End-use-based licensing

An economic perspective

Prepared for

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LIST OF ABBREVIATIONS

AIPLA	American Intellectual Property Law Association
CMA	Competition and Markets Authority (UK)
CPU	Central Processing Unit
DoJ	Department of Justice
EC	European Commission
EMVR	Entire Market Value Rule
ETSI	European Telecommunications Standards Institute
EV	Electric Vehicle
FRAND	Fair, Reasonable and Non-discriminatory
FSA	Fair Standards Alliance
FTC	Federal Trade Commission
GSM	Global System for Mobile Communications
HEVC	High Efficiency Video Coding
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IP	Intellectual Property
IPR	Intellectual Property Rights
LTE	Long Term Evolution
OEM	Original Equipment Manufacturer
R&D	Research and Development
RAND	Reasonable and Non-discriminatory
SDO	Standards Developing Organization
SEP	Standard Essential Patent
SME	Small and Medium-sized Enterprises
SSO	Standard Setting Organization
SSPPU	Smallest Saleable Patent Practicing Unit
UHD	Ultra-High Definition
UMTS	Universal Mobile Telecommunications System
WI-FI	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access

INTRODUCTION AND EXECUTIVE SUMMARY

Policymakers recognize the importance of ensuring voluntary licensing of standard essential patents (SEPs) on fair, reasonable, and non-discriminatory (FRAND) terms. Policy ensuring widespread licensing of standardised technologies on such terms is an essential precursor to maximising the benefits unlocked by standardization to society as a whole. The importance of safeguarding effective availability of licences to standards will grow further with the advent of the Internet of Things.

SEP holders are increasingly seeking to differentiate requested royalties based on the "end-use" and the value of end-products or services ("end-use-based licensing") – even if the standard is implemented and the technology is licensed at an intermediate level in the value chain.[1] CRA has been asked by the Fair Standards Alliance to assess the practice of end-use-based licensing from an economic perspective. **This report seeks to answer how end-use-based licensing can be assessed in the general framework of SEP licensing and to identify likely effects of end-use-based licensing**.

We begin by offering a brief discussion of relevant aspects of SEP licensing in Section 1, and introduce methodologies for the determination of SEP royalties. The issue of end-use-based licensing is part of a larger debate about how to ensure that SEPs are licensed in a way that spurs the widespread adoption of standards and successfully balances the interests of consumers and all firms along the supply chain. After a standard has been defined, users of standards are "locked in" as they cannot substitute alternatives to the technologies included in the standard. The inclusion of patented technologies into a standard therefore typically results in increased market power of the patentee. Well-known standardisation issues such as patent hold-up and royalty stacking may arise (Sections 1.1 and 1.2). To mitigate these issues, SEP holders typically commit before the standard is set to licence their SEPs on FRAND terms. However, in practice, the meaning of FRAND terms is a point of contention. The extent to which the FRAND regime, given present enforcement, mitigates abuse of the market power gained via standardization is unclear and there is a growing body of empirical evidence indicating that despite FRAND commitments SEP royalties are inefficiently high.[2]

An important framework to determine FRAND royalties that has gathered significant attention in the economic literature and (US) courts is the so-called "*ex ante* negotiation benchmark" (Section 1.3): the outcome of a hypothetical licence negotiation between the SEP holder and the implementer (i.e. potential licensee) before the standard is set can serve as a benchmark for determining FRAND royalties *ex post*. These hypothetical negotiations take place during the standard-setting process, when alternative technologies could still be included in the standard. In such hypothetical negotiations, potential licensees would be willing to pay at most the incremental value of the ultimately included technology over and above its next-best alternatives. When negotiating with SEP holders, potential licensees would also take their additional investments for complementary downstream innovations into account. These factors typically materially dampen the royalty level a

1 For the purpose of this report, end-use-based licensing also includes charging royalties that depend on the value of the end-product. Section 3.1 discusses end-use-based licensing in more detail.

2 See Section 1.2.1 for a summary.

patentee could reasonably expect to obtain in *ex ante* licensing negotiations and at the same time limit the patentee's scope for discriminating royalties by end-use. Whereas courts have recognised the relevance of the *ex ante* negotiation benchmark, implications of that approach are not always reflected in the quantification of FRAND royalties. In practice, FRAND royalties are typically based on one of three main methodologies: the comparable licence, top-down, and bottom-up approach (Section 1.4).

Section 2 describes the challenge of apportioning between downstream innovations and FRAND royalties for upstream innovations for the standard. End products typically derive their value from a variety of sources (Section 2.1). Sometimes a reference to the "added value" of the standard is made, defined as the difference of the product value *with* the standard-implementing features and the value of the same product *without* these features. However, this "added value" of a standard does not only come from the standardised technologies but also from standardisation itself, complementary downstream innovations, as well as unpatented technologies. SEP holders should only be allowed to appropriate the value of the technology covered by their SEPs in hypothetical *ex ante* negotiations, which usually amounts only to a fraction of the "added value".

The *ex ante* negotiation framework not only provides important insights on the level of royalties but also on the question of whether end-use-based licensing, i.e. price discrimination, would be compliant with a SEP holder's FRAND commitment (Section 2.2). Over the course of the standard-setting process, patented and unpatented technologies compete for inclusion in the standard. Economic theory predicts that, in a competitive environment, firms are generally less able to price discriminate. If downstream innovators have, *ex ante*, the choice between different alternative technologies, they would not be willing to concede much of the value stemming also from their own complementary innovations to patentees. **End-use-based licensing would only be in line with the *ex ante* negotiation framework if the SEP holder also would have been able to vary his royalty demands by end use when competing against alternative technologies for inclusion into the standard**.

There are several licensing disputes related to SEPs in which courts have determined FRAND royalties (Section 2.3). Especially in the US, courts have provided guidance as to how the value from SEPs can be apportioned from the value of other inputs and from the value of standardization. Concerns over potential overcompensation of SEP holders have led the US Federal Circuit to articulate the rule that royalties should generally be based on the Smallest Saleable Patent Practicing Unit (SSPPU) in the accused product, and that the use of the "entire market value" of the end product is not permissible as a royalty base when the patent does not drive the demand for the end product. While use of the SSPPU has been subject to debate, when it is applied to the same component for different end uses, the FRAND royalty cannot be discriminative.

Section 3 examines whether end-use based licensing increases the risk of misappropriation by SEP holders under approaches commonly used in practice to quantify FRAND royalty rates. End-use-based licensing can take different forms and may be implemented both at the device level and component level (Section 3.1). For example, SEP holders may price discriminate between end uses either by directly varying per-unit royalty rates by end use, or indirectly by demanding an ad-valorem royalty rate that is applied to the end product's selling price (with more expensive products resulting in higher absolute per-unit royalties). In Section 3.2, we discuss conditions under which royalties determined on the basis of the top-down or comparable licence approach would reflect the outcome of hypothetical *ex ante* negotiations. **We find that, with both approaches, end-**

use-based licensing increases the risk that SEP holders misappropriate value from downstream innovators through price discrimination that would have not been feasible under *ex ante* technology competition:

- The top-down approach can lead to seriously biased royalties if an inappropriate royalty base is selected for ad-valorem royalties or if royalty rates are not properly adjusted. In principle, a top-down approach that considers all patents essential to a standard and allocates a fair aggregate royalty burden among them can be a useful tool for avoiding royalty stacking. However, the aggregate royalty burden must be carefully determined to accurately reflect the *ex ante* value of all the relevant SEPs. Ad-valorem royalties are especially prone to misappropriation when a broad royalty base (such as an end-product's selling price) is selected without assessing in detail whether such royalty structure would have emerged in *ex ante* negotiations. The prices of end products are reflective of value from product features that are independent or complementary to the standard and a result of downstream innovation efforts. As implementation of the top-down approach has usually not been based on any assessment of *ex ante* substitutable technologies, a static determination of ad-valorem royalty rates applied to end products' values entails a significant risk of taxing independent and complementary innovations. Similar to ad-valorem rates, per-unit royalties can also lead to value misappropriation where differentiated royalties for different end uses do not reflect differences in the degree of technology competition when the standard was developed. This is especially likely if per-unit rates are just mechanically derived from end products' prices.
- **Implementing end-use-based licensing using comparable licences as a benchmark poses even greater challenges and risks**. First, the comparable licence approach is itself associated with several severe problems. If an allegedly comparable licence suffers from hold-up, royalties that use this licence as a benchmark are likely to be excessive as well. As SEP holders' market power typically increases once their patents are included in a standard, licences concluded after standardisation have an increased likelihood of being subject to hold-up. To avoid the comparable licence approach perpetuating patent hold-up (known as the "cyclicality problem"), courts would have to exclude from the list of comparable licences those negotiated in circumstances giving rise to hold-up (e.g. where licensees accepted non-FRAND rates to avoid the risk of injunctions). In practice, it may turn out to be difficult or even impossible to find licences that reflect recent market developments, and at the same time do not suffer from potential hold-up. These issues are exacerbated by end-use-based licensing. Comparable licences will typically not be available for each and every use case. Royalty rates differentiated by end-use entail an increased risk of not reflecting the outcome of hypothetical *ex ante* negotiations and may lead to misappropriation of downstream value by SEP holders. As in the case of the top-down approach, licences with ad-valorem royalties applied to a broad royalty base are especially prone to misappropriation if the royalty bases and rates of existing licences are "rubber-stamped" without paying attention to differences between the products in terms of downstream innovations. The difficulty of identifying comparable licensing terms for all use cases extends to per-unit royalties as well.

Besides the increased risk of misappropriation, end-use-based licensing may also create significant inefficiencies (Section 4). The form and magnitude of potential inefficiencies depends on the level of licensing:

Implementing end-use based licensing at the end device level may give rise to several inefficiencies. First, total transaction costs from negotiating and litigating SEP licences increase at the end-device level, since typically the number of potential licensees is higher at the end-device level and hence the number of licensing negotiations increases. Licensing negotiations for SEPs are often lengthy and complex processes that require technical, legal and economic expertise. With the advent of the Internet of Things, the issue of excessive transaction cost will be exacerbated in the future due to an ever-increasing number of different devices, end-use cases and consequently potential licensees practicing the same standards. Second, end-use based licensing implemented at the device level likely leads to more imbalanced licensing negotiations, increasing the risk for patent hold-up. Compared to component level licensees, downstream device manufacturers may lack the technical expertise to evaluate the validity of SEP holders' licensing claims and possibly also lack an understanding of the FRAND licensing process more generally. This is especially true if the end-device manufacturers are start-ups and SMEs, who may not have the resources to meet SEP holders on equal terms. More generally, in light of the sizable (fixed) costs of negotiating and potentially litigating non-FRAND royalty offers, end device manufacturers with small sales volumes will be more likely to leave non-FRAND licensing terms unchallenged.[3]

- **However, inefficiencies may also arise from charging differentiated royalties across end uses at the component level.** End-use based licensing implemented at the component level may result in other inefficiencies. The tracking of components and their inclusion into various end-products results in monitoring costs for component manufacturers. Those costs naturally increase in the number of different end-use cases. Again, the advent of the Internet of Things that gives rise to an expansion of end-use cases for the same standard emerging over time will exacerbate inefficiencies from end-use based licensing.

Excessive SEP royalties and inefficiencies from end-use-based licensing may stifle innovation and ultimately result in consumer harm (Section 5). In the debate revolving around end-use-based licensing, SEP holders often claim that the possibility to price discriminate between use cases and the accordingly higher royalty payments would allow them to obtain a higher return on their investments. However, from a welfare perspective, any positive impact of end-use-based licensing on upstream investments and innovation efforts need to be balanced against potential negative effects on downstream innovation. To assess whether the negative impacts of end-use-based licensing on downstream innovation are a genuine concern from a welfare perspective, we first study the relative importance of upstream and downstream innovation in the smartphone industry (Section 5.1). We find that the contribution of downstream innovators to total R&D materially exceeds the contribution of SEP holders. This shows that downstream innovators' contributions within the value chain are significant and that potential negative effects of end-use-based licensing on downstream innovation can result in consumer harm. Especially high-value end products may be unduly taxed if the returns on complementary innovations are misappropriated by SEP holders (Section 5.2). Downstream innovators

3 This in turn may lead to 'laddering' where multiple SMEs accept non-FRAND terms, and then SEP holders use the number of signed licences (by number but not by market share of products) as 'evidence' of industry acceptance of the value of the portfolio.

may decrease their own innovative efforts to develop new products if they must pay more for use of the patented technology, and standard adoption may be stifled. Higher SEP royalties will also be typically passed-on by implementers to consumers who end up paying higher end product prices (Section 5.3). While end-use-based licensing might stifle downstream innovation and increase end product prices, higher SEP royalties may in principle have a positive impact on upstream innovation. Recent studies, however, could not find that an IPR policy change by the Standards Setting Organization (SSO) responsible for the development of the Wi-Fi standard which implies restrictions on end-use-based licensing had any material impact on the availability of upstream technologies for inclusion into the Wi-Fi standard (Section 5.4). Yet, one needs to balance the positive and negative effects on innovation and consumers when assessing end-use-based licensing from an economic perspective (Section 5.5). An analysis to determine the level of royalties that would optimally balance the incentives to innovate along the value chain and thus maximise welfare is necessarily complex and difficult to conduct in practice. As a general guiding principle, the SEP holders' *ex ante* incremental contribution to a product's value seems an appropriate upper bound for the FRAND royalty. We therefore consider that limiting end-use-based royalties that exceed the *ex ante* incremental contribution of SEPs to the product value is an important policy objective.

1. BACKGROUND: STANDARDISATION, PATENT-HOLDUP, FRAND COMMITMENTS AND FRAND LICENSING

The issue of end-use-based licensing is part of a larger debate about how to ensure that SEPs are licensed in a way that spurs the widespread adoption of standards and successfully balances the interests of consumers and all actors along the supply chain. This section therefore offers a brief discussion of the relevant aspects of SEP licensing and concepts for the determination of SEP royalties:

- We first briefly introduce the concept of standardisation and SEPs (Section 1.1).
- Economic issues in the context of standardization with particular relevance for end-used based licensing are patent hold-up and royalty stacking. The concept of a FRAND commitment was established as a way to mitigate hold-up; yet guidance on its interpretation in practice remains vague (Section 1.2).
- The *ex ante* negotiation benchmark constitutes a useful theoretical framework for assessing FRAND royalties (Section 1.3).
- In practice, the quantification of FRAND royalty rates is mainly based on one of three approaches: comparable licence, top-down, or bottom-up (Section 1.4).

1.1. Standardisation and Standard Essential Patents (SEPs)

Standard setting is a voluntary process. A Standards Setting Organization (SSO) may be formed to develop standards that will increase the compatibility of devices made by different

companies.[4] This may require choosing a specific manner of addressing technological aspects. Patents may read on elements of the standard. A patent that is necessary to implement a technology standard is known as a standard essential patent (SEP).[5]

1.2. Relevant standardisation issues

SSO-based standardisation must overcome a number of challenges to achieve the objective of designing efficient standards that are widely available on reasonable and non-discriminatory terms. In the following we briefly review issues identified in the literature with particular relevance to end-used based licensing.

1.2.1. Patent hold-up and FRAND commitments

The notion of "patent hold-up" has been pivotal in both economic literature and policy debates related to patents and standardization.[6] Patent hold-up in general refers to opportunistic behaviour by the patent holder when licensing negotiations take place ex post, i.e. after downstream innovators (often also referred to as implementers) have sunk investments into products that use the patented technologies. In the context of standard-setting, patent hold-up also refers to the potentially abusive use of market power conferred to patent holders through standardisation which may result in inflated royalties ("hold-up premium").[7]

Baumol and Swanson (2005) pointed out long ago that "*standard-setting exercises normally arise only when there are technological alternatives to select among, and so, almost by definition, are likely to occur in competitive - perhaps very competitive - technology markets*. *Even when conditions are competitive before the selection of a standard, however, the act of selection may lead to increased ex post market power for owners of the IP necessary to practice the winning standard"*.

Indeed, patents that are "essential" to a standard will often be infringed by products implementing the standard, as downstream innovators cannot substitute alternative

4 For example, an SSO may consider many existing options and agree upon the shape of a wall plug and socket so that blow dryers and televisions made by different companies can plug into wall sockets made by different companies. This is technical standard setting in its simplest form. But rather than selecting between known options, standard setting can also involve the integration of technologies (what occurs in what some call a standards development organization or SDO). In the wireless communication industry, for example, SDOs seek to develop technology that does not currently exist in order to create the next generation of wireless technology — e.g., 1G, 2G, 3G, 4G and now 5G wireless communication.

5 Definition according to the ETSI IPR policy: Technical contributions to standards may contain patented technologies which are commonly known as Standard Essential Patents (SEP). When it is not possible on technical grounds to make or operate equipment or methods which comply with a standard without infringing a SEP, i.e. without using technologies that are covered by one or more patents, we describe that patent as 'essential´.

6 Firms using standards may in principle engage in opportunistic behaviour known as "hold-out" or "reverse hold-up", which refers to using essential technology without a licence and deliberately drag or undermine licensing negotiations. Patent "hold out" can induce royalty losses for SEP holders. The prospect of such hold-out may moreover result in reduced royalty rates agreed in negotiations. Shapiro and Lemley (2020) point out that hold-out fundamentally differs from hold-up in various aspects and is less of a concern than patent hold-up, among others because patent holders can always seek damages from infringers that are holding-out. Hold-out is of limited relevance for the assessment of end-use based licensing and therefore not covered in more detail in this report.

7 Lemley and Shapiro (2007); Shapiro and Lemley (2020), Farrell et al. (2007).

technologies for the technologies included into the standard anymore. Once the standard is adopted and downstream innovators are "locked in", SEP holders are thus able to negotiate royalty rates higher than those that could have been achieved *ex ante* when competing with alternative technologies. Section 1.3 below covers this in more detail.

SSOs typically require their members to commit before the standard is set to licensing their SEPs to those that use the standard. Often, the commitment is to licence on "fair, reasonable and non-discriminatory" (FRAND) terms. The term FRAND is often used by SSOs to describe terms and conditions that a patent owner may agree to in licensing its standard essential patents (SEPs) under an SSO's intellectual property rights (IPR) policy. However, not all SSOs provide clear guidance on the meaning of FRAND.[8] In the absence of guidance from the SSOs, FRAND commitments remain vague.

Indeed, what FRAND means in practice is subject to interpretation. Assessing the meaning of FRAND has absorbed the attention of legal and economic scholars in recent years but on many aspects no consensus has been reached yet.[9]

Concerns have been voiced that the current reward for SEP holders might be inefficiently high despite the fact that SEP holders generally have committed to licence their SEPs on FRAND terms. A recent report published by the European Commission's Joint Research Centre finds that "*overall, the remuneration of SEPs – even when it is regulated by FRAND terms – appears to be attractive*. *Many SEPs are found to generate substantial economic revenues, e.g., through licensing (Stasik, 2010). Pohlmann and Blind (2015) find that firms owning SEPs achieve higher returns on assets than firms owning other patents. The highest returns on assets are achieved by firms owning a mix of declared SEPs and other, non-essential patents. Hussinger and Schwiebacher (2015) study the effect of patents on the market value of a firm's stocks, and find that the number of declared SEPs correlates with a firm's market value, also if controlling for the number of patents in general. These studies suggest that SEPs can generate higher economic returns for their owners than other patents.*"[10]

One hypothesis for the higher value of SEPs could be that these are inherently more valuable. However, these findings could also indicate that SEP holders may have been able to extract royalties exceeding the *ex ante* incremental value of their patents. Recent findings by Love, Lefouili and Helmers (2021) support this interpretation. The authors examined over 1,800 US court dockets related to disputes between SEP licensors and licensees between 2010 and 2019 in an attempt to quantify the extent of patent hold up.

8 SSOs' IPR policies can be used to clarify an SSO's approach to FRAND. For example, in 2015 the Institute of Electrical and Electronics Engineers provided guidance as to how FRAND should be interpreted for its standards. Some SSOs require SEP holders to offer royalty free licences under certain conditions (e.g. the Bluetooth Special Interest Group).

9 Geradin (2020). This has been recognised by policy makers around the globe and various initiatives are underway. For instance, the European Commission is working on modernising the framework for standard-essential patents (https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13109-Intellectual-property-new-framework-for-standard-essential-patents_en).
There seems to be consensus on some aspects of FRAND. For instance, the European Commission (2011) has clarified that "*FRAND can also cover royalty-free licensing*" (p.60, FN 3).

10 Pentheroudakis and Baron (2017), p. 22. Some commentators make the claim that in practice hold-up is of minor importance (Pentheroudakis and Baron (2017), p. 28), which seems at odds with these findings. Shapiro & Lemley (2020) discuss the challenges of empirically identifying hold-up despite its prevalence.

They reviewed court documents for various categories of "opportunistic behaviour" that can be linked to hold up strategies by SEP holders. In around 75% of cases, some form of opportunistic behaviour could be identified. Although the authors seem to have chosen a rather broad definition of opportunistic behaviour, their findings suggest a wide-spread prevalence of hold up issues and consequently inflated SEP royalty rates.

