millwardbrown.com/brandz/top-global-brands/2016.

Neubig. T.S. and S. Wunsch-Vincent (2017). A Missing Link in the Analysis of Global Value Chains: Cross-Border Flows of Intangible Assets, Taxation and Related Measurement Implications. *WIPO Economic Research Working Paper No. 37*. Geneva: WIPO.

Organisation for Economic Co-Operation and Development (OECD) (2005). Digital Broadband Content: Music. DSTI/ICCP/IE(2004)12/FINAL: www.oecd.org/internet/ieconomy/34995041.pdf.

OECD (2008). ICT research and development and innovation. In *OECD Information Technology Outlook 2008*. Paris: OECD, Chapter 4.

OECD (2011). Global Value Chains: Preliminary Evidence and Policy Issues. DSTI/IND(2011)3. Paris: OECD.

Phadnis, S. (2016). Apple plans to make iPhones in Bengaluru from April. *The Times of India*, December 30, 2016.

Pohlmann, T. and K. Blind (2016). Landscaping Study on Standard-Essential Patents (SEPs). Berlin: IPlytics GmbH. Commissioned by the European Commission.

PricewaterhouseCoopers (PwC) (2017). *2017 Patent Litigation Study – Change on the Horizon?* and earlier editions: www.pwc.com/us/en/forensic-services/publications/assets/2017-patent-litigation-study.pdf.

Reidenberg, J.R., D. Stanley, N. Waxberg, J. Debelak, D. Gross and E. Mindrup (2012). The Impact of the Acquisition and Use of Patents on the Smartphone Industry. *WIPO Working Paper. IP and Competition Division*. Geneva: WIPO: www.wipo.int/export/sites/www/ip-competition/en/studies/clip_study.pdf.

Reidenberg, J.R., N.C. Russell, M. Price and A. Mohan (2014). Patents and Small Participants in the Smartphone Industry. *WIPO Working Paper, IP and Competition Division*. Geneva: WIPO. ssrn.com/abstract=2674467.

Shapiro, C. and H.R. Varian (1998). *Information Rules: A Strategic Guide to the Network Economy*. Boston, MA: Harvard Business School Press.

Sharma, C. (2016). Mobile Patents Landscape 2016: An In-Depth Quantitative Analysis, and previous editions of this report. Chetan Sharma Consulting: www.chetansharma.com/publications/mobile-patents-landscape-2016.

Shimpi, A.L. (2013). The ARM diaries, part 1: How ARM's business model works. *AnandTech*, June 28, 2013: www.anandtech.com/show/7112/the-arm-diaries-part-1-how-arms-business-model-works.

Sidak, J.G. (2016). What aggregate royalty do manufacturers of mobile phones pay to license standard-essential patents? *Criterion*, 1, 701-719.

Song, J., K. Lee and T. Khanna (2016). Dynamic capabilities at Samsung: optimizing internal co-opetition. *California Management Review*, 58(4), 118-140.

Stitzing, R. (2017). World IP Report – Smartphone Case Study – Presentation at the workshop for the World Intellectual Property Report. Geneva, March 16 and 17, 2017.

Sullivan & Cromwell (2013). Royalty rates for standard-essential patents. April 30. New York: Sullivan & Cromwell LLP: www.sullcrom.com/siteFiles/Publications/SC_Publication_Royalty_Rates_for_Standard_Essential_Patents_414F.pdf.

Teece, D.J. (1986). Profiting from technological innovation: implications for integration, collaboration, licensing and public policy. *Research Policy*, 15, 285-305.

Thomson Reuters (2012). Inside the iPhone Patent Portfolio. Thomson Reuters IP Market Reports.

Thumm. N. and G. Gabison (2016). *Patent Assertion Entities in Europe*. European Economics for the Joint Research Centre. European Commission.

World Intellectual Property Organization (WIPO) (2011). The economics of IP – Old insights and new evidence. In *World Intellectual Property Report: The Changing Face of Innovation*. Geneva: WIPO, Chapter 2, 75-107.

WIPO (2013). Branding in the global economy. In *World Intellectual Property Report: Reputation and Image in the Global Marketplace*. Geneva: WIPO, Chapter 1, 21-79.

WIPO (2015). Historical breakthrough innovations. In *World Intellectual Property Report: Breakthrough Innovation and Economic Growth*. Geneva: WIPO, Chapter 2, 49-93.

WIPO (2016). *World Intellectual Property Indicators 2016*. Geneva: WIPO.

WIPO (2017). *PCT Yearly Review 2017.* Geneva: WIPO.

Wunsch-Vincent, S., M. Kashcheeva and H. Zhou (2015). International patenting by Chinese residents: constructing a database of Chinese foreign-oriented patent families. *China Economic Review*, 36, 198-219.

Yoo, Y. and K. Kim (2015). How Samsung became a design powerhouse. *Harvard Business Review*, September, 72-78.

Zhang, Y. and Y. Zhou (2015). *The Source of Innovation in China: Highly Innovative Systems*. London: Palgrave, Appendix 2.2.