1.2.2. Royalty stacking

Royalty stacking arises when downstream innovators must pay royalties to multiple patent holders, so those royalties cumulate or "stack" on top of each other from the perspective of downstream innovators.[11]

With royalty stacking the sum of individual payments requested by different patent owners is higher than the payment that a single firm would have requested if it owned all of the patents. This is confirmed by economic literature demonstrating that when multiple essential inputs are priced independently, collective overpricing tends to result, due to the "Cournot complements" problem.[12] This overpricing reduces the collective returns to downstream innovators.[13]

1.3. The *ex ante* negotiation benchmark

Much attention in the economic literature has been devoted to using the outcome of a hypothetical negotiation between an SEP holder and the potential licensee at the time a standard is developed as a benchmark to determine FRAND royalties – the so-called "*ex ante* negotiation approach". Attention was raised to how certain parameters – namely timing, incremental value, alternative technologies, complementary technologies, and scope of application of the rate – of this hypothetical negotiation should be set to account for the above-mentioned issues surrounding standardisation.[14]

The *ex ante* negotiation framework can provide useful guidance for the determination of FRAND royalties. In Section 2.2 below we discuss that it also provides insights on restrictions that *ex ante* competition imposes on IP holders' ability to price discriminate. Technology competition is often eliminated through standardization, which may create the conditions enabling SEP holders to price-discriminate, for example by means of end-use-based licensing. The SEP holders' FRAND commitments therefore should be thought of as imposing a limit on the degree of price discrimination. These restrictions would in principle have to be enforced by competition authorities or courts.

The outcome of a hypothetical negotiation that takes place at the time the SSO is selecting the standard provides a useful benchmark for FRAND royalties of SEPs. Put differently, a FRAND royalty should reflect what would happen as a result of well-informed *ex ante* technology competition. The European Commission's Horizontal Guidelines also make reference to the *ex ante* negotiation framework. They suggest that royalty rates can be

11 Lemley and Shapiro (2007).

12 The Cournot complements problem arises when multiple necessary inputs are supplied by separate firms, each with market power.

13 Sometimes it is claimed that royalty stacking also tends to reduce the SEP holders' profits. However, this may be true only from an *ex ante* perspective. From an ex-post perspective, SEP holders' profits tend to increase in the royalty level.

14 Swansen and Baumol (2005); Lemley and Shapiro (2014).

derived by comparing royalties charged "*before the industry has been locked into the standard (ex ante) with those charged after the industry has been locked in (ex post), assuming there is a reliable and consistent method for such a comparison*".[15]

The notion of hypothetical negotiations is deeply embedded in the US patent law.[16] There seems to be a consensus (also reflected in the US jurisprudence) that hypothetical negotiations over SEPs subject to a FRAND commitment must, however, be properly adapted to reflect the value added by standardisation and the constraints on royalties imposed by FRAND commitments.[17] The U.S. FTC recommended that courts should "*cap the royalty at the incremental value of the patented technology over alternatives available at the time the standard was chosen*".[18] FRAND royalties should be confined to the value of the patent itself (i.e., the value of the underlying technology) as distinct from "*any value added by the standard's adoption of the patented technology"*.[19] This is consistent with the recent EC communication on patents, which emphasises that the value of the licence needs to focus on the value of the technology and in principle "*should not include any element resulting from the decision to include the technology in the standard*."[20] In other words, **FRAND royalties should exclude any value derived from standardisation as well as from subsequent investments** of downstream innovators.[21] In the following, we will refer to such a limit on FRAND royalties as "*ex ante* incremental value rule".

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15 European Commission, "Guidelines on the applicability of Article 101 of the Treaty on the Functioning of the European Union to horizontal co-operation agreements." 2011, para 289.

16 Such hypothetical negotiations constitute the theoretical underpinning of the *Georgia-Pacific* framework. This framework is based on an evidentiary list of 15 factors for the assessment of patent damages. *Georgia-Pacific Corp. v. United States Plywood Corp.*, 318 F 1970 and 446 F.2d 295 (District Court, S. D. New York 1970 and 2nd Circuit 1971). For non-SEPs, the hypothetical negotiation attempts to ascertain the royalty upon which the parties would have agreed had they successfully negotiated an agreement just before infringement began and necessarily involves an element of approximation and uncertainty.

See also *Lucent Techs., Inc. v. Gateway, Inc.* 580 F.3d 1235 (Fed. Cir. 2009): "*The hypothetical negotiation tries, as best as possible, to recreate the ex ante licensing negotiation scenario and to describe the resulting agreement. In other words, if infringement had not occurred, willing parties would have executed a licence agreement specifying a certain royalty payment scheme"*.

17 In *Microsoft v. Motorola*, the court suggested a modified list of *Georgia Pacific* factors to account for the FRAND commitment and the asserted essentiality of the patents. *Microsoft Corp. v. Motorola, Inc.*, C10-1823JLR at paras 99 et seq, (W.D. Wash. 04.25.2013).

See also, e.g., Lemley and Shapiro (2007).

18 U.S. Federal Trade Commission (2011), p. 22. While the Federal Circuit in Ericsson referred to the ''incremental value of the invention,'' it was not referring to the FTC's ''incremental value approach,'' but rather to apportioning any value awarded from the value of the standard as a whole.

19 *Ericsson, Inc. v. D-Link Sys.*, Inc., 773 F.3d 1201, 1232 (Fed. Cir. 2014). See also, e.g., Pentheroudakis and Baron (2017); *Apple Inc. v Motorola Inc*., 757 F.3d 1286 (Fed. Cir. 04.25.2014)*; In re Innovatio IP Ventures, LLC Patent Litig.*, MDL No. 2303, 2013 WL 5593609 (N.D. Ill. 10.03.2013).

20 European Commission (2017), p.6.

21 Layne–Farrar et al. (2014), for instance, argue that a rule which limits the remuneration of SEPs to the incremental value added by the patent over the next-best alternative provides insufficient incentives to the owners of existing patents to participate in the standard development effort. However, lack of SEP's holders participation in SSOs in the past seems not to have been an issue in the past. To the contrary, even several standards that are essentially royalty free, like Bluetooth, have been successfully developed.

Parameters of hypothetical negotiations should be chosen as follows:[22]

- **Timing of negotiation**. To avoid hold-up, the relevant time of the hypothetical negotiations should be before the standard was adopted. Hypothetical negotiation needs to take place under conditions where the alternative specifications have been identified, so that the parties are well informed about the best potential non-infringing alternatives to the proposed standard. Consistently, it was held in *Microsoft v. Motorola* that the hypothetical negotiation should be deemed to have taken place prior to the date on which the patented invention was adopted as a part of the industry standard. On appeal, the Ninth Circuit Court of Appeals affirmed the determination of the FRAND rates and upheld both the jury's and Judge Robart's decisions.[23]
- **Incremental value.** The incremental value of the patented technology over and above the next-best alternative serves as an upper bound to the reasonable royalties.[24] This so-called "incremental value rule" caps the royalty in at least two respects. First, only the value of the patent itself (i.e. the "technology" value of the patent) is the basis for the FRAND royalty, not the value associated with its inclusion in the standard. Second, only the incremental value of the patents over the next-best alternatives at the time the standard was chosen is relevant. US Courts have endorsed and further refined these principles in various cases.[25] The *ex ante* incremental value is an upper bound because in a typical negotiation the patentee and licensee would negotiate to split the incremental value.

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22 SEP holders may seek to licence exclusively at the end-product level. As set out in Section 4.1 below, this practice appears to result in material inefficiencies. In any event, the *ex ante* negotiation approach is equally applicable if a SEP holder *after standardisation* refuses to licence at the component level.

23 Also in *Apple v. Motorola*, the date of the hypothetical negotiation was deemed to be the date on which the patent became essential to the standard, rather than the date of first infringement. *Apple, Inc. v Motorola Mobility, Inc.*, 869 F. Supp.2d 901 (U.S. District Court, N.D. Illinois 06.22.2012).

24 Lemley and Shapiro (2014). In practice, *ex ante* negotiations would normally have covered several SEPs reading on a standard if they are held by the same SEP holder. There may be valid reasons to consider only a subset, e.g. if part of a portfolio is already licenced or exhausted. Non-SEPs must normally be treated separately. Of course, if a portfolio materially changes after the rates are determined (e.g. because of SEPs being sold), this will have to be reflected in the royalty rates.

25 In *Microsoft Corp. v. Motorola*, the court concluded that "*under a RAND obligation, reasonable parties in a hypothetical negotiation would not consider the value associated with incorporation of the patented technology into the standard. Instead, the negotiating parties would consider only the economic value of the patented technology— based on the technology's contribution to the standard and to the implementer's product itself— apart from the value associated with the standard*." *Microsoft Corp. v. Motorola, Inc.*, C10-1823JLR at para. 258, (W.D. Wash. 25.04.2013).

In *Ericsson v. D-Link,* the court clarified that damages awards for SEPs must be premised on methodologies that attempt to capture the asserted patent's value resulting not from the value added by the standard's widespread adoption, but only from the technology's "superiority". *Ericsson v D- Link,* 773 F.3d 1201 at *1233 (Fed. Cir. 12.04.2014).

In *CSIRO v Cisco*, the Federal Circuit vacated a district court judgement because SEPs can only be valued for the value of the patented feature and not for any added value from standardization of such technology (even when not subject to a RAND commitment). *CSIRO v. CISCO Systems, Inc.*, 809 F.3d 1295 at *1301 (Fed. Cir. 12.03.2015).

Whereas the incremental value rule has been conceptually endorsed, it presents challenges in practice.[26] Yet, legal scholars recently pointed out that they "*perceive a widespread consensus among innovation economists and lawyers that the social value of a technology is its incremental value over the next-best alternative, and that the economic value of a patented technology to an implementer is the (actual or expected) profit or cost saving the implementer derives from the use of the patented technology over the next-best available non-infringing alternative. We therefore recommend that policymakers adopt, subject to (…) [certain considerations] the guiding principle that the royalties awarded in litigation should be commensurate with the value of the patented technology as so defined*."[27]

- **Licensed volumes**. Contributors in the hypothetic negotiation would be aware that inclusion in the standard would grant them a large licensing market. This makes inclusion into the standard more attractive, and patentees might therefore be willing to accept lower royalties compared to a scenario where the same technology would be licensed for use outside the standard.
- **Complementary technologies**. The value of a product must be apportioned among the multiple contributors to that value (including the downstream innovator). A real-world negotiation would not consider one party's SEP portfolio in a vacuum, or even the SEPs associated with one of many standards being implemented in a given product. The price any downstream innovator would be willing to pay for a given SEP portfolio depends on other costs (including royalties) needed to bring a product to market. For that reason, the hypothetical negotiation needs to account for any royalties due on (standard essential) patents held by others. This important point of apportioning the product value will be revisited in Section 2 below.

In *In re Innovatio*, this analysis was further deepened. For example, because of doubts that competing patented technologies would be available for free, the court found that the existence of patented alternatives does not provide as much reason to discount the value of Innovatio's patents as the existence of alternatives in the public domain does. *In re Innovatio IP Ventures, LLC Patent Litig.*, MDL No. 2303, 2013 WL 5593609 at *37 (N.D. Ill. 10.03.2013).

26 In *Microsoft v. Motorola*, Judge Robart noted that such analysis lacks "real-world applicability" not least because SSOs do not conduct *ex ante* negotiations as part of the standard setting process. The court also found that approaches linking the value of a patent to its incremental contribution to a standard are hard to implement. Because of these challenges, in *Microsoft v. Motorola* the FRAND rate was ultimately determined based on "comparable" royalty rates. *Microsoft Corp. v Motorola, Inc.*, C10-1823JLR at paras 77-79 (W.D. Wash. 25.04.2013).

27 Cotter et al. (2019).

- **Alternative technologies**. All alternative technologies that could have been incorporated into the standard, both patented or non-patented, as well as competing standards, are relevant. SSOs may have considered alternative technologies when developing the standard.[28] However, the list of alternatives need not be limited only to those considered by the SSO. In addition to the alternatives explicitly considered by the SSO, alternatives might also include: (1) prior art, (2) technology available in prior versions of the standard, (3) delaying the incorporation of features to wait for alternatives that might soon be available, (4) dropping the SEP from the standard altogether if it relates to an ancillary feature of the standard,[29] and (5) other technical workarounds (e.g., technologies that achieve similar results).

Finally, we note that the *ex ante* negotiation approach has been less commonly used by European courts so far. One reason could be that FRAND rate determination by courts is much less common in Europe and to our knowledge has been done only in the UK so far.[30]

- *Unwired Planet v. Huawei* sets a prominent precedent, as in this case the court determined FRAND rates and commented on a number of relevant aspects. The court directly referred to the *ex ante* approach for the derivation of FRAND rates by accepting that from an economic perspective the FRAND rate could represent the rate which would be agreed "*ex ante*" i.e. before the patented technology is included into the standard.[31] The court considered this to be equivalent to saying that the FRAND rate seeks to eliminate hold up. The FRAND terms are later defined as "*the terms which a truly willing licensor and truly willing licensee would agree upon in the relevant negotiation in the relevant circumstances absent irrelevant factors such as hold up and hold out*."[32]

28 Many SSOs have working committees that develop the technical specifications for various components of the standard. In fact, committees typically start with a number of technical proposals put forth by members, iterating for months or years, drafting specifications, and voting on different proposals.

29 Leonard and Lopez (2014).

30 In Germany, courts are generally reluctant to determine FRAND rates, limiting the number of relevant court opinions. Courts do not seem to have yet placed much weight on hypothetical *ex ante* negotiations. See Pentheroudakis and Baron (2017), p. 99.

31 *Unwired Planet International Ltd v Huawei Technologies Co Ltd*, EWHC 711 at para 97 (Pat Ct. 2017). We note however, that the court ultimately relied to a large extent on the comparable licence approach in determining the FRAND rate, which seems problematic for the reasons set out in Section 3.2.2 below.

32 *Unwired Planet International Ltd v Huawei Technologies Co Ltd*, EWHC 711 at para. 156 (Pat Ct. 2017). Interestingly, the court considered that the economists' opinions showed it is not necessary to "*deprive the patentee of its fair share of the value that is associated with the inclusion of his technology into the standard and the value of the products that are using those standards in order to eliminate hold up and fulfil the purpose of FRAND*" (para 97). This view seems inconsistent with the approach continuously communicated by the European Commission.

- In *Nokia v. IPCom*, Justice Floyd alluded to the *ex ante* negotiation approach during a hearing dated 6 December 2012: "*…in the case of a patent which is essential to a standard, it is appropriate to enquire into* ***what licence terms would have been agreed between a willing licensor and a willing licensee on the basis of the invention which the patent protects but without knowledge that the patent will be incorporated into the standard.*** *The reason that that is said to be relevant is because the patent forces companies who wish to participate in the standard to make use of it. That fact alone may skew the appropriate royalty rate which has to be paid. The approach is called the 'ex ante' approach to the settling of the terms because it is* ***based on the assumption that the terms are being agreed before the standardisation has taken place***."[33]

1.4. Quantifying FRAND royalties in practice

Broadly speaking, three methodologies have been mainly used to quantify FRAND royalties in practice.[34]

Comparable licences

Comparable licences are commonly used to estimate (FRAND) royalties around the globe.[35] Comparable licences can provide valuable evidence to the extent existing licences account for market conditions at the time of the hypothetical negotiation, including a number of factors that are difficult to value, such as the cost of available, non-infringing alternatives.

Courts stressed that prior licences, however, are almost never perfectly analogous to the infringement action. Hence, testimony relying on licences must account for such distinguishing facts when invoking them to value the patented invention. In Section 3.2.2 we discuss that the comparable licensing approach suffers from several profound methodological issues, which are exacerbated in the case of end-use based licensing.

Top-down approach

The top-down approach has been used both in the US and in Europe for FRAND royalty determination. Usually, the following three main steps are performed.

First, the royalty base is selected in case a percentage royalty rate is applied. In past cases, either the royalty base was not much contested (e.g. *Unwired Planet v Huawei* for handsets)[36], or the royalty base of licences of SEPs on the standard under consideration was used.[37] If the royalty is derived in absolute terms, it is not necessary to determine the royalty base.

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33 Lundie Smith, R., "High Court builds up momentum to determine FRAND Licensing terms (PART 2).", Kluwer Patent Blog, 02.19.2013. http://patentblog.kluweriplaw.com/2013/02/19/high-court-builds-up-momentum-to-determine-frand-licensing-terms-part-2.

34 Further approaches have been proposed, but also present challenges. For example, Friedl and Ann (2018), propose to derive FRAND royalties based on the typical level of R&D investment for the patented technologies.

35 Licencing terms of patent pools can also serve as benchmark. The assessment then depends on the setup of the pool. In principle, also licencing offers of patent pools may include a hold-up premium.

36 *Unwired Planet International Ltd v Huawei Technologies Co Ltd*, EWHC 711 at para 269 (Pat Ct. 2017).

37 E.g. *In re Innovatio IP Ventures, LLC Patent Litig.,* MDL No. 2303, 2013 WL 5593609 at *82 (N.D. Ill. 10.03.2013).

Second, the total royalty rate to all SEP holders of a standard is determined. To this end, statements of stakeholders at the time the standard is developed can be taken into account.[38] For example, in *TCL v. Ericsson,* the court awarded a royalty based on a total maximum aggregate royalty level of 6% of the device price derived from Ericsson's public statements.[39]

In *In re Innovatio*, the Wi-Fi chip was found to be the relevant component, and the component producer's average profit per chip was considered as the aggregate FRAND royalty for the standard.[40]

Third, the total royalty for the standard is apportioned among SEP holders. The simplest form is to apportion proportionally to the number of SEPs. Alternatively, one can weight by the importance of patents.[41]

The Top-down approach also presents certain methodological issues as set out in Section 3.2.1, which are likely to be exacerbated by end-use based licensing.

Bottom-up approach

The bottom-up approach is based on the consideration that a licensee in the hypothetical negotiation would not pay more for the patents at issue than the costs of implementing reasonable alternatives to the technologies at issue. First, the cost of implementing reasonable alternatives that could have been adopted into the standard is determined. Then that cost is divided by the total number of infringing units to determine the maximum per-unit royalty the patents at issue would have merited in the hypothetical negotiation.[42]

Although conceptually valid if strictly applied from an *ex ante* perspective, the approach is not often applied in practice for FRAND royalty determination, mainly because courts found that "*approaches linking the value of a patent to its incremental contribution to a standard*

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38 *Ericsson v D- Link*, 773 F.3d 1201 (Fed. Cir. 12.04.2014) and *In re Innovatio IP Ventures, LLC Patent Litig*., MDL No. 2303, 2013 WL 5593609 at *82 (N.D. Ill. 10.03.2013).

39 In April 2008, at a time when the LTE standard was competing with the WIMAX standard, Ericsson had posted on its webpage that "Ericsson believes the market will drive all players to act in accordance with these principles and to a reasonable maximum aggregate royalty level of 6-8% for handsets". TCL v. *Ericsson*, 8:14-cv-00341-JVS-DFM, Document 1802 at *22 (District Court, Central District California, 12.21.2017).

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The court inter alia found such statements important because there were "*made prior to, or around, the time the respective standards were being set, such that they reflect the ex ante expectations of what a reasonable aggregate royalty burden should be before the standard was adopted and manufacturers are locked-in*". *TCL v. Ericsson*, 8:14-cv-00341-JVS-DFM Document 1802 at *19 (District Court, Central District California, 12.21.2017).

In *Unwired Planet v Huawei*, the candidate court determined FRAND royalties were cross-checked using a top town approachsams.

40 *In re Innovatio IP Ventures, LLC Patent Litig.,* MDL No. 2303, 2013 WL 5593609 at *82 (N.D. Ill. 10.03.2013).

41 For instance, in *In re Innovatio*, in line with preceding studies it was assumed that the top 10% of the SEPs on the relevant standard would account for 84% of the aggregate royalties for all IP on the standard. The reasonably royalty for Innovatio's SEPs was then determined by multiplying the chip profits attributable to the top 10% Wi-Fi patents by Innovatio's share of the top 10% Wi-Fi SEPs. See *In re Innovatio IP Ventures, LLC Patent Litig*., MDL No. 2303, 2013 WL 5593609 at *85 (N.D. Ill. 10.03.2013).

42 See V.A of *In re Innovatio IP Ventures, LLC Patent Litig.,* MDL No. 2303, 2013 WL 5593609 at *82 (N.D. Ill. 10.03.2013).

are hard to implement".[43] Despite the conceptual appeal of this approach, it is therefore not covered in more depth here.

2. DOWNSTREAM INNOVATIONS AND FRAND ROYALTIES

Downstream innovations are critical for the development of valuable end products. This section examines in more detail how downstream innovations contribute value to end products using a standard and draws implications for FRAND royalties for patented upstream innovations for the standard implied by the *ex ante* negotiation approach.

- We find that the "added value" from a standardised feature comes from multiple sources, including downstream innovations that use and build upon standards (Section 2.1).
- The *ex ante* negotiation framework provides useful guidance on how to apportion the added value from a standard to SEPs and other inputs. In particular, the existence of (i) cost saving technologies, (ii) alternative technologies, and (iii) *ex ante* dispensable technologies, as well as the level of (iv) downstream innovators' costs of investment and R&D limit the royalties licensees could expect in a hypothetical *ex ante* negotiation (Section 2.2).
- Two principles are currently applied by US courts to help guide apportionment in legal proceedings to determine the value of patents generally, whether or not FRAND-committed. The Entire Market Value Rule establishes that royalties must be based on a fraction of the total market value of an end product if the patented feature does not drive demand for the product. The SSPPU principle further suggests that the Smallest Saleable Patent Practicing Unit should serve as the royalty base when determining royalty rates for complex products in order to avoid overcompensation from misappropriation under too-wide royalty bases. These principles effectively impose restrictions on end-use based licensing when determining FRAND rates (Section 2.3).

2.1. Value sources for end products and the challenge of apportionment

Most (end) products are complex and consist of multiple components. These products derive their value from a variety of features, only a subset of which will directly use the standard.

Negotiations over SEP royalties are effectively about how the product value should be split among SEP holders, downstream innovators/product developers, and ultimately consumers. Apportioning the (end) product's value is not straight-forward. Sometimes reference is made to the "added value" of a standard to end products. The added value can be thought of as the difference between the product value *with* the standard-implementing features and the value of the same product *without* these features (Figure 1 below). In economic terms, the "added value" captures the "marginal contribution" of the standard-compliant features, taking as given all other components of a product.[44] If

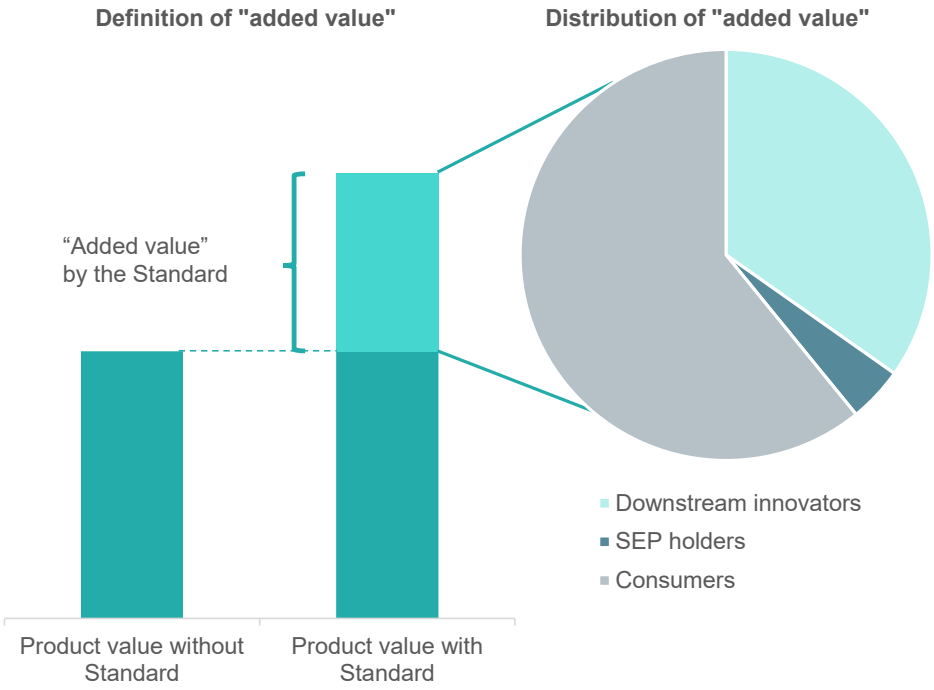
43 *Microsoft Corp. v. Motorola, Inc.*, C10-1823JLR at *27, (W.D. Wash. 04.25.2013).

44 The added value therefore excludes any value from features entirely separate from the (relevant) standards, e.g., entirely based on downstream innovations.

a standard adds value to features of the end product which themselves do not implement the standard, this extra value is also included in the "added value".

The *ex ante* negotiation approach implies that SEP holders are at most entitled to a fraction of the added value. The "added value" from standards to end products comes from: the standardised technologies, standardisation, downstream innovations implementing and building on standards as well as unpatented technologies. Without these other inputs the "added value" could not be achieved. To determine the FRAND royalty, one therefore needs to apportion the added value among the contributors.

Figure 1: Definition and distribution of "added value" by the standard



Source: CRA

Importantly, the marginal contribution of an input *relative to the next best alternative* matters. This distinction is important if substitutes for inputs exist. For example, normally several competing display manufacturers offer displays for a given smartphone. There is no reason why one should pay more than the competitive price for the display, and the value naturally apportioned to the remainder of the smartphone is the total value of the smartphone minus the competitive price of the display. Put differently, it is competition between display manufacturers that ensures that the price of a display amounts to only a portion of the smartphone's total price, although a smartphone is of little use without a display.

The example of competition between display manufacturers illustrates why price discrimination is less likely when there is competition among input suppliers. Indeed, display manufacturers cannot charge a higher price if the same display is integrated into a more valuable smartphone, or put differently, they cannot misappropriate value stemming from other smartphone features and innovations. This is because smartphone OEMs would simply resort to a competitor if a display manufacturer tried to price discriminate by the value of smartphones.

These same principles apply to SEPs and FRAND royalties: when there are *ex ante* substitutes for the SEPs included in a standard, the FRAND royalties are constrained by competition to their marginal contribution to the standard relative to the next best alternative technology. When good substitutes exist, the marginal contribution of the chosen patented technology—and thus the FRAND royalty—will be only a small fraction of the added value of the standard (see also Case Study 1 below). Although standardisation eliminates technology competition for the inclusion into the standard, the FRAND commitment is meant to ensure that SEP holders are not abusing the market power obtained from this elimination of competition. The FRAND royalty should not exceed the level that could have been obtained *at the time of standardisation,* that is, reflecting the SEPs marginal contribution *relative to the next best alternatives* for inclusion into the standard. The "added value" of the standard normally *includes* the value that could have been achieved with alternative technologies. It is critical to ensure that FRAND royalties *exclude* the value that could have been achieved with alternative technologies. The display example illustrates that technology competition may materially constrain the patentees' ability to price discriminate. As discussed in more detail in the following section, technology competition similarly implies restrictions on the scope for discriminating the level of FRAND royalties by end-use.

Case Study 1: In re Innovatio (Part I)

Court awarded SEP royalties often amount to only a tiny fraction of the "added value" of features involving technical standards, as illustrated by the *In re Innovatio* case.

In that case, Innovatio estimated for each device a so-called "Wi-Fi feature factor". The value of the device (e.g., the access point, laptop, tablet or tracking device) attributable to the 802.11 Wi-Fi standard was then derived by multiplying the Wi-Fi feature factor (ranging from 10% for laptops to 95% for access points) with the device's selling price.[45]

In court, Innovatio argued that the royalties for their asserted Wi-Fi SEPs should be calculated by applying a uniform rate of 6% to portion of the devices' value attributable to Wi-Fi. Innovatio's suggested method would have resulted in per-unit royalties from $3.39 to $36.90 depending on the device. Thus, the requested royalty differed across use cases.

However, the court found that a uniform rate of $0.0956 per unit across devices reflected the value of Innovatio's technologies included in the Wi-Fi standard. The court also calculated that the total aggregate royalty burden ("ARB") for all Wi-Fi SEPs would be $1.80 per unit. The following table illustrates that the court awarded royalties are only a very small proportion of the "added value" of Wi-Fi, as claimed by Innovatio.

Table 1: Court awarded aggregate royalty burden v. Wi-Fi added value in *Innovatio*

Measure	Access Point	Laptop	Tablet	Tracking Device
Wi-Fi added value ($)	57	79	270	615
Court derived Wi-Fi aggregate royalty burden ($)	1.80	1.80	1.80	1.80
% of Wi-Fi added value	3.2%	2.3%	0.7%	0.3%

Source: CRA based on *In re Innovatio.*

2.2. Implications of the *ex ante* negotiation framework for FRAND royalties

When a standard is developed, patented and unpatented technologies compete for inclusion into the standard. A standard economic insight is that in a competitive environment, price discrimination – such as "end-use-based pricing" – is generally less likely to emerge. Where alternative technologies are available for inclusion into a standard, downstream innovators would "*ex ante*" not be willing to concede much of the value created by complementary downstream innovations to patentees.

The *ex ante* negotiation framework can provide useful guidance on what is FRAND. Whereas it is generally hard to predict the exact outcome of negotiations, standard economic principles provide guidance as to how technology competition for inclusion into standards will generally affect the ensuing royalty rates. For the application of this framework, the contributions of downstream innovators are of critical importance.

45 *In re Innovatio IP Ventures, LLC Patent Litig.*, MDL No. 2303, 2013 WL 5593609 (N.D. Ill. 10.03.2013).

Multiple economic models to predict the outcomes of such negotiations have been proposed. These include notably the "*ex ante* auction" approach, whereby an SSO holds a hypothetical auction over competing technologies during the development phase, with the winner of the auction becoming part of the standard.[46] During the auction, IP holders would need to submit a licence fee per unit of output to downstream users of the standard, who would then choose which patent should be embodied in a standard.[47] According to Swanson and Baumol the outcome of such an auction would provide a basis for what constitutes reasonable royalties because it would fully reflect the state of competition among potential IP providers that existed prior to the selection of a standard. This reasonable level of royalty rates would also be constrained by the price of the final product in the downstream market. Baumol and Swanson (2005) only examine scenarios where the standard consists of a single patent. Layne-Farrar et al. (2007) extend this framework and allow for multiple complementary or competing patents.[48]

To derive reliable conclusions, it is critical to properly account for complementary downstream innovations, but the existing studies do not achieve this. Baumol and Swanson (2005) assume that the IP holder could also produce competitive downstream products, which is often not the case. In reality, downstream innovators also incur R&D and contribute unique innovations into their products implementing the standard. Baumol and Swanson (2005) point out that "*when access to a particular piece of IP is not necessary to produce the final product - as when there are multiple competing types of IP suitable to the task - there is no reason to assume that the IP owner has any legitimate claim on any residual profits that downstream sellers obtain*".[49] Whereas they do not explicitly cover this point, the "efficient component pricing rule" promoted by Baumol and Swanson (2005), which effectively implies that the SEP holder should be compensated for opportunity profits, also implies that the SEP holder would not be entitled to residual profits in addition to the IP holder's opportunity profits.

One can show that the following factors limit both the level of royalties patentees would be expected to obtain in *ex ante* negotiations and the potential for price discrimination:

46 See Swanson and Baumol (2005) and Layne-Farrar et al. (2007).

47 In the relevant models, all participants to the *ex ante* auction (including IP holders) are supposed to be perfectly informed. Since IP holders submit bids, they can extract the entire surplus over competing technologies. The downstream innovator receives the surplus that can be achieved with alternative technologies.

48 We note that if several complementary patented technologies are critical (i.e. extra value is only created if all technologies are used), the combined royalty of *all* those technologies included in the standard amounts to the surplus compared to the next-best alternatives. The framework however cannot pin down the exact royalty rate for each complementary patent.
Layne-Farrar et al. (2007) also examine the economic bargaining concept of the "Shapley value". This approach divides the surplus among group members according to their average marginal or incremental contribution to alternative combinations of the members of the cooperative group. This approach, however, yields some undesirable properties. For example, IP holders of technologies that for efficiency reasons will not be included into the standard would still receive a compensation. It therefore seems less suited to model *ex ante* negotiations.

49 Swanson and Baumol (2005), p. 39.

- **Cost saving technologies**. Some technologies facilitate the implementation of a standard, i.e. they result in cost savings. In such cases, (e.g. in the case of a technology that reduces the production costs of modems) the size of the cost savings may not vary by end use. For example, if a technology reduces modem chip production costs, the cost saving per unit will be similar for all products incorporating a given modem chip. Consequently, one would expect the royalty rate obtained in *ex ante* negotiations not to vary by end use.
- **Alternative technologies**. For many technologies, direct substitutes for inclusion into the standard may have been available at the time of standard setting. In this case, competition between these various technologies constrains the pricing power of IP holders and makes price discrimination significantly less likely. Put differently, technology competition *ex ante* limits the IP holders' ability to misappropriate the value of downstream innovations. Case Study 2 provides an illustration for a non-patented technology that constrained the level of royalties a SEP holder could have charged before the technology was incorporated into the standard. Before standardisation, alternative technologies also constrain the scope for differentiating the royalty level by end use: if a patent holder were to selectively charge inflated royalties from downstream innovators with "high value applications", the latter would have an incentive to switch to competing technologies. Indeed, one can observe that upstream innovators of very valuable *non-standardised* IP are often not discriminating royalties by end use. For instance, the chip developer Arm is a strong IP holder and yet it has not imposed device-level licencing, possibly because of the threat of competition from alternative technologies.[50]

  Of course, certain technologies may not have been facing competition for inclusion into the standard. Even in those cases, "developing around" a technology or dropping certain features of the standard might have been a relevant option in case royalty demands had been excessive.

50 Arm uses an upfront fixed licence fee combined with a royalty per chipset and does not seem to discriminate based on the net selling price of the end-device. See https://www.arm.com/-/media/global/company/investors/PDFs/Arm_SB_Q1_2018_Roadshow_Slides_Final.pdf?revision=b4fbed8a-def4-42aa-b9e1-d7717e620586&la=en.

Case Study 2: "NDI-toggling"

Recent patent litigations related to "NDI-toggling" have brought up evidence suggesting that, at the time the 4G standard was set, there existed royalty-free, equally good alternatives to patented technologies ultimately included in the standard. The ex ante valuation approach implies that potential licensees' willingness to pay for such patents ex ante would have been zero.

In 2021, Japanese national patent licensing firm IP Bridge sued Ford at the Munich Regional Court for infringement of its EP2294737B1 patent essential to the 4G standard.[51] The patent-in-suit relates to "NDI-toggling"[52] and was initially declared essential to the 4G standard by Japanese electronics maker Panasonic, and later-on obtained by IP Bridge.[53].

During the court proceedings, evidence of an existing alternative to the patent-in-suit at the time the 4G standard was set had been presented. The alternative technology with reference "Tdoc R1-082083" had been suggested by Motorola in ETSI meetings in May 2008 to the 4G SSO 3GPP for inclusion in the standard.[54] The defendants claimed that the alternative solution would have achieved similar results as the patented technology owned by IP Bridge which was ultimately included in the standard.

Under the *ex ante* negotiation framework, implications of the existence of the royalty free alternative "Tdoc R1-082083" on potential licensees' willingness to pay must be accounted for when deriving FRAND royalty rates. The royalty-free technology presents itself as the "next best alternative" when assessing the incremental contribution of IP Bridge's EP2294737B1 patent. Should the royalty free alternative indeed be considered equivalent to the patented technology, it is conceivable that the incremental contribution of the latter – and thus consequently the FRAND rate – would be (close to) zero.

51 IP Bridge v Ford, 7 O 9572/21 (Munich Regional Court). The EP2294737B1 patent is about "Control channel signaling for triggering the independent transmission of a channel quality indicator". See also https://patentimages.storage.googleapis.com/4b/71/bf/7b0781ed902412/EP2294737B1.pdf.

52 "NDI-toggling" in technical terms is the technology that enables control channel signaling for triggering the independent transmission of a channel quality indicator.

53 The same patent is the subject of parallel patent litigations against smartphone maker OPPO (IP Bridge v OPPO, 7 O 8133/21; Munich Regional Court) and was previously asserted against HTC (and possibly also others).

54 Document submitted by Motorola during the meetings available at https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_53/Docs/R1-082082.zip.

- ***Ex ante* dispensable technologies**. An important option of SSOs is to modify prospective standards so as to reduce the royalties due for the standard. From an *ex ante* perspective, SSOs in principle can "develop around" existing IP similarly to how this is done regularly in relation to non-SEPs or declare certain parts of the standard optional.[55] The threat to "develop around" existing IP is an important factor driving negotiation outcomes in non-SEP negotiations. Moreover, the ultimate issue to a licensee is the incremental value of the patented technology to the licensed product, which may not use or need all functionality provided by the standard. The option of developing around IP should therefore also play an important role in hypothetical *ex ante* negotiations. For example, downstream innovators of products that do not make use of parts of the standard would have had a limited willingness to pay for the corresponding IP in *ex ante* negotiations.[56]
  Courts seem to have (implicitly) applied such reasoning. For example, in *Microsoft v. Motorola* Judge Robart for the Xbox products attributed little value to encryption patents included in the Wi-Fi standard since Microsoft had implemented its own encryption for transmissions from the Xbox all the way through the Wi-Fi connection and Internet to a remote server.[57]
  This option to develop around existing IP also limits the scope for royalty price discrimination: if the SEP-holder's demanded royalty for a "high value" use case is excessive a downstream innovator would likely have chosen to "develop around" the IP in a hypothetical *ex ante* negotiation.
- **Downstream innovators' costs of investment and R&D**. It is widely acknowledged that FRAND royalties should exclude any hold-up premium associated with subsequent investments of downstream innovators (Section 1.3). Since the hypothetical *ex ante* negotiations take place before these investments are sunk, downstream innovators would undertake these investments only if this was profitable. SEP royalties must therefore be low enough to compensate downstream innovators for their investments to develop products implementing the standards in the first place. This naturally also dampens the SEP holders' ability to price discriminate by end-use: downstream innovators would take the costs of complementary investments, inputs and innovations into account in hypothetical royalty negotiations. On average, higher investments will give rise to more valuable use cases. The *ex-ante* willingness to pay for SEPs is thus most reduced for downstream innovators with higher value use cases who incur higher upfront costs in comparison with downstream firms with lower value use cases.

2.3. Apportionment in practice

FRAND royalties have been determined by courts in several proceedings around the globe.[58] Predominantly, this has been done in the US, where the calculation of FRAND

55 Note however, that sometimes SSO do not "invent around" despite a missing/negative LoA. For example, IEEE continued to rely on the patented technology at issue in *CSIRO v CISCO* even though "CSIRO declined to issue letters of assurance and in the face of ongoing litigation involving the patent."

56 This may even hold for technologies that became a mandatory element of the standard.

57 *Microsoft Corp. v. Motorola, Inc*., C10-1823JLR at paras 401-406 (W.D. Wash.04.25.2013).

58 Pentheroudakis and Baron (2017) and Layne-Farrar and Wong-Ervin (2017) provide overviews of proceedings in other jurisdictions.

royalties is subject to the requirement of apportionment (similar to other cases where reasonable royalties are determined) because damages awarded for patent infringement "*must reflect the value attributable to the infringing features of the product, and no more.*"[59] According to US case law, the value of the SEPs at issue should be apportioned from the value of other features of the standard, features protected by other patents and unpatented features of the infringing products, including from downstream innovations. In principle, apportionment can be addressed in a variety of ways, including "*by careful selection of the royalty base to reflect the value added by the patented feature [or] ... by adjustment of the royalty rate so as to discount the value of a product's non-patented features; or by a combination thereof*."[60]

Concerns over potential overcompensation of patentees have led the US Federal Circuit to articulate that the use of the "entire market value" of the end product as the royalty base is permissible only when the patent drives the demand for the end product and that royalties should generally be based on the Smallest Saleable Patent Practicing Unit (SSPPU) in the accused product. Below we discuss that these two principles materially restrict the scope for end-use based licensing.

- **Entire Market Value Rule (EMVR)**. Using the entire market value of the end product as the royalty base when calculating damages for infringement is permissible only when the patent drives the demand for the end product.[61]

  The EMVR responds to the concern that reliance on the product's entire market value might be misleading, creating a risk of unduly high royalty awards. Below we summarise several studies that confirm the existence of cognitive biases which may result in upward biased royalty awards for patents covering small elements of "multi-component" products.

  In *Ericsson v D- Link*, the court found that placing undue emphasis on the value of the entire product could result in inflated royalty awards. The court noted that "*where a multi-component product is at issue and the patented feature is not the item which imbues the combination of the other features with value, care must be taken to avoid misleading the jury by placing undue emphasis on the value of the entire product. It is not that an appropriately apportioned royalty award could never be fashioned by starting with the entire market value of a multi-component product - by, for instance, dramatically reducing the royalty rate to be applied in those cases - it is that reliance on the entire market value might mislead the jury, who may be less equipped to*

59 *Ericsson, Inc. v. D–Link Sys., Inc. 773 F.3d 1201 at *1226 (Fed.Cir. 2014)*. This goes back to *Garretson v. Clark*, 111 U.S. 120, 121 (1884). More recently, the Federal Circuit described that "*[n]o matter what the form of the royalty, a patentee must take care to seek only those damages attributable to the infringing features*.", *VirnetX, Inc. v. Cisco Sys*., Inc., 767 F.3d 1308, 1326 (Fed. Cir. 2014).

60 *Ericsson v D- Link*, 773 F.3d 1201 at *1226 (Fed. Cir. 12.04.2014). The issue of royalty base selection is linked to the on-going discussion on whether FRAND includes a "license to all" requirement, see e.g. Layne-Farrar et al. (2020). When the SEP owner is allowed to licence only at the device level, it may appear more natural to take the device value as the royalty base even though this many not be a good approximation of the *ex ante* bargaining situation.

61 See also Cotter et al. (2019), p. 71 et seq. and Pentheroudakis and Baron (2017), p. 87 et seq. for more details.

understand the extent to which the royalty rate would need to do the work in such instances."[62]

Smallest Saleable Patent Practicing Unit (SSPPU). Concerns over large royalty bases resulting in overcompensation led the Federal Circuit to articulate the general rule that the royalty base should be the SSPPU in the accused product. The Federal Circuit affirmed in *Ericsson v. D-Link* the "evidentiary principle" that where the entire value of a product is not properly and legally attributable to the patented feature, the royalty base "*must insist on a more realistic starting point for the royalty calculations by juries - often, the smallest saleable unit and, at times, even less.*"[63] This was confirmed in *VirnetX, Inc. v. Cisco Systems.*[64] Also in *LaserDynamics Inc. v. Quanta Computers* it was reaffirmed that "*in any case involving multi-component products, patentees may not calculate damages based on sales of the entire product, as opposed to the smallest saleable patent-practicing unit, without showing that the demand for the entire product is attributable to the patented feature*".[65] Several US courts held that the preference given to the SSPPU as a starting point for damages models does not preclude damages calculations based on comparable licences at the component level or the end product level.[66] Such comparable licences, however, must exclude the value of standardisation and be supported by facts to show that the licences are sufficiently comparable, both technologically and economically (see also Section 3.2.2).[67]

Assessment of apportionment principles

First, there is ample empirical evidence that cognitive biases may result in an unduly high royalty award if the royalty is only a very small share of the royalty base.[68] One bias, known as "anchoring", is the influence of reference points (or "anchors") on an individual's decision making. For example, the order in which an individual encounters different data points might have impact on the individual's interpretation of the data overall: The first data point with which the individual is confronted might serve as an anchor relative to which the individual will evaluate the remaining data points. Such kind of anchoring bias was found in several experimental studies involving mock juries about personal injury and punitive damage cases with plaintiffs that requests more damages tending to receive a larger award.[69] According to Lemley and Shapiro (2007), U.S. juries tend to award royalty rates that are

62 *Ericsson v D- Link*, 773 F.3d 1201 at *1226 (Fed. Cir. 2014).

63 *Ericsson v D- Link*, 773 F.3d 1201 at *1227 (Fed. Cir. 2014).

64 *VirnetX, Inc.v. Cisco Systems, Inc.*, 767 F.3d 1308 at *1330 (Fed. Cir. 2014).

65 *LaserDynamics Inc. v. Quanta Computers*, 694 F.3d 51 at *68-69. (Fed. Cir. 2012).

66 *HTC v Ericsson*, 12 F.4th 476 (5th Cir. 2021), *HTC v Ericsson*, 6:18-cv-00243-JRG, Document 538 at *11 (U.S. District Court, Eastern District Texas 05.23.2019); *CSIRO v. Cisco Sys., Inc.*, 809 F.3d at *1307 (Fed. Cir. 2015); *Ericsson v D- Link*, 773 F.3d 1201 at *1227 (Fed. Cir. 2014).

67 *CSIRO v Cisco,* 809 F. 3d 1295 at *1302-1303 (Fed. Cir. 2015); *See* also *Omega Patents, LLC v. Calamp Corp.*, 13 F.4th 1361, 1337, (Fed. Cir. 2021).

68 Cotter et al. (2018), p. 73 et seq.

69 See e.g. Chapman & Bornstein (1996), Hastie et al. (1999) and Campbell et al. (2016). While these studies found that juries were suffering from these biases, it cannot be excluded that also judges may be subject to similar biases.

within the general vicinity of 10 percent, regardless of the size of the base to which that rate is applied.[70] Studies have found anchoring biases also in judges.[71] Thus, there is a risk that reasonable royalty awards based on the entire value of the accused multi-component products will systematically overvalue patent rights that cover just a fraction of the products' components or features.[72] The above-mentioned evidence supports principles aimed at narrowing down the royalty base, including the EMVR and the SSPPU, in order to minimise the risk of bias.

Second, application of the SSPPU rule normally precludes end-use based licensing for end products where the same component is integrated across multiple end products. In that case, the reasonable royalty will be based on the value of the SSPPU, not on the end product value. For instance, in *In re Innovatio* the court used the average per-unit profit on a Wi-Fi chip as royalty base and determined a uniform per-unit royalty across multiple end products that greatly differed in value (see Case Study 5).

3. ENSURING FRAND LICENSING ACROSS THE VALUE CHAIN IN PRACTICE

After conceptually discussing the apportionment of end product's value and the implications of the *ex ante* negotiation framework, we assess in this section to what extent the economic principles presented in Section 2 are reflected in commonly applied approaches to derive SEP royalties in practice and draw implications for the assessment of end-use based licensing. One of the most intensely debated topics revolving around SEP licensing in practice concerns the level of the value chain at which the patents should be licensed. Closely related to this issue is the question to what extent SEP holders who have committed to licence their patents at FRAND terms should be able to distinguish their royalty demands by the end use of their IP (i.e. to implement end-use-based licensing).

- Section 3.1 first briefly describes the issue of the level of licensing, defines end-use-based licensing and finally discusses the relationship between them. While end-use-based licensing can be implemented both at the device and the component level, it is mainly applied at the end device level.
- Following this, Section 3.2 discusses when and why end-use-based licensing bears an increased risk of misappropriating value. In particular, royalties differentiated by end-use may misappropriate value from downstream innovation, above levels that would have been feasible under *ex ante* technology competition. While in principle end-use based licensing can be implemented both at the device and component level, licensing at the component level typically limits the scope for differentiating royalties in practice.

70 Lemley and Shapiro (2007), finding in a study of 58 patent verdicts awarded between 1982 and 2005 that "*[t]he royalty rate for components is approximately 10.0%, compared with 13.1% for all inventions and 14.7% for integrated product claims*" (85 *Texas Law Review* 1991, p. 2034).

71 See, e.g. Englich et al. (2006), Englich and Mussweiler (2001) and Wistrich et al. (2005).

72 For instance, the royalties awarded by the court in *In re Innovatio* amounted to 0.01% to 0.16% of the average device values. *In re Innovatio IP Ventures, LLC Patent Litig.*, MDL No. 2303, 2013 WL 5593609 (N.D. Ill. 10.03.2013). See also Case Study 5 for further background.

- End-use based licensing increases the risk of misappropriation by SEP holders under both the top down and comparable licence approach, both of which are commonly used in practice to quantify FRAND royalty rates.

3.1. Level of licensing and royalty determination

Level of licensing

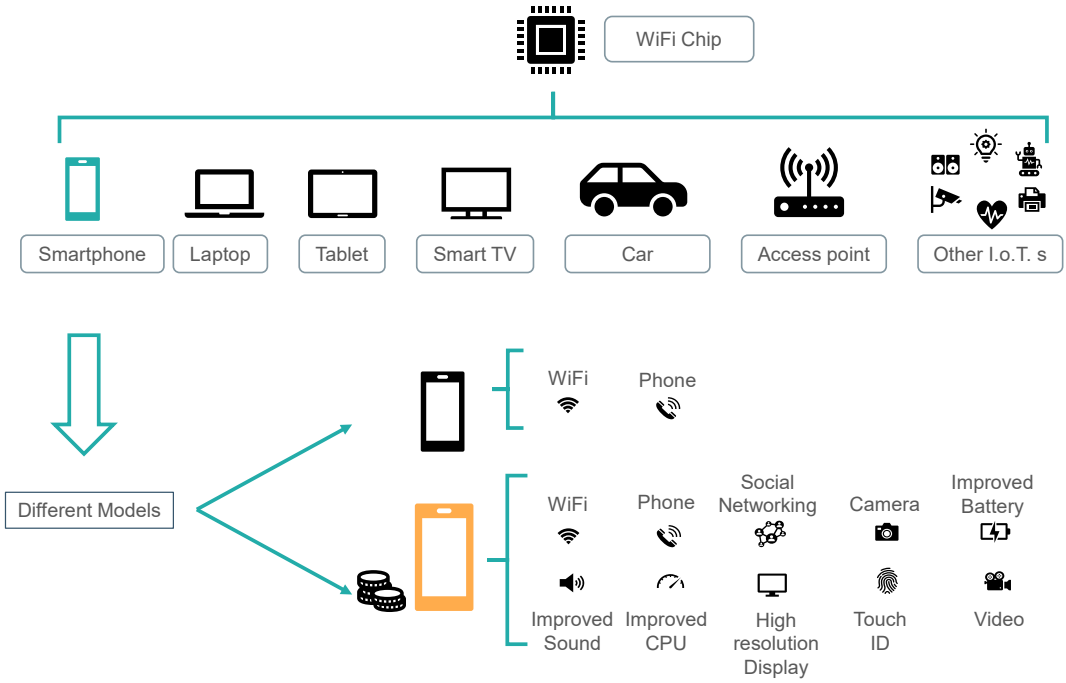
The issue of the level of licensing occurs in multi-tiered supply chains in which device manufacturers of end products source components that implement a specific standard and thereby infringe the SEPs covering that standard. One example concerns the production of Wi-Fi enabled devices (such as laptops) for which the manufacturer purchases a Wi-Fi chipset from chipset manufacturers. Another example might be a 3G/4G cellular module in smart Electric Vehicle (EV) chargers. End products that integrate and use standard-implementing features and components also infringe their respective SEPs.

End-use-based licensing

End-use-based licensing refers to the practice whereby SEP holders differentiate the level of royalties depending on the end product in which the respective standard is implemented. As standardised technologies are often implemented in a wide array of products, the scope for such price discrimination is accordingly large. For example, chips implementing the Wi-Fi standard are integrated into a wide range of different end product categories (such as smartphones, laptops, access points, smart home appliances, EVs, smart EV chargers etc.) that fundamentally differ from each other in their purpose, functionalities, and price (Figure 2 below).

Furthermore, there might be significant vertical differentiation within a product category, as is evidenced by the example of basic feature phones and premium smartphones. In contrast to basic feature phones, premium smartphones typically host a myriad of additional features that are either independent from or complementary to the standard-implementing features and are often the result of significant downstream investment and innovation. The additional upfront investment costs (e.g. R&D expenditures), input and production costs that a firm has to incur to equip its products with additional features will typically be reflected in a higher end product price. This observation is relevant as higher end product prices increase SEP holders' scope to misappropriate value from downstream firms.

Figure 2: Complementary and independent features to the Wi-Fi standard along the value chain



Source: CRA

In practice, SEP holders can implement end-use-based licensing in the following two ways:

- SEP holders might directly price discriminate by charging absolute per-unit royalty rates that vary across products.
- Alternatively, SEP holders might indirectly implement end-use-based licensing by charging ad-valorem royalty rates, in which case the licensee is typically obliged to cede a specific percentage of the infringing end product's selling price to the SEP holder.[73] An ad-valorem royalty rate that is charged uniformly for all products within a specific product category or even across products from different product categories automatically implies price discrimination, as the absolute per-unit royalty is higher for more expensive products. Using the end product's selling price as royalty base for the ad-valorem rate can thus lead to substantially differentiated absolute royalty claims.

Accordingly, we define end-use-based licensing to include both price discrimination by end product category and charging royalties that depend on the end device value. Of course, SEP holders do not need to engage in end-use-based licensing; rather, they can decide to charge the same absolute per-unit royalty independent of the end product.

Relationship between level of licensing and royalty determination

In principle, end-use-based licensing can be implemented both at the device and the component level. However, as end-use-based licensing implies that royalties vary across end uses and are often linked to the value of the *device*, it is mainly applied at the device level. Nevertheless, an SEP holder who wishes to licence at the device level but not to price

73 Similarly, other royalty structures whereby the royalty per unit depends on the value of the end-product/service would also be instances of end-use based licensing.

discriminate by end use could still charge a royalty in the form of a fixed amount per unit for every product that infringes on the SEP holder's patents, regardless of the product type.[74] In contrast, royalties for the same component rarely differ by end use/device value when SEPs are licensed to component manufacturers.

3.2. Risk of misappropriation under end-use-based licensing

It was mentioned above that the likely outcome of hypothetical *ex ante* negotiations provides the relevant benchmark for FRAND royalty determination. In particular, *ex ante* competition would constrain IP holders' ability to price discriminate. This section assesses under which circumstances the quantitative approaches used in practice approximate such an outcome. And whether, also in a SEP context, excessive price discrimination – for instance in the form of end-use-based licensing – bears an increased risk of SEP holders being able to extract excessive (average) royalties.

We examine the implications of end-use-based licensing in the context of the two main approaches used by courts to determine FRAND royalties: (i) the top-down approach and (ii) the comparable licences approach, both of which have been discussed in Section 1.4 above.

It turns out that, with both approaches, end-use-based licensing exacerbates a number of known risks and can lead to inflated rates for SEP holders and distorted incentives for downstream innovators. The royalties under end-use-based licensing may not reflect the outcome of *ex ante* negotiations. When there is competition from alternative technologies, the scope for price discrimination is often limited and licensing often takes place at the component level (see Section 2.2). Consequently, **licensing at component level** and **without price discrimination by end-use (e.g. based on the component's selling price)** is an approach for determining SEP royalties that is less prone to distortion by the issues discussed above and hence tends to be closer to the *ex ante* negotiation benchmark.

3.2.1. End-use-based licensing under top-down approach

A top-down approach may lead to substantially biased absolute royalties if an inappropriate royalty base is selected or an ad-valorem royalty rate is not adjusted to account for additional features added to the royalty base over time. These issues are exacerbated under end-use-based licensing. Per-unit rates derived with a top-down approach do not pose the same risk of misappropriating value from future downstream innovations. In any event, end-use-based licensing requires a close assessment of *ex ante* substitutable technologies to avoid inflated royalty rates.

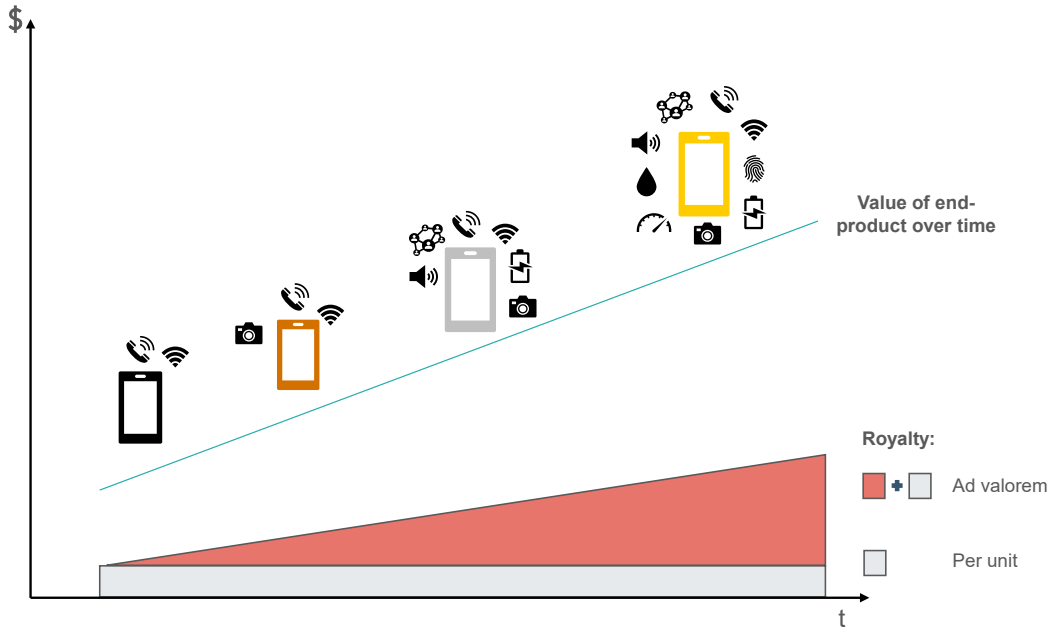
Ad-valorem royalties applied to the device value

Royalties determined by means of the top-down approach can be seriously biased if an inappropriate royalty base is selected for ad-valorem royalties. The choice of royalty base obviously has an implication on the set of complementary innovations potentially taxed by the royalty. For the reasons discussed in Section 2, if features unrelated

74 For example, for the HEVC (H.265) video codec standard, the patent pool MPEG LA does not differentiate by use case and charges a uniform royalty rate per unit (https://www.mpegla.com/wp-content/uploads/2018/11/HEVCweb.pdf). In contrast, the patent pool Access Advance implements end-use-based licensing, differentiating its royalty rates by device type (https://accessadvance.com/hevc-advance-patent-pool-detailed-royalty-rates/).

to the standard features are added to products over time that are included in the royalty base, the royalty rate would normally have to be adjusted. This is illustrated by Figure 3 below using the example of a smartphone that increases in value as additional features are added over time.

Figure 3: Total ad valorem and per-unit royalty rate for with increasing number of complementary and independent features



Source: CRA

However, courts seem to select the royalty base according to historic statements or based on existing licences. Little attention is given to developments that may militate for updating the choice of the royalty base or of the aggregate royalty rate. For instance, thirty years ago, the main functionality of mobile phones was to enable mobile phone conversations. Nowadays, smartphones have a range of functionalities not directly related to mobile communications, and most of the smartphones' mobile traffic data is transmitted through Wi-Fi, not by cellular technologies. Simply maintaining the royalty rate and base as postulated in earlier years may therefore not be justified. In addition, whereas it seems accepted that public statements may be self-serving,[75] **such statements may not only be self-serving in relation to the royalty rate, but also regarding the royalty base** or related aspects. For example, a statement that the aggregate royalty is around x% *of the end device price* implies that of any additional value created by complementary innovation or even innovation entirely unrelated to the standard, x% would have to be paid to SEP holders.

The top-down approach is usually not based on any assessment of *ex ante* substitutable technologies.[76] Whereas doing such an assessment may be generally challenging, the above-mentioned insights imply that, in the presence of competing technologies, IP holders

75 *Unwired Planet International Ltd v Huawei Technologies Co Ltd*, EWHC 711 at para. 269 (Pat Ct. 2017).

76 *Microsoft Corp. v. Motorola, Inc.,* C10-1823JLR (W.D. Wash. 04.25.2013) and *In re Innovatio IP Ventures, LLC Patent Litig.,* MDL No. 2303, 2013 WL 5593609 (N.D. Ill. 10.03.2013).

would be unlikely to be able to appropriate surplus from complementary innovations, implying that the royalty rate would likely need to be adjusted if additional features were included in the royalty base. It would therefore seem warranted to adjust the royalty rate when more downstream innovations are added to devices over time. One alternative solution to reduce the risk of misappropriation would be to determine FRAND royalties using a narrower royalty base or per-unit royalties if a proper *ex ante* assessment is not undertaken.

It is unlikely that aggregate FRAND royalties will be available by end use. If an overly broad royalty base (such as the end device selling price) is used, courts would have to adjust the aggregate royalty rate by end use in order to properly account for differences in complementary features or for restrictions in the ability to price discriminate implied by *ex ante* competition.[77] If such an adjustment were not made properly, this would increase the risk of taxing complementary innovations and overcompensating SEP holders as set out above.

Therefore, basing royalties derived by the Top-Down approach on the end use entails a material risk of taxing complementary innovations, resulting in royalty rates beyond the *ex ante* incremental value of SEPs.

Per-unit royalties

When applying the Top-Down approach to determine end-use-based, per-unit royalty rates, an aggregate royalty burden has to be established for each individual end use case. Following common practice, the aggregate royalty burden is often derived from public announcements. In principle, such announcements would have to be made available for every end use case. Further, each additional end use case added over time would require for a new aggregate royalty burden to be determined.

Per-unit royalties can also lead to value misappropriation if differences between the absolute royalties for different end uses are not reflective of technology competition when the standard was developed. Naturally, competition from alternative technologies may differ depending on the use case. In a similar vein, certain SEPs may be considered dispensable depending on the use case, and downstream firms may have invested considerably into product innovations. As set out in Section 1.3 above, these factors may substantially constrain the pricing power of IP holders and consequently the royalty rate in an *ex ante* negotiation framework. However, in particular where per-unit rates are derived applying fixed assumptions on device prices, differences between use cases with respect to *ex ante* negotiation outcomes are likely ignored. The inflated per-unit royalty rates proposed by Innovatio in *In re Innovatio* constitute such an example (see Case Study 5 below).

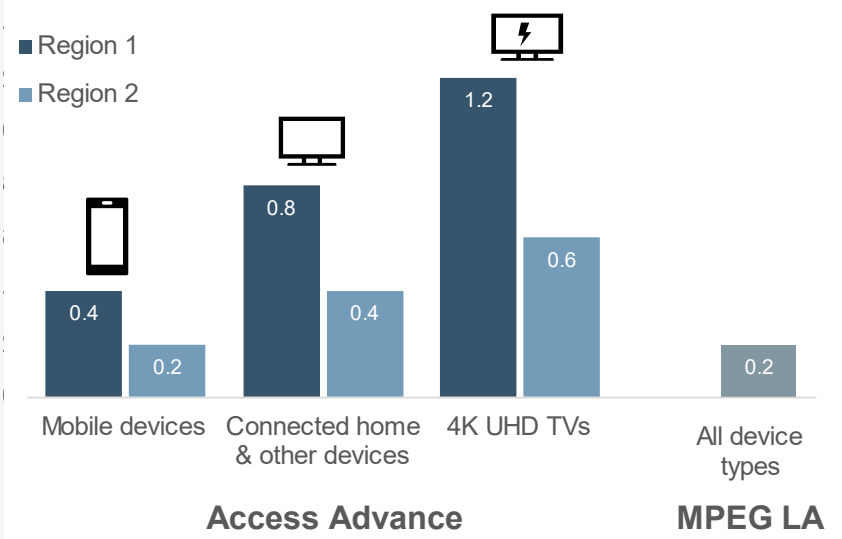
77 For example, if in *ex ante* negotiations the SEP holder would have been able to extract a uniform absolute royalty for low value and high value applications, if the end product's value is used as a royalty base, this automatically means a lower percentage aggregate rate should be applied to high value products.

Case Study 3: HEVC video codec licensing – MPEG LA v. Access Advance

Access Advance's end-use based per unit royalty rates for the HEVC video codec standard offer an example for royalty rates justified by means of a Top-Down approach based on aggregate royalty rates that lack a proper evaluation in light of an ex ante negotiation framework.

Both the Access Advance and MPEG LA patent pools for SEPs to the video codec standard HEVC follow a per unit royalty structure. However, while MPEG LA applies a flat royalty structure for different device types, the royalty rate set by the Access Advance patent pool is generally higher and differentiates by use case. Figure 4 depicts the headline per unit royalty rates for each patent pool.

Figure 4: Per unit royalty (USD) – MPEG LA v. Access Advance



Source: CRA illustration. Access Advance HEVC licensing programme.[78] MPEG LA HEVC licensing programme.[79]

Note: Headline per unit rates of both pools are presented for illustration. For a thorough comparison of the royalty rates, one would have to take account of the number of SEP families licensed through each pool. Many SEP holders have left the MPEG LA pool in recent years, which may necessitate a downward revision of the MPEG LA pool rate.

Access Advance published a paper titled "Explanation of the Fairness and Reasonableness of HEVC Advance's Royalty Rates" [80] ("FRAND White Paper") which attempts to establish the FRAND nature of Access Advance's royalty rates *inter alia* by means of a Top-Down approach. The aggregate royalty rate for the different use cases is benchmarked against the distribution of royalty rates in the electrical and electronics industry.

78 https://accessadvance.com/wp-content/uploads/2021/06/HEVC-Advance-Program-Overview-Platform-Dec-2021.pdf

79 https://www.mpegla.com/wp-content/uploads/HEVCweb.pdf

80 https://accessadvance.com/licensing-programs/frand-paper/

In light of the reasoning in the present section, the approach undertaken in the FRAND White Paper has to be seen critically for the following reasons:

First, benchmarking against the distribution of royalty rates in an industry as diverse and dissimilar as the "electrical and electronics" industry entails a material risk of taxing complementary and independent innovations. This is particularly relevant in the case of Access Advance's HEVC rate, as only limited effort is apparently undertaken to obtain different royalty rates for the different use cases. The FRAND White Paper distinguishes between mobile devices, 4K UHD TVs and connected home devices as the latter supposedly "*derive most or all of their value by incorporation of HEVC*" (FRAND White Paper p. 51). However, it is doubtful whether the resulting aggregate royalty rates benchmarked against a large variety of royalty rates in the electronics sector sufficiently capture all relevant differences to prevent misappropriation of value from downstream features.

Second, the approach undertaken in the FRAND White Paper appears to lack a proper evaluation of royalty rates in light of an *ex ante* negotiation framework. Competition from alternative video codec technologies such as AV1 and VP9 is ignored. Both alternative standards have properties broadly comparable to those of the HEVC standard.[81] These standards show that similar or even better compression rates can be achieved with alternative technologies – which implies a limited incremental value of technologies used for HEVC. It can be questioned if, in an *ex ante* negotiation outcome, licensees would have accepted the pronounced royalty rate discrimination by end use case in Access Advance's licensing offer, rather than opting for alternative technologies. Ignoring these constraints to the pricing power of SEP holders thus poses the risk of deriving inflated royalty rates.

3.2.2. End-use-based licensing under comparable licence approach

Our assessment of the risks of end-use-base licensing under the comparable licence approach consists of three parts. We first summarise general issues of the comparable licence approach, as these are directly relevant to the assessment of end-use-based licensing. Thereafter, further challenges and risks that arise when trying to implement end-use-based licensing using comparable licences as benchmark are discussed. Finally, we stress the importance of assessing in detail whether the royalty structure of comparable licences is actually suitable for the SEPs at issue. In this context, it is important to note that the comparable licence approach has a direct impact on the royalty structure determined for the SEP portfolio at issue. The way in which the comparable licence's royalties are expressed (i.e. per-unit or ad-valorem royalties) and the royalty base from which they were derived (e.g. that of the end products' or the components' selling price) typically serve as a benchmark for the adjudicated royalties in a case at hand. This also implies that if the royalties set in comparable licences vary across end uses, the comparable licence approach might automatically perpetuate end-use-based licensing.

General issues of the comparable licence approach

Determining FRAND royalty rates using a comparable licence approach poses several challenges:

81 http://aomedia.org/press%20releases/the-alliance-for-open-media-kickstarts-video-innovation-era-with-av1-release/; https://www.androidauthority.com/av1-codec-1113318/.

- **First, the comparable licence approach suffers from the "cyclicality problem":** if licences deemed "comparable" themselves suffer from hold-up, a royalty rate derived based on them will also contain a hold-up premium. Cotter et al. (2019) argue that "*if there is any systematic and predictable error in the courts' assessment of the royalty, this error will then be amplified through the use of comparables*".[82] The authors suggest that a solution would be for courts to exclude from the list of comparable licences those negotiated in circumstances giving rise to hold-up, such as negotiations taking place after the licensee has incurred sunk costs. However, they also point out that there are practical challenges in the implementation of a rule to exclude licences suffering from hold-up, as the circumstances under which comparable licences were negotiated are not always fully known to the court.

  In principle, all licences concluded after standardisation may suffer from hold-up. A proper methodology for assessing, controlling, and adjusting comparable licences for hold-up premia would therefore be needed. In *CSIRO v. Cisco*, the Federal Circuit accepted such a process is needed by affirming that the calculation of FRAND rates must discount the royalty for the value accrued through inclusion of the patent into the standard.[83] However, this methodology was generally not applied in cases where no comparable licences concluded before standard setting were available, even where the conceptual problem was acknowledged.

  For instance, in *Unwired Planet v. Huawei*, it was recognised that "*asking what a willing licensor and a willing licensee in the relevant circumstances acting without holding out or holding up would agree upon is likely to help decide*" on the level of FRAND royalties.[84] The court recognised that, even though comparable licences may be useful in deciding what is FRAND, "*many factors may have been in play which make the licence less relevant. The negotiations may have involved a greater or lesser degree of hold up or hold out and it may be impossible to know that from the evidence available*."[85] Yet, no systematic analysis was done to ascertain whether comparable licences were suffering from hold-up. Investments by licensees are a distinct source of hold-up, which may further contaminate the comparable licence approach.[86]

82 Cotter et al. (2019).

83 Pentheroudakis and Baron (2017), p. 61.

84 *Unwired Planet International Ltd v Huawei Technologies Co Ltd,* EWHC 711 at para. 170 (Pat Ct. 2017).

85 *Unwired Planet International Ltd v Huawei Technologies Co Ltd,* EWHC 711 at para. 170 (Pat Ct. 2017).

86 The court acknowledged in *St Lawrence Communication v. Vodafone* that in principle licence agreements that are concluded in parallel to a legal infringement proceeding may not be valid precedents for FRAND royalties. However, the court pointed out that on the other hand, not every licence fee concluded under the threat of an injunction, is necessarily excessive. The burden of proof to show hold-up was shifted to the licensee and it was found that it was not demonstrated that the comparable licences in this case would suffer from abusive hold-up. *St Lawrence Communication v. Vodafone*, 4a O 73/14, para. 289 (LG Düsseldorf, 03.31.2016).

In *Dolby v MAS Elektronik Aktiengesellschaft*, *a* similar approach was pursued. *Dolby v MAS Elektronik Aktiengesellschaft*, 4c O 44/18 (LG Düsseldorf, 07.05.2020).

- **Second, dated licences may not reflect recent (market) developments**. Courts have therefore shown a preference to rely on recent licences, including licences concluded after the relevant standard was adopted.[87] For example, despite the above-mentioned caveats, in *Unwired Planet v. Huawei*, the court eventually relied on recent licences concluded only after the relevant standard was adopted.[88] Often, it will be **difficult or even impossible to find recent licences, that do not suffer from potential hold-up**, as all licences concluded after standardisation have typically been negotiated with locked-in licensees.

Determining FRAND royalties based on comparable licences therefore implies a great risk of perpetuating hold-up premia and royalty structures that might not be appropriate for SEPs at issue. The courts' preference for "recent" licences, as in *Unwired Planet v. Huawei,* coupled with the challenge of finding adequate evidence for assessing whether existing licensing terms suffer from hold-up premium, exacerbates this risk.

Whereas the cyclicality problem is a major issue potentially undermining the validity of the comparable licence approach in most cases, European courts seem to presume that licences concluded after standardization provide a valid benchmark unless strong evidence of hold-up is shown. For example, in *St Lawrence Communication v. Vodafone*, the German court pointed out that firms who previously took a licence to the patents at issue could have litigated had they deemed the offered rate excessive, and that recent jurisprudence would limit the risk of an injunction.[89] However, this view disregards the fact that, in practice, litigating FRAND rates exposes defendants to substantial costs and risks, including the risk of their own products being enjoined from the market.[90] The observation that some firms have entered into licences therefore cannot be taken as conclusive evidence that the requested royalty rates are FRAND. Some US courts have recognised the risk of perpetuating hold-up premia: in *Microsoft v. Motorola* a pre-existing licence between Motorola and VTech was not found to be a reliable indicator of a FRAND royalty rate among other reasons because it was concluded under the threat of a potential infringement lawsuit.[91] The court awarded FRAND rate of $0.03471 per unit for Motorola's Wi-Fi SEPs was only a fraction of the royalties implied by the rate of 2.25% applied on the end-device price that had been agreed with VTech (e.g. $9 royalties per Xbox assuming an average price of an Xbox 360 of around $400 at the time). In *In re Innovatio*, the same Motorola/VTech licence was also not deemed a valid indicator and the court noted that *"MMI may have engineered the MMI-VTech agreement only to bolster its position in the Microsoft-Motorola litigation, further casting doubt on its validity as a comparable license".*[92]

87 *Unwired Planet International Ltd v Huawei Technologies Co Ltd,* EWHC 711 at para. 175 (Pat Ct. 2017).

88 *Unwired Planet International Ltd v Huawei Technologies Co Ltd,* EWHC 711 at para. 462 (Pat Ct. 2017).

89 *St Lawrence Communication v. Vodafone*, 4a O 73/14 at para. 289 (LG Düsseldorf, 31.03.2016). The court also criticized that that the defending party did not derive the level of the unbiased royalty rates.

90 In the same case, the court confirmed an injunction against Vodafone, although the latter had submitted various licensing offers. A FRAND defence was denied because the court confirmed the lower court's view that the defendant did not comply with its *Huawei/ZTE* obligation to express its willingness to conclude a licensing agreement because it reacted belatedly and in an evasive manner.

91 *Microsoft Corp. v. Motorola, Inc*., C10-1823JLR at para 415 (W.D. Wash. 04.25.2013).

92 *In re Innovatio IP Ventures, LLC Patent Litig*., MDL No. 2303, 2013 WL 5593609 at *61 (N.D. Ill. 10.03.2013).

Issues of comparable licence approach exacerbated by end-use-based licensing

As set out above, the comparable licences approach, although preferred by courts as a seemingly pragmatic, reality-based method for determining FRAND rates, suffers in practice from several challenges that can give rise to flawed results. These issues may be aggravated by end-use-based licensing. If comparable licences are applied on an end-use basis, then it is not realistic that they will be available for every use case for which a FRAND royalty needs to be determined. The issue will be exacerbated in the future as more use cases for the same connectivity standards are explored. This development has been propelled in particular by the advent of the IoT. While previously connectivity standards served only very specific purposes (e.g., cellular standards enabling mobile phone connectivity), in the IoT, these connectivity standards now find a large variety of different use cases (e.g., smart metering, smart charging, video surveillance, connected vehicles etc.).

Courts could be left with the dilemma of dismissing available options as non-comparable (in which case the comparable licence approach is moot) or using licences for significantly dissimilar products as "comparable" to derive the royalty rate benchmarks. Using licences as a benchmark that were originally agreed for another end use significantly increases the risk that the derived royalty rates are biased and do not reflect the outcome of hypothetical *ex ante* negotiations. This holds both for ad-valorem and per-unit royalties, as shown in the following:

Ad-valorem royalties

Ad-valorem licences with a broad royalty base must be treated with particular care.[93] In the case of multi-component products, a broad royalty base, such as the device selling price, means that the absolute royalty will depend also on the value of features that are unrelated to the standard, and proper apportionment is of particular importance.[94] Considering a single product, apportionment can be done, in principle, through adjusting either the royalty rate or the royalty base to arrive at a given absolute royalty. The royalty rate then represents the SEPs' value expressed as a share of the royalty base. However, a uniform royalty rate is often applied to a whole range of the licensee's products that implement a standard (e.g. a range of different smartphones). If the value share of complementary and independent features included in the royalty base varies across devices or is changing over time, then the royalty rate would normally have to be adjusted. A rate that is FRAND at one point in time may not be FRAND at a later point in time if product changes over time are not properly accounted for.

For example, if a given royalty rate is applied to the device selling price of newly introduced products with additional independent features (e.g. a smart watch made of higher value

93 Layne-Farrar et al. (2020) claim whether component or end product pricing is appropriate can be answered on a case by case basis, giving the example of technology "*where no single component captures the full functionality of the invention and the value to the device maker is commensurate with the value to the end user*". However, even in this example the end device value would not necessarily be the appropriate base: while one doesn't necessarily need to base the royalty on the chip price, especially if it is not reflective of the technology value, mechanically using the device value as royalty base risks resulting in patent hold-up.

94 Layne-Farrar et al. (2020) suggest an alternative licencing practice where SEP holders charge royalties in terms of fixed dollar amounts per unit (e.g., $1 per device) which could operate like coupons and be made available at any level of the production chain. For such "coupons" to work, no differentiation by use case should be made. Otherwise, they would be subject to the usual issues related to price discrimination on the device price level.

materials), the SEP holder effectively obtains a share of the extra features' value although this may not have been feasible to obtain in hypothetical negotiations *ex ante*. The SEP holder thus misappropriates the value deriving from independent features.

Applying the comparable licence approach to ad-valorem licences with a broad royalty base that differs by end use would therefore require an in-depth assessment of whether the licensed products are sufficiently similar. To also account for potential developments over time, the range of products for which the FRAND rate is determined would have to be compared to the range of licensed products *at the time the royalty rate of the original licence was set.* In practice, such assessment is often only done in a cursory manner. For example, in *Unwired Planet v. Huawei*, mobile devices were grouped into 2G, 3G and 4G single- or multi-mode, but no in-depth assessment of the similarity of the products within each group was undertaken.[95] Not adjusting for potential product differences gives rise to a risk of potential misappropriation. Note that this problem is less acute in the case of ad-valorem licences with a narrow royalty base: differences of products without material impact on the outcome of *ex ante* negotiations outside of the royalty base would not affect the absolute royalty and therefore would not have to be assessed.

Case Study 4: Wi-Fi v. Cellular standard - End-use-based licensing

Licences for the Wi-Fi standard commonly do not distinguish by end-use, while end-use-based licences have become common for cellular SEPs.

Various attempts to implement end-use-based licensing for the Wi-Fi standard have been rejected by courts in past decisions (see, for example, *In re Innovatio*, *Microsoft v. Motorola* and *CSIRO v. Cisco*). In contrast, such end-use-based licensing has been allowed for cellular SEPs (see for example *HTC v. Ericsson* and *Unwired Planet v. Huawei*). This differentiation in the licensing structure does not seem to be based on sound economic reasoning.

- First, the value chain of Wi-Fi as well as cellular standards for mobile devices is similar: Both standards are mainly implemented in chipsets, which are then integrated into the devices.
- Second, there appears to be no convincing economic argument for why an *ex ante* negotiation framework should lead to different outcomes for both standards with respect to end-use-based licensing. In particular, the WiMAX standard suggests that competing cellular technologies were available, which in *ex ante* negotiations may have limited the IP holders' ability to price discriminate.
- Third, cellular standard licensing terms were not always differentiated by end product. At the time when many important cellular SEP holders were also producing mobile handsets, chipset level licensing seems to have been common practice.[96]

95 See e.g. *Unwired Planet International Ltd v Huawei Technologies Co Ltd,* EWHC 711 at paras. 478, 586, 591 (Pat Ct. 2017) where benchmark FRAND rates are given based on a similar grouping.

96 https://www.ipwatchdog.com/2021/05/11/ssppu-appropriate-royalty-base-frand-royalties-cellular-seps/id=133403/.

- A key underlying reason for implementing end-use-based licensing for the cellular standard was to extract larger royalty payments, suggesting that value from complementary downstream innovations may have been misappropriated.[97] Yet, in the *HTC v. Ericsson* judgement, it was merely assessed whether other recent Ericsson licences (concluded after standardisation) were based on a narrow royalty base, not whether Ericsson could have likely achieved end-use-based licensing in *ex ante* negotiations. Sticking to the "industry practice", seemingly agreed expressly or by implication between a small group of SEP holders as an approach to be adopted, without examining whether a broad royalty base would have been justified from an *ex ante* perspective, risks perpetuating misappropriation.

Per-unit royalties

Note that the **difficulty in identifying comparable licensing terms for all use cases also extends to per-unit royalties**. As set out above, comparable licences (that are not potentially suffering from hold-up) will often not be available by end use case, implying the comparable licence approach will have little bite for deriving per-unit royalty rates and entailing the risk that non-comparable licences might be used as comparison. In this case, it is of great importance to ensure that the average rate properly reflects the constraints the IP holder would have faced in a hypothetical *ex ante* negotiation.[98] An (absolute) royalty rate that is not differentiated by end-use (but which depends on the component implementing the standard) might by an approximation that is closer to the outcome of hypothetical *ex ante* negotiations.

Missing assessment of whether royalty discrimination would have been feasible in ex ante negotiations

As discussed above, end-use-based licensing may lead to misappropriation if too broad a royalty base (coupled with an inadequate royalty rate) is chosen. It is surprising that, in relation to the royalty base, courts typically just stick to the "industry practice" when relying on the comparable licence approach, without examining in detail whether a given royalty base implies a proper treatment of downstream innovations.

97 In *FTC v Qualcomm,* a Qualcomm executive explained Nokia's and Ericsson's switch to end-use-based licensing: *"[S]o they also – following our lead I might say – you know, decided hey, we can license these patents and make money by doing and we can make more money licensing this than licensing the chip. So like they licensed the cell phone, not the chip*." FTC, 411 F. Supp. 3d at 755 (quoting CX-6786-R at 42:17-21).

Ericsson's Director of Technology Licensing himself actually admitted as much when noting: "*One big advantage with this* [device level licensing] *strategy [is also that it is likely that the royalty income will be higher since we calculate the royalty on a more expensive product*." (http://www.fosspatents.com/2014/01/ericsson-explained-publicly-why-its.html).

98 For the reasons mentioned in Section 1.4, sometimes royalty rates charged for components might provide useful guidance.

- In *CSIRO v. Cisco*, the Federal Circuit stated on appeal that a licence may not be excluded from the fact finder's consideration solely because of its chosen royalty base.[99] Although the Court of Appeals recognised that the negotiated royalty rates may need to be adjusted to account for certain factors, it affirmed that excluding licences that are not basing royalties on the SSPPU "*would necessitate exclusion of comparable license valuations that—at least in some cases—may be the most effective method of estimating the asserted patent's value. Such a holding would often make it impossible for a patentee to resort to license-based evidence.*"
- In *HTC v. Ericsson*, HTC argued that, due to the proliferation of features in modern smartphones that are not related to cellular connectivity, the royalty for Ericsson's cellular SEPs should be based on the baseband processor (the alleged SSPPU) in order to apportion the value of features that were not related to the cellular connection. The court found that there were no examples in the industry of licences that have been negotiated based on the profit margin, or the cost, of a baseband processor and concluded that Ericsson's device-level licences provide a valid benchmark.[100]
- In *St Lawrence Communication v. Vodafone*, the Düsseldorf District Court was presented with (anonymized) licensing agreements of six mobile telecommunication companies with a comparable royalty. The court found a licence offer on a *per-device* basis with royalties within the range of comparable licence agreements to be FRAND.[101]

However, accepting a comparable licence with end-use-based royalties as a benchmark without assessing whether royalty discrimination would also have been feasible in the case at hand bears the risk of hold-up being perpetuated through the comparable licence approach. For instance, accepting in *In re Innovatio* the comparable licence approach including the purported "industry standard" of device-level licensing as advocated by the claimant would have implied that Innovatio could have misappropriated some of the complementary downstream innovations' value (see case study below).[102]

99 *CSIRO v Cisco*, 809 F. 3d 1295 at *1307 (Fed. Cir. 12.03.2015).

100 Ericsson did offer to HTC the option of a fixed royalty of $2.50 per device, that is, it offered a per-unit licence instead of ad-valorem licence. Since the royalty of a per-unit licence does not automatically increase in the device value, additional complementary innovations are not automatically taxed.

101 *St Lawrence Communication v. Vodafone*, 4a O 73/14, para. 277 (LG Düsseldorf, 03.31.2016).

102 *In re Innovatio IP Ventures, LLC Patent Litig.*, MDL No. 2303, 2013 WL 5593609 at *61 (N.D. Ill. 10.03.2013).

Case Study 5: In re Innovatio (Part II)

The *In re Innovatio* case illustrates the risk of misappropriating value from downstream complementary innovations when applying the comparable licences approach to an inappropriate royalty base.[103]

In court, Innovatio argued that the royalties for their asserted Wi-Fi SEPs should be calculated as a percentage of the discounted selling price of the device that is infringing its patents. Innovatio's suggested method consisted of the following steps:

1. As a first step, Innovatio estimated for each device a so-called "Wi-Fi feature factor" that was supposed to "*take into account the value of the end product (e.g., the access point or terminal device) that is attributable to the 802.11 functionality*". The royalty base for each device was then derived by multiplying the feature factor (ranging from 10% for laptops to 95% for access points) with the device's selling price.
2. To determine the absolute per-unit royalty rate Innovatio proposed to apply a uniform benchmark royalty rate of 6% to the devices' respective royalty bases.[104] The benchmark rate itself was derived from other licence agreements that Innovatio deemed to be comparable. Innovatio's suggested method would have resulted in per-unit royalties from $3.39 to $36.90 depending on the device. Essentially, Innovatio was therefore proposing end-use-based licensing, as the requested royalty differs across use cases.

Innovatio's proposed (and ultimately rejected) approach illustrates the risk of misappropriation associated with end-use-based licensing:

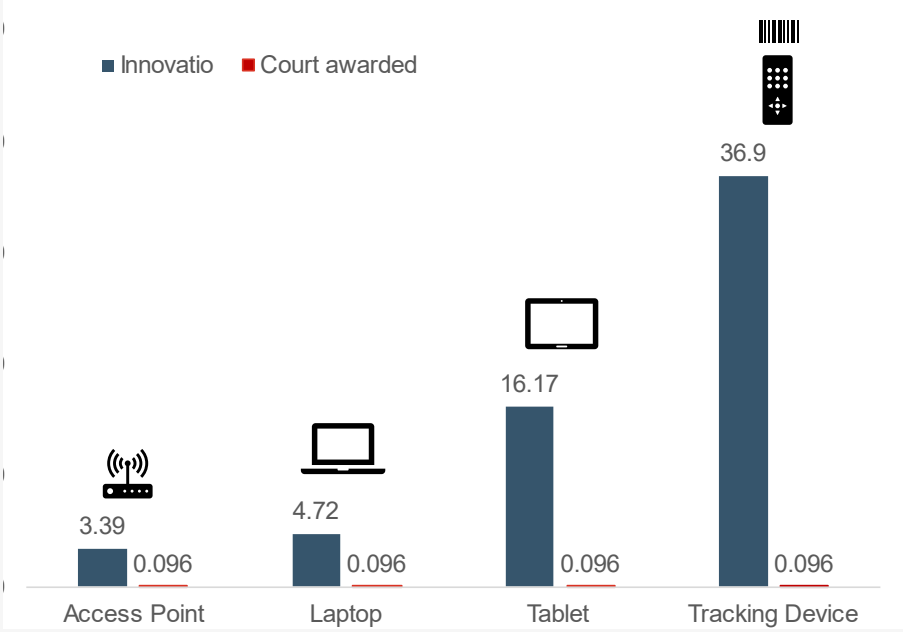
The Wi-Fi feature factor attempted to capture the "added value" of Wi-Fi and carve this added value out from independent features. Yet the added value also stems from contributions of complementary features and from standardisation (see Section 2). By applying a single (inflated) benchmark rate derived from a supposedly comparable licence, Innovatio ignored that the extent to which complementary features and standardisation are contributing to the added value varies across devices.

The Court rejected Innovatio's proposal and instead derived a **uniform per-unit royalty** for all devices of $0.0956 starting from a much narrower royalty base, the average per-unit profit on a Wi-Fi chip (Figure 5). Put differently, the court found that Innovatio's technologies included in the Wi-Fi standard had a uniform value across end products and that end-used based royalty rates would have violated Innovatio's FRAND commitment. This uniform rate implies that the standardised technology accounted for a much lower percentage of the added value in the case of a high-value product with many complementary features.

103 *In re Innovatio IP Ventures, LLC Patent Litig.*, MDL No. 2303, 2013 WL 5593609 (N.D. Ill. 10.03.2013).

104 According to Innovatio the benchmark royalty rate of 6% was based on licences for allegedly comparable SEP portfolios for the Wi-Fi and other standards. Inter alia, Innovatio referred to the 6% royalty awarded by a jury on sales of Proxim's wireless bar code scanners that were found to infringe two Wi-Fi SEPs hold by Symbol Technologies (*Symbol Techs., Inc. v. Proxim Inc.*, No. 01-801 (D. Del.)).

Figure 5: Innovatio v. court awarded royalty rates (USD per unit)



Source: CRA based on *In re Innovatio.*

4. POTENTIAL INEFFICIENCIES IMPLIED BY END-USE-BASED ROYALTIES

End-use-based licensing may give rise to additional inefficiencies.[105] The type and magnitude of these potential inefficiencies depends on whether licensing occurs at the component level or at the device end level. This section develops the following findings:

- End-use-based licensing implemented at the device level may result in higher total transaction costs and a greater risk for patent hold-up (Section 4.1).
- End-use-based licensing at the component level increases monitoring costs for component manufacturers (Section 4.2).

4.1. Potential inefficiencies associated with device level licensing

As pointed out above, end-use-based licensing is mainly implemented by SEP holders who licence their patents at the device level, that is, end-use-based licensing generally goes

105 It is well known that under certain circumstances, price discrimination may also have pro-competitive effects. In particular, charging discounted prices to customers with a low willingness may result in additional sales. While in principle end-use-based licensing may have a similar effect, the examples presented in this report suggest that end-use-based licensing is often deployed to selectively charge higher royalties (see e.g. Case Study 5), which would preclude any such benefit.

hand in hand with device-level licensing.[106] If SEP holders insist on device-level licensing with a view to implementing end-use-based licensing, the following three issues may arise.

Higher transaction costs of device-level licensing

The licensing of SEPs necessitates negotiations between SEP holders and downstream innovators that can be complex and lengthy, and require legal, technical, and economic expertise. Thus, to reach a licensing agreement, both the SEP holder and the potential licensee typically bear significant transaction costs in form of in-house human resources and fees for external legal, technical, and economic advice. The aggregate transaction costs incurred by SEP holders and licensees for the licensing of patents for a specific standard naturally depend on the number of licensing agreements. The number of agreements is in turn determined by the numbers of SEP licensors and licensees. Since the level of licensing has an impact on the number of licensees, it ultimately also affects the number of licensing negotiations and agreements, and thus the aggregate transaction costs.

With standardised technologies such as cellular connectivity and Wi-Fi, the number of device manufacturers who integrate standard-implementing components (e.g., baseband and Wi-Fi chipsets) into their devices is materially higher than the number of firms supplying these components. This asymmetry in the number of device manufacturers downstream and component suppliers upstream has become more pronounced with the advent of the IoT, which has given birth to a large and increasing number of device manufacturers who make use of standardised technologies (see box below for the estimated number of potential licensees of cellular SEPs in the smartphone and IoT industry).

Implementing end-used-based licensing at the device level is therefore likely to increase the number of potential licensing negotiations and result in materially higher aggregate transaction costs of SEP licensing. While the formation of patent pools (which reduce the number of negotiations) and the fact that SEP holders may only selectively assert their patents might be able to mitigate this issue,[107] device level licensing may still give rise to inefficiently high transaction costs – especially in the context of the IoT, where the number of end device producers is rapidly increasing.[108]

106 There are several examples in the recent past where SEP holders have pushed for end-use based licensing despite certain inefficiencies. For instance, the agreement between Nokia and Nordic Semiconductor of January 2022 effectively established end-use based licensing of SEPs for many downstream innovators in the IoT space using Nordic Semiconductor chipsets (see http://www.fosspatents.com/2022/01/daimler-style-strategic-breakthrough.html). Another example is the cellular patent pool Avanci which prominently differentiates by device type and case in its licensing structure: "*Royalties will vary from one type of device to the next based on the value the technology brings to the device, not its sales price. For example, the royalty will be different when the licensed product is a vehicle […], rather than a rental bike […]*" (https://www.avanci.com/marketplace/#li-pricing).

107 See, for instance, the discussion in SEPs Expert Group (2021).

108 Henkel (2021) points out that it is unlikely that patent pools like Avanci will attract a majority let alone all owners of cellular SEPs due to the large number and heterogeneity of patent owners. In addition, as SEP owners may achieve higher royalties when licensing on their own, they only have an incentive to join a patent pool if the efficiency gains of doing so outweighs the loss of royalty revenues. According to Henkel, this is unlikely to be the case for most SEP holders.

Case Study 6: Transaction costs for licensing cellular SEPs at the device level

Cellular technologies have seen a surge in use cases spreading across an ever-increasing number of industries and device types. With the IoT being characterised by a large number of downstream innovators adopting device level licensing may lead to enormous transaction costs for the licensing of cellular SEPs.

SEP holders are increasingly requiring that SEPs for cellular standards be licensed at the end device level. As cellular technologies had been primarily used by mobile phones until recently, SEP holders intending to licence their cellular patents at the device level have only had to deal with a limited number of device manufacturers. In fact, in the smartphone market the 15 largest manufacturers accounted for about 90% of global smartphone shipments in 2020. SEP holders would consequently have needed to reach licensing agreements with those smartphone manufacturers to cover about 90% of global smartphone sales.[109] Yet, negotiation and litigation costs are already inefficiently high in the smartphone sector.

The advent of the IoT is an example for cellular SEPs being implemented by a large, growing, and diverse group of companies across a wide range of devices. The large number of application areas and use cases as well as the dynamic nature of the IoT makes it difficult to derive a precise estimate of the number of potential licensees in the IoT. However, in order to illustrate the substantial change in the landscape of potential licensees due to the IoT, we derive a ballpark estimate based on a sample of almost 800 cellular IoT projects gathered by IoT specialist Berg Insight in two datasets:

- **Dataset I - 500 largest cellular IoT projects:**[110] According to Berg Insight, this dataset contains the 500 largest cellular IoT projects worldwide, undertaken by 483 different companies. These 500 projects are estimated to account for 24% of the total number of cellular IoT connected devices worldwide at the end of 2020.
- **Dataset II - 300 emerging cellular IoT projects:**[111] This dataset lists 300 emerging cellular IoT projects that account for less than 1% of global connections but exhibit strong growth potential.

These two datasets combined include 769 companies whose identified cellular IoT projects account for 24% of the global cellular IoT connections. As the combined dataset includes large widespread cellular IoT projects as well as smaller emerging cellular IoT projects, we assume that the average number of connections per firm in this combined dataset is representative of the remaining 76% of IoT connections. Scaling up the number

109 These 15 major smartphone OEMs are (global smartphone sales units and share in 2020 in brackets): Samsung (255.7m, 19.2%), Apple (201.1m, 15.1%), Huawei (187.7m, 14.1%), Xiaomi (145.8m, 10.9%), Oppo (111.8m, 8.4%), Vivo (108.5m, 8.1%), ZTE (45m, 3.4%), Realme (42.4m, 3.2%), Lenovo (33.3m, 2.5%), LG (24.7m, 1.9%), Tecno (22.8m, 1.7%), Nokia (8m, 0.6%), Google (3.7m, 0.3%), Sony (2.9m, 0.2%) and HTC (1.7m, 0.1%). Source: Statista, https://screenrant.com, https://www.thetealmango.com, https://nokiamob.net).
The Global Mobile Suppliers Association identified about 990 LTE device manufacturers in 2022 (see https://gsacom.com/paper/lte-ecosystem-may-2022-quarterly-update/).

110 Berg Insight Report "The 500 Largest Cellular IoT Projects Worldwide", 2021 (available at: https://www.berginsight.com/the-500-largest-cellular-iot-projects-worldwide).

111 Berg Insight Report "300 Emerging Cellular IoT Projects Worldwide", 2021 (available at: https://www.berginsight.com/300-emerging-cellular-iot-projects-worldwide).

of firms proportional to the share of IoT connections, implies that the estimated total number of IoT device manufacturers that account for 90% of connections amounts to around 2,840.[112]

While the relevant number of cellular SEP licensors might be slightly smaller for IoT licensees than for smartphone manufacturers,[113] this difference is clearly dwarfed by the huge difference in the number of potential licensees (2,840 IoT licensees vs 15 smartphone licensees). Adopting the practice of end-use-based licensing at the device level in the IoT space would thus likely lead to a large increase in licensing negotiations and thus to potentially enormous transaction costs.[114]

Increased likelihood of patent hold-up due to SME's lack of licensing experience

Besides generating significant transaction costs, end-use-based licensing at the device level likely leads to more unbalanced negotiations and thus a higher likelihood of patent hold-up than does licensing at the component level. Downstream device manufacturers might lack both the understanding of the FRAND licensing process and the resources to meet SEP holders on equal terms. In addition, they also might not have the necessary technical understanding of the technologies behind the standard needed to evaluate the validity of the SEP holder's licensing claim. For example, in contrast to their component suppliers, car manufacturers are not likely to have extensive knowledge of mobile wireless technologies (encapsulated in components procured from suppliers) and typically rely on sourcing components for which there are no associated unlicensed third-party IP rights.[115]

SMEs – and in particular start-ups - are likely to lack licensing experience, expertise, and resources to properly evaluate and challenge the demands of SEP holders. For this reason, they could be more intimidated by the possible consequences of patent infringement (e.g., facing an injunction) and thus be prone to simply accept non-FRAND royalty demands instead of engaging in further negotiations. Hence, end-use-based licensing at the device level might increase the likelihood of patent-hold up. This holds especially for licensing in

112 $\frac{769}{0.244} \times 0.9 \approx 2{,}840$

113 There are several cellular SEP holders who have joined the Avanci patent pool which currently offers SEP licences for connected vehicles and possibly smart metres and plans to expand its programme to other IoT devices in the future (https://www.avanci.com/marketplace/#li-faqs). On the other hand, the pool operator Via has recently decided to end its LTE licensing programme which also extended cellular licences to mobile phone manufactures (https://www.iam-media.com/article/licensing-ending-wireless-patent-pool-double-down-audio-codec-programmes). Some of the former Via licensors may be joining the Avanci or Sisvel cellular licensing pools in the future. Nevertheless, at least for the moment, while smartphone OEMs might have to negotiate with additional licensors individually, IoT device manufactures (currently the manufacturers of connected vehicles and smart metres) could licence the licensors' cellular SEPs through the Avanci pool.

114 According to proponents of device level licensing the transaction cost argument is overstated as SEP holders are unlikely to seek royalties from all infringers but would rather focus on the larger downstream innovators. However, unless SEP licensors would give a joint and irrevocable commitment to not demand royalties from downstream firms below a certain volume or revenue threshold, the uncertainty with respect to possible royalty demands and costs for negotiating licensing agreements is still likely to have a significant effect on smaller downstream firms.

115 Geradin (2020), p. 17.

the IoT arena which has led to continuous entry of new start-ups that implement standardised technologies in their IoT devices.[116]

While implementing end-use-based licensing at the component level might avoid the transaction costs and unbalanced negotiations caused by device level licensing, it may create other inefficiencies as described in the following.

Impediments in relation to R&D at the component level

If component suppliers cannot obtain SEP licences for their products, this evidently reduces their incentives to invest in R&D. Unlicensed component suppliers are exposed to injunctions and hold-ups, which put any returns from R&D at risk.

SEP holders licensing at the end-device level are advocating for so-called “have-made” rights which are supposed to protect licensed end device manufacturers’ suppliers from the risk of being enjoined from the market. “Have made” rights included in the licensing agreement with the device manufacturer may protect manufacturers of intermediary products from infringement actions by SEP holders - they are however not a substitute for a full licensing agreement.

While the concept of have-made rights suffers from multiple issues,[117] these rights particularly entail frictions in relation to R&D. A major issue in relation to R&D is that have-made rights would be restrictive in that they only allow the component supplier to the licensed OEM to produce components for the sole use of that OEM. In other words, the supplier would not be allowed to produce components for other OEMs, unless other OEMs can also confer have made rights to that supplier. Even with have-made rights from one OEM, the supplier’s ability to spread R&D costs, that are often of a fixed nature, across several customers remains severely compromised. Similarly, the ability to undertake R&D for new products not covered by have-made rights is severely hampered. The component supplier is also exposed to uncertainty regarding the level of the royalties borne by the customer, which affects demand for the supplier’s products.

4.2. Potential inefficiencies of end-used based licensing at component level from tracking end use of components

For some component manufacturers it would be prohibitively costly to track the end use of their products. Such monitoring may be costly or technically difficult. Moreover, in fast-moving spaces such as IoT, application-agnostic component manufacturers may not be able to anticipate all possible end uses of their products. Already at the time of writing, the IoT hosts a myriad of different heterogenous use cases, ranging from consumer-oriented (e.g., consumer electronic devices such as wearables, smart household appliances, smart speakers etc.) to industrial applications (e.g., smart manufacturing and metering). The advent of 5G and other, new connectivity standards will further propel the number of different IoT end-use cases in the future,[118] rendering a comprehensive monitoring of end use cases even more costly and making it even more difficult, if not impossible, for

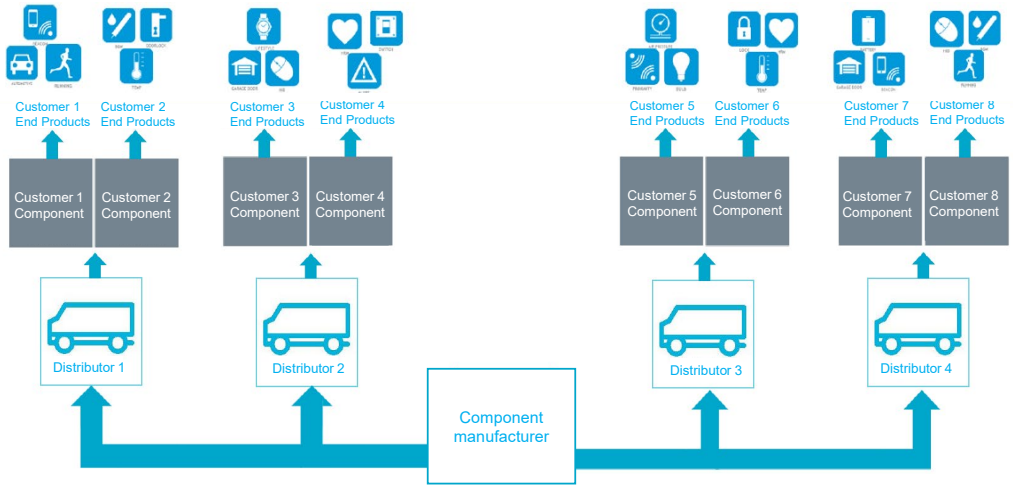
116 https://iot-analytics.com/iot-startup-landscape/

117 Geradin and Katsifis (2021).

118 https://www.telit.com/blog/state-of-5g-and-iot-current-future-applications/.

component manufacturers to anticipate use cases of the devices manufactured. Figure 6 illustrates a multi-tiered supply chain with various end-use cases.

Figure 6: Multi-tiered supply chain for standard-implementing component



Source: CRA illustration.

If such transaction costs preclude end-use-based royalties in hypothetical ex-ante negotiations, they should also be precluded after the standard is adopted. Licensing of non-SEPs, where potential licensees have more bargaining power, supports this outcome. For non-SEPs licensed at the component level, use-based pricing is the exception rather than the norm.

5. POTENTIAL CONSUMER HARM FROM INFLATED SEP ROYALTIES AND HIGHER TRANSACTION COSTS

Having discussed the extent to which end-use based licensing may result in inflated SEP royalties and increased transaction costs, we now turn to potential effects this may have on downstream innovation, and on consumers. Our key findings in this section are:

- Downstream R&D spend in the smartphone sector is substantial and materially higher than R&D spend by upstream SEP holders (Section 5.1).
- R&D of downstream innovators is critical to develop end products and thus important to preserve (Section 5.2).
- Moreover, running royalties are variable costs that are typically (partly) passed on to consumers (Section 5.3).
- The claim that higher levels of SEP royalties would spur upstream innovation and participation in standards development is not supported by empirical evidence (Section 5.4).
- Even if increased SEP royalties were to stimulate upstream innovation, the associated benefits are likely to be outweighed by negative effects on downstream innovators and their customers (Section 5.5).

5.1. R&D spend of IP holders vs R&D spend of downstream innovators

Both upstream and downstream innovations are important in the total value chain. Their relative importance can be illustrated by comparing their respective R&D spend. A closer look reveals that much of the innovation in the value chain is done by downstream innovators, not by holders of SEPs. In this section we compare the R&D spend of upstream innovators for cellular technology with the R&D spend of smartphone original equipment manufacturers (OEMs, including their contract manufacturers). This sector is highly relevant, because smartphone OEMs account for the vast majority of royalties for cellular SEPs.

A direct comparison of SEP holders' and downstream innovators' R&D spend for (technologies used in) smartphones would be ideal. However, SEP holders have extensive operations apart from R&D expenditure on technologies contributing to standards used by smartphones. Moreover, connectivity standards are also used for other products, including mobile network equipment and IoT products. Using SEP holders' total R&D spend would materially overestimate their contribution to smartphone-related SEP innovation. Similarly, some of the smartphone OEMs are also selling products other than smartphones.

A precise comparison of R&D spend is therefore beyond the scope of our report. However, in the following paragraphs we develop two approaches that allow us to derive insights on the order of magnitude of R&D spend upstream and downstream. Based on this, we can then make inferences with respect to the relative size of upstream versus downstream R&D spend.

First, we estimate upstream smartphone R&D by assuming that SEP holders allocate R&D spend to their business segments in proportion to their segments' revenues. The revenue from smartphone related upstream technology development is given by the upstream innovator's SEP royalties. We therefore estimate smartphone R&D spend as an SEP holder's total R&D times the estimated revenue share from smartphone SEP royalties relative to total revenue.[119] Appendix A presents a more detailed discussion of the methodology. For smartphone OEMs we apply a similar approach and estimate smartphone R&D by multiplying the total R&D by the share of revenues from smartphones.

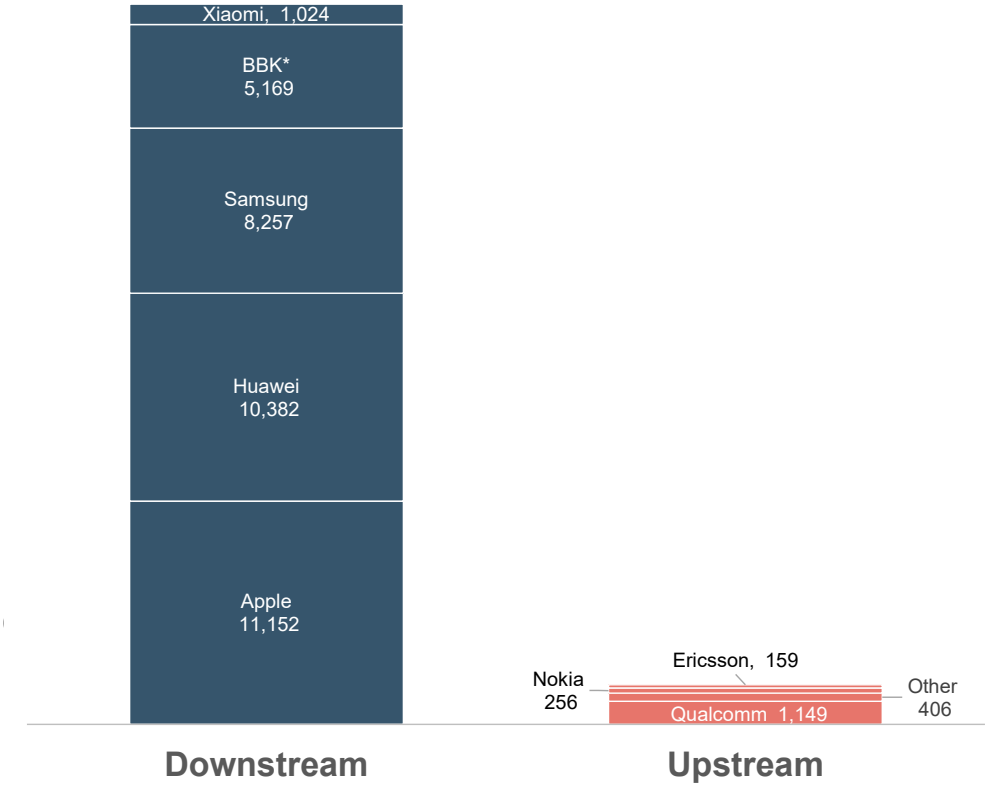
Figure 7 below illustrates that downstream smartphone R&D exceeds upstream R&D by far: around 95% of the total smartphone related R&D of approximately $38bn are invested by the largest downstream innovators, whilst SEP holders account for around 5% only. The five largest smartphone OEMs in terms of 2020 shipment volume (Apple, Huawei, Samsung, BBK[120] and Xiaomi) account for a total smartphone R&D spend of about $36 billion in 2020. In contrast, the estimated smartphone-related upstream R&D spend of SEP holders in 2020 amounted, roughly, to only $2 billion. Upstream firms with the largest estimated smartphone R&D are Qualcomm ($1.1bn in 2020), Nokia ($256m) and Ericsson

119 We note that our methodology does not fully capture upstream R&D spend of firms to the extent they are cross-licensing their SEPs and are using standards for their own downstream business, because cross-licences are less likely to contribute to SEP royalties. We essentially estimate the upstream innovator's R&D spend for technologies monetised by means of SEPs. This is a useful approximation because firms that are cross-licensing their technology (such as Huawei) are typically also active downstream and therefore directly benefit from cross-licensing. In any event, even if one added the value of cross-licences, our qualitative findings remain unchanged.

120 BBK is the provider of Oppo, Vivo, Realme and OnePlus smartphone brands, and currently the largest manufacturer of smartphones.

($159m). Other upstream innovators[121] are estimated to have invested $406 million in smartphone related R&D.

Figure 7: Upstream smartphone SEP related R&D vs. downstream R&D, 2020 (USD millions)



Source: CRA analysis of company financial statements and SEP licensing revenue data.

Note: R&D spend of downstream innovators apportioned based on revenues. To calculate R&D spend of upstream SEP holders we fist identify a set of 14 licensees which have relevant R&D spend related to smartphone SEP development. We then collect data on total R&D spend and derive smartphone related R&D by multiplying with the SEP royalty share of total revenue. For a detailed explanation of the methodology see Appendix A. * BBK does not publicly disclose figures on R&D spend. BBK's smartphone R&D spend is imputed using the R&D spend of the remaining four OEMs and multiplying with the ratio of BBK total 2020 smartphone revenue over total smartphone revenue of the remaining four OEMs.

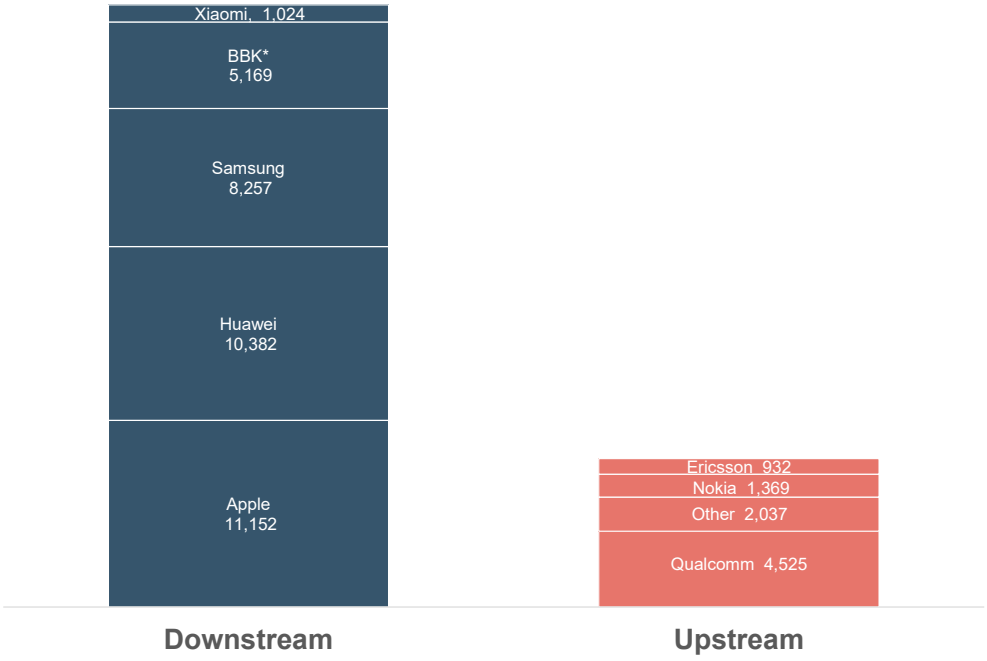
Second, to improve the robustness of our analysis, we also compare the upstream innovators' SEP royalties for smartphone sales with downstream smartphone R&D. SEP royalties can be considered an upper bound for the upstream R&D spend, because the latter is a cost position for IP holders when developing SEPs, and thus normally will not exceed the related revenues – namely, the SEP royalties.[122] A detailed description on how these licensing revenues are compiled can be found in Appendix A.

121 See Appendix A for further details.

122 Upstream innovators may invest into upstream R&D to obtain IP that is later cross-licensed or used for its own downstream business. As mentioned above, in upstream innovators already receive rewards in the form of cross-licences or downstream profits, and the SEP royalties can be thought of as a compensation for a portion of the R&D spend that is recouped through licensing out.

Figure 8 below compares SEP royalty revenues associated with smartphones in 2020 to the R&D spend of the five largest smartphone OEMs in terms of 2020 shipment volume. We find again that the estimated smartphone R&D spend of downstream innovators in 2020 materially exceeded the total SEP royalties paid in 2020. The global estimated R&D spend of downstream innovators for smartphones in 2020 amounts to around $36bn, compared to total SEP royalty payments of $8.86bn. The contribution of downstream innovators to the total R&D spend in 2020 is therefore around 80% - compared to only 20% for upstream SEP holders as measured by SEP licensing revenues. The R&D share accruing to these five downstream smartphone OEMs has been steadily increasing over time, from 54% in 2014 and 61% in 2016 to ultimately 80% in 2020.

Figure 8: Upstream SEP licensing revenues for smartphones vs. downstream R&D, 2020 (USD millions)



Source: CRA analysis of company financial statements and SEP licensing revenue data.

Note: R&D spend of downstream innovators apportioned based on revenues. Upstream licensing revenue is based on the global smartphone SEP royalties of the main smartphone SEP licensors. See Appendix A for a detailed explanation. * BBK does not publicly disclose figures on R&D spend. BBK's smartphone R&D spend is imputed using the R&D spend of the remaining four OEMs and multiplying with the ratio of BBK total 2020 smartphone revenue over total smartphone revenue of the remaining four OEMs.

The smartphone R&D spend of downstream innovators likely exceeds the R&D spend of the relevant SEP holders by more than suggested by the assessment above.

- First, we have restricted the analysis to the five largest smartphone OEMs only. Industry wide R&D spend will likely be materially higher. The five largest smartphone OEMs shown account for around 92% of total smartphone revenues. Assuming R&D spend is in proportion to revenues, other smartphone OEMs might add up to around 9% to the downstream R&D spend as identified above.

- Second, for simplicity, the above Figure 8 only captures R&D of OEMs. However, most components in smartphones are procured from suppliers, who also invest into R&D. For the purpose of our assessment, OEMs' suppliers are also "downstream innovators" and hence their R&D in principle is equally relevant.

The estimated total SEP royalties exclude the value of cross licences. Sidak (2016) estimated the implicit value of cross-licences of large implementers—the licensing revenue that firms like Samsung, Huawei or Apple would have obtained had they not engaged in cross licensing deals but charged royalties to one another. Sidak's estimates imply an additional $4 billion in non-cash value of cross licences in 2013 and $3.7 billion in 2014 (roughly one percent of mobile phone sales in each year). Adding these to the estimated R&D spend would not materially change the overall picture.

Going forward, as mobile connectivity will be used much more widely in IoT devices and hence many new players will contribute to downstream R&D, it can be expected that the R&D of downstream innovators will further increase compared to that of SEP holders. This follows directly from the forecasted revenue growth of the IoT sector in the years to come. Global IoT revenue is predicted to increase by almost threefold from around $389bn in 2020 to over $1tn in 2030.[123]

5.2. Reduction in downstream innovations

As discussed in Section 3, end-use-based licensing increases the risk of misappropriation in the form of inflated royalties and might lead to significant transaction costs if implemented at the device level. Inflated royalties and transaction costs may reduce downstream firms' incentives and ability to invest in product research and development, and may even prevent firms' from marketing new products involving the standard in the first place.

Impact of inflated SEP royalties and transaction costs on downstream innovation

- **Impact of inflated SEP royalties:** Downstream innovators' incentives to invest into the development of products implementing a standard depend on the level of (expected) SEP royalties. If SEP holders can misappropriate downstream innovators' returns from investing into products implementing a standard, the latter will be less incentivised to invest into such products in the first place, giving rise to potential underinvestment.
- **Impact of higher licensing transaction costs:** In Section 4.1, we discussed that implementing end-use-based licensing at the device level in the IoT is likely to result in significant transaction costs due to the large number of potential licensees. While these transaction costs are undesirable from an efficiency point of view, they may also further reduce firms' incentives and ability to invest in product research and development.

Consumer harm from potential underinvestment in product development

Underinvestment in products implementing the standard directly decreases the total value that consumers enjoy from the standard: if the socially efficient downstream investment level is not achieved, the benefits from standardisation erode. A drop in downstream investments triggered by end-use based licensing tends to have more severe adverse

123 Transforma Insight 2020, available at https://www.statista.com/statistics/1194709/iot-revenue-worldwide/.

consequences for consumers if even in the absence of end-use-based licensing more downstream investments would be desirable from a consumer perspective. In Section 2.1 above, we saw that downstream innovations are often complementary, that is, one innovation will have a positive externality on the value of other complementary innovations. As discussed above, under those circumstances the level of innovations will generally remain below the socially optimal level. A further reduction in the level of downstream innovations because of SEP holders misappropriating returns from downstream innovators by means of end-use-based licensing will likely result in consumer harm.

This is particularly true in the case of "high value" applications of the standard. Typically, such high value applications require extensive complementary downstream investments into R&D. The risk of SEP holders misappropriating returns of such investments, including through use-based licensing, may undermine the commercial viability of investments into high value products. In extreme cases downstream innovators may abandon the development of these products altogether (Case Study 7). Consumers may be harmed from reduced choice as well as from a potentially decreased quality of products implementing the standard.

Depending on the circumstances, it may be possible for downstream innovators to develop products staying clear of standards with an elevated risk of patent-holdup. Relying on alternative standards is a feasible option only for certain applications where alternative standards are available, or where standardised functionalities are not essential.[124] Whereas such choice protects downstream innovators from being held-up by SEP holders, downstream innovators and their customers may still be harmed, for example if alternative standards are less well suited for a given application.[125] If such substitution occurs on a larger scale, this may more generally undermine the adoption of standards.

Case Study 7: Reduced innovation resulting from end-use based licensing

The following anecdotal evidence illustrates the potential impact of end-use based licensing.

Continental[126]

Continental used to build network access devices for telematic control units in-house. This came to an end around 2009 with the advent of 4G. Practicing 4G patents in its network access devices, Continental's component suppliers were unable to obtain a licence to the infringed patents because SEP holders either insisted to licence at the car OEM level or requested royalty rates at a commercially unviable level potentially driven by

124 For example, cellular standards may be hard to replace in practice, because then the corresponding infrastructure would have to be set up, which would be prohibitively costly. Depending on the application, other standards, e.g. for video compression, may be easier to substitute.

125 For instance, we understand that certain IoT chips that could have been made use of Wi-Fi or cellular connectivity were eventually designed for Bluetooth. While this obviates royalty payments for Wi-Fi or cellular standards, Bluetooth has a reduced wireless range.

126 See Continental amicus curiae letter in FTC v Qualcomm case, available at http://cdn.ca9.uscourts.gov/datastore/general/2020/02/27/19-16122-Continental%20Automotive%20Systems%20amicus%20brief.pdf.

misappropriation as discussed in Section 3.2. Uncertainties related to the licensing situation made Continental switch from making to buying network access devices.

Continental also claims that it currently has the technical know-how to create a "single circuit board with cellular communications and high-end infotainment functions". This would constitute a significant upgrade to the telematics control unit, increasing performance and reducing overall costs for consumers and further enabling new services and safety features in connected cars. However, due to the licensing issues discussed, it has decided not to pursue relevant innovations.

Dronesense[127]

Drone manufacturer and platform developer Dronesense planned to develop a novel drone device and associated software platform for firefighting agencies. The device and platform in question would have enabled firefighters to monitor dangerous conditions in their day-to-day work. However, concerns over patent hold-up and the company's inability to have certainty regarding SEP royalties and product costs undermined an otherwise-innovative new business. This case again illustrates the risk of downstream innovators being potentially held up by end-use specific royalties.

5.3. Increased end product prices

In addition to potential harm from reduced downstream innovation, consumers may suffer from higher end product prices. In the following we therefore examine the extent to which SEP licensees can be expected to pass on increased SEP royalties from end-use-based licensing in the form of higher end-product prices.

Pass-on of SEP royalties and transaction costs

While a certain degree of pass-on of SEP royalties is often presumed in the public debate and the literature about SEP licensing,[128] to our knowledge there is no theoretical or empirical literature that specifically discusses the degree to which licensees pass on SEP

127 http://www.fosspatents.com/2019/11/four-it-industry-bodies-support-ftc.html.

128 See, for instance, Farrell, Hayes, Shapiro and Sullivan (2007), Galetovic and Gupta (2020) and Layne-Farrar and Schmidt (2010). The pass-on of SEP royalties to end consumers has also been acknowledged in multiple FTC proceedings. In *Negotiated Data Solutions LLC*, the FTC noted that "in market-wide standard-setting contexts, the licensees have an incentive to pass along higher costs to the ultimate consumers who purchase the products. Thus, these end consumers who purchase products using N-Data's technology may face increased prices due to the higher royalties." (Analysis of Proposed Consent Order to Aid Public Comment, available at https://www.ftc.gov/enforcement/cases-proceedings/051-0094/negotiated-data-solutions-llc-matter). Similarly, in *Motorola Mobility LLC, and Google Inc.* the FTC concluded that "consumers will likely pay higher prices because many consumer electronics manufacturers will pass on some portion of unreasonable or discriminatory royalties they agree to pay to avoid an injunction or exclusion order" (Analysis of Proposed Consent Order to Aid Public Comment, available at https://www.ftc.gov/enforcement/cases-proceedings/1210120/motorola-mobility-llc-google-inc-matter).

royalties to their customers.[129] However, the broader economic literature has identified various factors that are said to affect the likelihood and degree of firms passing on own cost changes (e.g. an increase of royalty payments or transaction costs) to their customers.[130] Based on these pass-through factors, it is reasonable to expect that in particular SEP royalties are passed on to a significant extent:

- **SEP royalties are variable costs**. Economic theory predicts that at least in the short-term a firm sets its prices in accordance with its variable costs, while changes in a firm's fixed costs typically affect (short-term) pricing decisions to a lesser extent, if at all. Hence, pass-on is generally expected to be higher in the case of variable cost changes. Since SEP royalties are typically paid on a running basis and increase with the licensee's sales, SEP royalties should be regarded a part of the licensee's variable costs.[131]
- **SEP royalties and licensing transaction costs are often industry-wide costs**. The extent to which firms pass costs on to their customers depends on how widespread these costs are among the competing firms in the market. The degree of pass-on is generally higher the less firm-specific and the more industry-wide the costs are. The reason is that a firm has a larger incentive to increase its prices if its competitors incur the same kind of costs and thus might also decide to raise its own prices. In markets where all or at least a majority of products implement a specific standard, all the firms that implement this standard and are licensed will incur SEP royalties and licensing transaction costs.
- **Intensity of competition**. The competitive interaction between firms incurring the costs under consideration plays an important role for the degree of pass-on. As long as these costs are incurred by a sufficiently large number of firms in the market, pass-on of these costs typically increases with the intensity of competition. While the intensity of competition differs across markets, the industries and markets in which the main royalty-bearing standards are implemented (e.g., the consumer electronics industry) do not appear to suffer from a lack of competition that would prevent a significant pass-on of costs related to SEP licensing.

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129 While we are not aware of any empirical academic paper, pass-on of SEP royalties has been estimated as part of an ultimately terminated class action against Qualcomm (*In Re: Qualcomm Antitrust Litigation*). The plaintiffs' expert had identified "multiple pieces of testimony in which Qualcomm and other participants in the cellular industry (including OEMs and wireless carriers) stated that Qualcomm's royalty would be an added component to the price of the phone." (Order Granting Plaintiffs' Motion for Class Certification; Denying Qualcomm's Motion to Strike the Declaration of Kenneth Flamm, Case No. 17-MD-02773-LHK). In order to estimate the extent to which SEP royalties were passed on to consumers in form of higher cell phone prices, the plaintiffs' expert conducted a regression analysis which yielded positive pass-on rates across all sales channels with the overall channel-weighted pass-on rate amounting to 88%. This implies that an increase of SEP royalties by $1 was found to result in an average increase of the quality-adjusted cell phone price of $0.88.

130 For a more detailed summary of the economic literature about pass-on see: "Cost pass-through: theory, measurement, and potential policy implications", A Report prepared for the Office of Fair Trading, RBB Economics, February 2014.

131 In contrast, the level of the transaction costs incurred by the licensee for negotiating a licence agreement might depend on the business at stake (i.e., on the licensee's sales of standard-implementing products) but occur only once per negotiation and thus do not vary over time with the licensee's output. Transaction costs are therefore mainly seen as fixed costs from the licensee's perspective.

In conclusion, as SEP royalties constitute variable and industry-wide costs and are being paid in a competitive environment, we would expect SEP licensees to pass on royalties to a significant extent to their customers. The pass-on of licensing transaction costs, however, is likely to be lower as they are rather fixed costs and thus do not materially affect the licensee's (short-term) pricing behaviour.

Specific effects of end-use-based licensing

Since, as discussed, the risk of inflated royalties will be more prevalent for high quality products with a high degree of complementary downstream innovation, their prices may be disproportionally affected by excessive royalty pass-on. These higher prices may make consumers turn to cheaper alternatives, limiting the number of consumers that are able to enjoy the superior functionality of high quality devices.

Moreover, downstream competition can be distorted to the extent that downstream competitors are not all facing the same royalty fees due to excessive price discrimination associated with end use pricing. If inflated royalties are passed-on to downstream firms and this is more prevalent for high value products with high levels of complementary innovations, these firms may be disadvantaged against their rivals producing lower quality end products. Downstream producers of high value products will also pass on inflated royalties to consumers in the form of higher prices. Consumers may therefore ultimately be harmed due to higher prices for high value products and from potentially reduced choice.

5.4. Do higher royalties translate into more upstream technology innovation?

It is sometimes claimed that end-use-based licensing may foster upstream innovation by increasing the return to technology contributors. The related claim that a looser interpretation of the FRAND commitment, that results in a higher level of SEP royalties, is needed to spur upstream innovation and participation in standards development may not hold in practice for at least two reasons, as pointed out by Simcoe and Zhang (2021):

- First, in cases in which upstream innovation is complementary and sequential, higher returns from patenting might prevent the decentralised sharing of ideas and thus reduce innovation.[132]
- Second, many firms participate in the development of standards without deriving substantial licensing revenues from their contributions. This suggests that SEP royalties are not necessarily needed to incentivize firms to contribute to standards development. For instance, many of the largest smartphone manufacturers have SEPs, but are not among the SEP holders with material SEP royalties (see Appendix A).

In fact, the following case study illustrates that a clarification on the IEEE's IPR policy which restricts the use of end-used based licensing, does not appear to have led to a material reduction in upstream technologies for inclusion into the Wi-Fi standards.

132 See Bessen and Maskin (2009). Galasso and Schankerman (2013) also provides some empirical support for the idea that patents can stymie cumulative innovation in technology sectors.

Case Study 8: Impact of the IEEE's IPR policy revision in 2015

In 2015, the IEEE, the SSO responsible for connectivity standards such as Wi-Fi and Ethernet, revised its IPR policy, further clarifying the meaning and scope of SEP licensors' FRAND commitment. In particular, the policy update aimed to clarify the definition of "reasonable" royalty rates and "compliant implementation", the conditions under which licensors can seek or enforce "prohibitive orders" (e.g., injunctions) and demand reciprocal licences. At the time there was an intense debate among the various industry participants and stakeholders about how the IEEE's controversial policy revision would affect the standard development process and firm's innovation incentives.

It is unsurprising that since its implementation, the effects of the IEEE's policy revision have therefore been the subject of various empirical assessments with various results, for instance:

- With respect to the Wi-Fi (802.11) standards, Gupta and Effraimidis (2018) observe that the number of positive letters of assurance (LoAs) has strongly decreased since 2015, while at the same time several contributors appear to have submitted negative LoAs as a reaction to the new policy.[133] Furthermore, they find for IEEE's 802 working groups that the average yearly number of project authorization requests (PARs), which can be regarded as a measure of standard development activities, was 4% lower in the period 2015 to 2017 than during 2009 to 2014.[134] While Gupta and Effraimidis attribute these effects to the IEEE's policy revision of 2015, they do not provide any in-depth assessment of causality or alternative explanations, and their finding seems to be driven by the extraordinarily large number of PARs in 2014.
- In contrast, IPlytics (2018) assesses the impact of the IEEE policy revision inter alia by looking at the number of contributions to the main Wi-Fi standards 802.11n, 802.11ac and 802.11ax, which IPlytics regards as a measure for the "activity, engagement and willingness to contribute proprietary innovation within the 802.11 technical group". IPlytics does not find evidence for a negative impact of the policy revision on the number of contributions and points out that none of the firms who opposed the policy revision had been particularly important contributors before and after the policy revision.
- Going beyond the descriptive analyses conducted by Gupta and Effraimidis, and IPlytics, Simcoe and Zhang (2021) rely on more elaborate statistical tools to assess whether the policy revision has affected the number of contributions and patent applications relevant to the Wi-Fi standard. More precisely, Simcoe and Zhang analyse to what extent the number of contributions and patent applications have developed differently over time across different groups of firms, IEEE working groups, and different technology classes. Overall, Simcoe and Zhang do not find any solid evidence that the IEEE IPR policy revision reduced innovation in the form of new patent applications or participation of SEP holders in the standard development process.

The empirical evidence with respect to the IEEE's policy revision shows that it is not clear-cut whether a policy that can be regarded as rather licensee-friendly automatically leads to negative effects on standardization and upstream innovation related to standardised technologies.

A similar observation was made in relation to the policy revision by the VMEBus International Trade Association (VITA).[135] In 2007, the VITA adopted a new provision, according to which SSO participants must disclose the material terms required to licence any SEPs prior to adoption of a new VITA standard. A study by Contreras (2011) found no evidence of a change in the number of standards started or adopted at VITA, the length of time required to develop those standards, or their quality. While one prominent member did leave VITA, most of the members responding to Contreras' survey suggested that the revised policy improved the openness and transparency of its standards development process.

5.5. Is potential downstream harm likely to be offset by increased innovation by technology contributors to standards?

Even under the assumption that higher SEP royalties from end-use-based licensing does lead to increased innovation upstream, this effect has to be assessed together with the flip side of the coin: an increase in royalties to SEP holders at the same time means that the royalty burden of downstream innovators goes up. As set out previously, this will reduce the downstream innovators' incentives to invest and may be passed through in the form of higher prices. Since these effects go into opposite directions, which of these effects dominates inter alia depends on the level of royalties.[136]

In an ideal world, FRAND royalties could be set to maximise welfare by providing optimal incentives to innovate, both for "upstream" technologies that can be integrated into standards and "downstream" technologies integrated into the final products. Such analysis is complex and results seem to depend on specific assumptions. Yet, several more general insights can guide this assessment.

Value from standard-implementing products typically results from complementary investments. A well-known implication of complementary inputs is that the sum of the marginal contributions of all inputs exceeds the total value.[137] This principle holds for any form of complementary relationship between two inputs but is exacerbated in the case of perfect complements. Rewarding any one contributor with more than the full incremental value of its investment is not desirable because doing so will reduce the reward available

133 While negative LoAs are not directly indicative of a negative impact on upstream innovation, the refusal of some SEP owners to commit licensing their patents under the SSO's policy terms might increase the uncertainty for licensees and thus hamper the widespread adoption of the standard.

134 We note, however, that a simple comparison of the average number of PARs before and after the policy revision ignores that in 2010, 2011 and 2013 the number of PARs was actually lower than in all years from 2015 to 2017. As the small difference in the average yearly number of PARs of 4% is mainly driven by the extraordinarily large number of PARs in 2014, it seems rather far-fetched to attribute this difference to the IEEE's policy revision.

135 Contreras (2011).

136 Layne-Farrar and Stark (2020) implicitly assume SEP-holders could be undercompensated if patent hold-up from an excessive royalty base would be reduced. However, this ignores the other side of the coin, namely that SEP royalties are typically associated with reduced downstream investments.

137 The joint value of standard-implementing features and other features of multi-component products is normally greater than the sum of the inputs' values in isolation. An implication is that the sum of the *marginal* contributions of complementary inputs is greater than the total product value.

to other contributors. The royalties therefore must be balanced to foster both innovations for the standard as well as complementary downstream innovations.

On balance, the SEP holders' *ex ante* incremental contribution to the product value seems an appropriate upper bound for the FRAND royalty, for three reasons.[138] First, if SEP holders obtained more than their incremental contribution in a scenario of complementary inputs, downstream innovators will receive a smaller proportion of their incremental contribution, which may unduly suppress downstream innovation. Second, the *ex ante* incremental value is relevant, as otherwise there would be a risk that upstream innovators are over-rewarded: the ex-post incremental value may exceed the *ex ante* incremental value because technologies included in the standard in practice cannot be replaced by alternative technologies any longer after standardisation. Of course, from a welfare perspective it would be unreasonable to reward upstream innovators for the loss of competition from standardisation.[139] Third, if inventions can be pursued by multiple firms, granting a patent to the first successful firm, and setting the patentee's reward equal to the social contribution associated with the invention (taking competing technologies into account) results in wasteful duplication of effort, and in *socially too strong* incentives to innovate. The lesson from the relevant research is that the reward should be strictly less than the social benefit of an invention in a conventional patent system in which the first firm to achieve the invention receives a reward in the form of exclusive rights.[140] This insight seems to be of particular importance for technologies integrated into standards, which are commonly protected by patents.[141]

It follows that the royalty emerging in a hypothetical *ex ante* negotiation can form a useful benchmark for assessing the total effects of an increase of the SEP royalties.[142] If SEP

138 Shapiro (2007), p.114 et seq.

139 Importantly, standardisation usually results in a proliferation of technologies included in standards. In practice, SEP holders are benefitting from this proliferation in the form of an increased volume of licensed products.

140 See Shapiro (2007), p.115-116. Intuitively, the R&D effort of each innovator imposes a negative externality on competitors working on a similar innovation, which each firm individually does not take into account.

141 In contrast, much of the downstream innovation is not patented and the rewards for innovations seem to accrue less often exclusively to firms that are first to discover certain innovations.

142 We expect that because of the complementarity of inputs, the IP holder would typically obtain a return of less than the incremental value of its technology in *ex ante* negotiations. The level of the royalties would depend on the bargaining power of the parties. It has been argued that using an *ex ante* hypothetical negotiations benchmark when the standard is determined only takes place after the SEP holder has invested in (and borne the risks of) research, development, and patenting of the innovation (e.g. Froeb and Shor (2015), Ganglmair et al. (2012)). Innovation costs are therefore treated as "sunk" in the hypothetical negotiations, but if the SEP holder enjoys a strong bargaining power, it nevertheless can be expected to obtain a high payoff, giving rise to strong incentives to invest into upstream innovations.
Ganglmair et al. (2012) find that if licensees could request courts to impose FRAND rates equalling on average the *ex ante* negotiation outcome, this may curb incentives to invest into upstream innovations. However, this finding is driven by the artificial assumption that only the downstream innovator, not the SEP holder, can invoke the court to set FRAND rates. The paper also finds that if courts could not be invoked to determine FRAND rates, inefficient patent hold-up may occur, thereby justifying the importance of third-party FRAND setting in the first place.

royalties are already inflated, a further increase of the expected royalties through a further expansion of end-use-based licensing would reduce overall welfare.[143]

The empirical findings presented in Section 1.2.1 suggest that SEP holders have been able to extract royalties exceeding the *ex ante* incremental value of their patents already. In that case, although end-use-based licensing might stimulate upstream innovation, the associated social benefits would be insufficient to offset the harm from reduced downstream innovation and higher prices.

Finally, inflated SEP royalties following from end-use-based licensing may not only incentivize firms to invest in the development or improvement of a standard, but also to engage in rent-seeking with no value contribution to the standard. In this regard, Dewatripont and Legros (2013) argue that if the contribution of a patented invention to the value of a standard is difficult to observe, FRAND licensing policies induce an over-investment in patenting with respect to the social optimum. Bekkers and West (2008) document a strong increase in the number of patent declarations over time and claim that the obligation to licence SEPs on FRAND terms has proven insufficient to limit this "proliferation" of patents. Simcoe and Righi (2021) observe that continuations, which allow patentees to claim technology developed after the original filing date of a patent, are commonly filed immediately after the standard publishes and are more commonly used when the initial patent examiner is more lenient. The authors interpret the widespread use of continuation procedures as an attempt "*to opportunistically 'invent patents' that are infringed by already-published standards*".[144] Although the strong proliferation of patents and continuations is not necessarily caused by end-use-based licensing, an increase of the expected SEP royalties through end-use-based licensing may exacerbate this problem.

143 Shapiro and Lemley (2020).

144 Shapiro and Lemley (2020).

APPENDIX A: METHODOLOGY – UPSTREAM V. DOWNSTREAM R&D SPEND

The following annex outlines in detail how the downstream and upstream R&D spend estimates presented in Section 5.1 are compiled. We first explain how the R&D spend for the five largest smartphone OEMs downstream was estimated. We then present an overview of how (i) the licensing revenue of SEP holders is calculated, and based on this (ii) how upstream R&D spend is approximated.

Downstream R&D spend

Our estimation of downstream R&D spend focuses on the largest OEMs making up more than 90% of global smartphone revenues in 2020. These are Apple, Samsung, Huawei, BBK (comprised of brands Vivo, Oppo, Realme and One Plus) and Xiaomi.

We then obtain 2020 total revenue related to each firm's smartphone business,[145] as well as total revenue and R&D spend across all business segments from financial statements and annual reports. Smartphone R&D spend for downstream OEMs is calculated by multiplying the revenue share from smartphones with the total R&D spend. BBK is a privately held company and does not publicly disclose revenue or R&D figures. BBK's smartphone R&D spend has been imputed using the R&D spend of the remaining three OEMs and multiplying with the ratio of BBK total smartphone revenue over total smartphone revenue of the remaining OEMs.

Table 2: Revenue and R&D spend by smartphone OEM, 2020 (USDm)

OEM	Total Revenue	Smartphone Revenue	Total R&D	Smartphone R&D (imputed)
Apple	274,515	163,258	18,752	11,152
Huawei**	129,169	65,223	20,562	10,382
Samsung	200,637	92,142	17,980	8,257
BBK*		58,347		5,169
Xiaomi	35,629	27,205	1,341	1,024
Total				**35,985**

Source: Annual reports. Note: * BBK is privately held and does not publish figures on revenues or R&D spend. ** Huawei subsidiary HONOR was sold in November 2020 to Shenzhen Zhixin New Information Technology. 2020 Smartphone revenues are included under the Huawei brand.

Upstream R&D spend

In the following, we first explain how smartphone SEP royalties were derived. These are then used in a second step to calculate upstream smartphone related R&D spend.

145 Based on data provided by technology market research company Canalys.

SEP royalties

To estimate the level of global smartphone SEP royalties, we use a bottom-up approach: we identify the main smartphone SEP licensors and estimate their respective SEP licensing revenues from smartphones for 2020.[146]

We identified 31[147] main smartphone SEP licensors that in total earned around $8.9 billion in smartphone SEP royalties in 2020. As can be seen from Table 2, the distribution of these royalties is heavily skewed towards a small number of individual SEP holders with the largest SEP licensor accounting for 51% of the estimated total royalties.

Table 3: Smartphone SEP royalty revenues by licensor - 2020

Licensor	Category	Smartphone SEP Royalty revenue (USDm)	Methodology*
Qualcomm	Individual licensor	4,525	Documented
Nokia	Individual licensor	1,369	Documented
Ericsson	Individual licensor	932	Documented
Huawei	Individual licensor	375	Documented
Interdigital	Individual licensor	312	Documented
Microsoft	Individual licensor	212	Documented
Xperi	Individual licensor	153	Documented
HEVC Advance	Patent pool	134	Calculated
Via Licensing LTE	Patent pool	117	Calculated
Philips	Individual licensor	103	Documented
IBM	Individual licensor	88	Documented
MPEGLA AVC H.264	Individual licensor	77	Calculated
Broadcom	Individual licensor	66	Documented
Via Licensing AAC	Patent pool	62	Calculated
Intellectual Ventures	Individual licensor	60	Extrapolated
MPEGLA HEVC	Patent pool	50	Calculated
Via Licensing WCDMA	Patent pool	48	Extrapolated
Rambus	Individual licensor	32	Documented
Acacia Technologies	Individual licensor	25	Documented
Technicolor	Individual licensor	22	Documented
Blackberry	Individual licensor	19	Extrapolated
Conversant IP	Individual licensor	19	Extrapolated

146 We limit our identification of SEP holders to only those firms that are actively seeking licensing revenues for their SEPs, excluding cross licences.

147 We count the different licensing programmes of patent pools and the company AT&T as separate “licensors”. If each patent pool operator and AT&T are only counted once, the number of identified licensors amounts to 26.

Major SEP licensors have been previously identified by Galetovic et al. (2018) who estimate total smartphone SEP royalties for 2016. Galetovic et al. had identified 40 smartphone SEP licensors, eight of which we exclude from our analysis as their royalty revenues are likely negligible (in fact, Galetovic et al. did not provide a royalty estimate for them either). Alcatel-Lucent has been acquired by Nokia in the meantime (i.e. its royalty revenues are included in our estimate for Nokia). Based on our desk research, we find no evidence that additional major smartphone SEP licensors on top of those identified by Galetovic et al. have emerged since 2016.

Licensor	Category	Smartphone SEP Royalty revenue (USDm)	Methodology*
Unwired Planet	Individual licensor	15	Extrapolated
Quarterhill	Individual licensor	15	Extrapolated
ATT MPEG4	Individual licensor	13	Extrapolated
ATT 802.11	Individual licensor	7	Extrapolated
MPEGLA MPEG4	Patent pool	5	Calculated
ParkerVision	Individual licensor	2	Extrapolated
Tivo	Individual licensor	2	Extrapolated
PanOptis-Optis	Individual licensor	1	Extrapolated
VirnetX	Individual licensor	1	Extrapolated
Total		**8,863**	

Source: CRA estimates of 2020 smartphone SEP royalties based on licensors' financial reports, publicly available information and Galetovic et al. (2018).[148]

Notes: * *Documented* licensor revenues are based on annual report filings. *Extrapolated* figures based on adjusted estimates from Galetovic et al. (2018). *Calculated* licensor revenues are based on CRA calculations using available information.

** Microsoft and Philips are members of the Via AAC, MPEG LA MPEG4, MPEG LA AVC and Access Advance pool. AT&T licences its MPEG4 patents through the Via AAC pool. In order to avoid double-counting we have estimated the share of the pools' licensing revenues that accrue to these three licensors and subtracted them from the pools' total estimates revenues.

In estimating smartphone royalties for the 31 identified smartphone licensors, we employ a variety of different research methods.

Licensors with documented licensing revenues

Almost 90% of all licensing revenue in 2020 is estimated based on publicly disclosed financial reports. This includes a majority of the largest licensors by licensing revenue – Qualcomm, Nokia, Ericsson, and Interdigital. We estimate SEP royalties for these firms by reviewing their annual reports and extracting the relevant figures – usually this is categorized as licensing revenue or similar. From these figures, we make an assumption regarding what percentage of licensing revenue refers specifically to SEP licensing. We are guided by information provided within the annual reports, which often provide a short note on the components that make up licensing revenue. In instances where it is stated that licensing revenue is made up from more than just SEP licensing, we attribute 95% of licensing revenue to SEPs.

Having estimated total SEP royalties from company financial information, we next look to split this SEP revenue between smartphones and all other products. We estimate that in most cases about 90% of the SEP royalties we identify from companies' financial statements are smartphone related.[149]

148 Galetovic et al. (2018).

149 We leverage information on smartphone sales as a proportion of major consumer electronic sales, as well as the fact that smartphones implement most of the standards we identify. See https://www.statista.com/outlook/cmo/consumer-electronics/tv-radio-multimedia/worldwide..

These licensors are referred to as 'documented' in Table 3 above.

Patent pool revenues

For pools where publicly available information regarding licensees and royalty structure is available, we can estimate total royalties attributable to smartphone sales. This is possible for many major patent pools including the MPEG LA pools for MPEG4, AVC, and HEVC, as well as the Access Advance and Via AAC patent pools – all present within the list of 31 identified licensors.

In order to calculate pool royalties attributable to smartphones, information on the pool royalty structure, licensees, and the number of smartphones sold by each licensee of the pool is required. The list of licensees and royalty structure are often retrievable from the patent pool website, whilst for smartphone sales we make use of data from Statista[150] Combining this information allows us to calculate total smartphone royalties paid by each licensee of a given pool for 2020, thus estimating total smartphone SEP revenue for the patent pool.

The patent pools for which we estimate royalty revenues in this way are referred to as 'calculated' within in Table 3 above.

All other licensors

For a handful of licensors with low licensing revenue below $50m[151], the 2020 royalties are estimated by extrapolating the 2016 estimates by Galetovic et al. assuming their share of total licensing revenue remained constant over time. Each of these extrapolated licensor's 2020 licensing revenue figures is multiplied by 90%, to account for the fact that firms' licensing revenue are unlikely to entirely stem from smartphone SEP royalties.[152]

These licensors are referred to as 'extrapolated' in Table 3 above.

Smartphone upstream R&D spend

To calculate smartphone related upstream R&D spend, we first identify the set of SEP holders which (i) have R&D activities related to smartphone SEP development and (ii) publicly report figures on total R&D spend. This leaves us with a set of 14 licensors, excluding pools and non-practicing entities (NPEs).

For these SEP holders, we collect data on total R&D spend and derive smartphone SEP related R&D spend by multiplying with the SEP royalty share of total revenue. This

150 Statista is a global business data platform, https://www.statista.com.

151 Based on Galetovic et al. (2018). These cases make up for only around 2.6% of total smartphone SEP royalties in 2016.

152 There are instances where Galetovic et al. attribute zero smartphone SEP royalties to a potential licensor due to a lack of available information. In these instances, unless there is material evidence of licensing revenue being generated, the 2020 figures for these potential licensors are also set at zero. Royalties generated from these licensors are consequently almost certainly underestimated. These licensors include patent pools run by Sisvel (LTE, Wireless, and Wifi), Via (WCDMA), Velos (HEVC), and Vectis (Wifi), as well as private non-practicing entities including IPcom and IP Bridge. Note that some pool operators run more than one pool and a licensee of one standard is not necessarily a licensee of another offered by the same pool operator. For instance, licensees of the Via AAC pool may not be licensed to the Via LTE pool.

methodology implicitly assumes that upstream SEP holders allocate R&D spend to the various business segments in proportion to each segments' share of total revenue.

The aggregate R&D spend of pool members is derived by first calculating the ratio of pools' SEP royalties over royalties from the 14 SEP holders with relevant R&D activity. This ratio is then multiplied by the total, smartphone related R&D spend of individual SEP holders.

Table 4: Revenue and R&D spend SEP holders, 2020 (USDm)

Licensor	Total revenue	Smartphone SEP royalties	Total R&D spend	Smartphone & SEP related R&D*
Qualcomm	23,531	4,525	5,975	1,149
Nokia	24,945	1,369	4,666	256
Ericsson	25,232	932	4,312	159
Huawei	129,165	375	20,561	60
Interdigital	359	312	85	74
Microsoft	143,015	212	19,269	29
Xperi	892	153	195	35
Philips	22,300	103	2,186	48
IBM	73,620	88	6,333	8
Broadcom	23,888	66	4,968	14
Rambus	243	32	140	18
Technicolor	3,432	22	96	1
Blackberry	893	19	215	5
VirnetX	303	1	9	0
Quarterhill	108	15	2	0
Pool members		513	4,302**	116
Total				**1,970**

Source: Financial reporting, Table 3. Notes: * The financial reporting of Xperi and Philips allows for a refined derivation of upstream R&D spend. Xperi reports separately R&D spend related to its IP licensing segment. We assume that 90% of the R&D spend is smartphone related and use this figure as the basis for Xperi's upstream R&D spend. Philips reports separately revenues and R&D spend for "other" segments which include business operations related to "Innovation & Strategy" as well as "IP royalties". In the case of Philips, we derive upstream R&D spend as R&D spend for "other" segments multiplied with the SEP royalty share of revenues related to "other" segments. ** Imputed R&D spend of pool members.

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APPENDIX C: GLOSSARY

Ad-valorem royalties

Royalty rates derived as fixed percentage of the value (e.g., selling price) of a product or component.

Cournot complements problem

Arises when individual firms choose royalty rates without internalizing the effect of their royalties on the aggregate royalty burden and the profits of other firms. This may lead to royalty stacking and an excessive aggregate royalty burden.

Component-level licensing

Licensing terms are determined based on a component of an end-device which implements a patented invention.

Device-level licensing

Licensing terms are determined based on the device. Typically refers to the end-device which implements a patented invention.

End-use-based licensing

Licences whereby the royalty is differentiated as a function of the "end-use" or the value of the end product or service.

Ex ante negotiation approach

Approach to determine FRAND royalties considering the outcome of a hypothetical licence negotiation between the SEP holder and the implementer (i.e. potential licensee) before the standard is set.

FRAND commitment

Commitment typically requested by standard setting organizations from IP holders to licence their patents at fair-reasonable and non-discriminatory terms.

Internet of Things (IoT)

The Internet of Things describes the network of physical objects that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. These devices range from ordinary household objects to sophisticated industrial tools.

Patent hold-up

Patent hold-up arises when a patent owner can extract a larger royalty *ex post* than it could have obtained in an arm's length transaction *ex ante*. In the context of SEPs, patent-hold-up can arise after a standard has been developed.

Royalty stacking

A situation in which a single product infringes on multiple patents, and thus bears an aggregate royalty burden across all patents infringed. Royalty stacking may lead to excessive aggregate royalties due to the Cournot Complements Problem.

Royalty base

Typically refers to the price of a product or component used to determine a royalty.

Standard essential patents

A standard-essential patent (SEP) is a patent claiming an invention that must be used in order to comply with a technical standard.

Smallest Saleable Patent Practicing Unit (SSPPU)

The smallest unit/module/component which implements the patented invention.

Standard Setting Organization (SSO)

Organization that develops and adopts an industry standard.

Transaction costs

Costs incurred when buying or selling a good or service. Include cost of identifying, negotiating or executing a purchase or sale.